Regional Biosecurity Plan for Micronesia and Hawaii

Volume IV

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Terrestrial Risk Assessment of Alien Invasive Species for Micronesia and Hawai'i

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EXECUTIVE SUMMARY

As a result of the Defense Policy Review Initiative conducted by the United States (U.S.) Secretary of State, the Secretary of Defense, the Japanese Minister of Foreign Affairs, and the Minister of Defense, the U.S. Department of Defense (DoD) has proposed relocation of U.S. military forces to the U.S. Territory of Guam and the island of Tinian within the U.S. Commonwealth of the Northern Mariana Islands (CNMI). The purpose of the relocation is to meet international agreement (Alliance Transformation and Realignment Agreement) and treaty (*U.S.-Japan Roadmap for Realignment Implementation*) requirements, and to fulfill U.S. national security policy requirements in the Western Pacific Region. Proposed actions include components of the U.S. Marine Corps, the U.S. Navy, and the U.S. Army.

To comply with the National Environmental Policy Act of 1969, 42 United States Code §§ 4321 et seq., as amended, DoD and other federal agencies must examine the environmental effects of the DoD's proposed actions for the relocation process. Council on Environmental Quality (CEQ) regulations (40 Code of Federal Regulations (CFR) §§ 1502.09 and 1502.20) govern supplemental and tiered environmental impact analyses. On behalf of DoD, the Department of the Navy prepared an Environmental Impact Statement (EIS) (Final EIS [FEIS] delivered July 2010) to inform decision makers of potential environmental consequences of the proposed Guam and CNMI military relocation actions so all parties can take measures to protect, restore, and enhance the environment.

According to the DoD FEIS, the military relocation beginning in 2011 and expected to peak by 2014[1] will have substantial impact on the population, economy, and environment on Guam. Other Micronesian Region islands and the state of Hawai'i will be impacted as well. DoD expects as many as 79,000 new residents on Guam by the peak year of the military relocation. Imports are expected to increase substantially with the increase in population during the military relocation and build-up, and may increase the risk of pests and diseases entering the Micronesia Region. Areas of U.S. jurisdiction under United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS) regulations 7 CFR § 318.13-1 and 9 CFR § 1-146 (under the Definitions subsection) include Guam, Hawai'i and CNMI (Saipan, Tinian, and Rota). These areas are defined the same as states (along with Puerto Rico, the U.S. Virgin Islands, and the District of Columbia) in regards to APHIS jurisdiction.

The primary objective of this terrestrial risk assessment is to propose detailed recommendations sufficient to prevent and mitigate risks to human health and safety, animal and plant health, the economy, and the ecology of the Micronesia Region from the intentional or unintentional introduction, spread, or establishment of terrestrial alien and potentially invasive animal, plants, and diseases. These recommendations are based on risk assessments by APHIS, APHIS regulations, and established policies

[1]The National Defense Authorization Act (NDAA) for Fiscal Year 2012 (FY 2012), signed into U.S. law on December 31, 2011, by President Barack Obama, imposed restrictions on the Secretary of Defense's usage of funds to develop infrastructure associated with the USMC relocation to Guam. Additionally, Congress did not authorize or appropriate funding for the Guam realignment in FY 2012. As the pace of construction is subject to the availability of funds, it is anticipated that the realignment will proceed at a slower rate than originally anticipated (NDAA for FY2012).

to determine the risks of introduction of invasive species or pathogens from the transport of passengers, baggage, cargo, commodities, and construction materials to Guam.

The recommendations are based on the risk assessments of APHIS-Plant Protection and Quarantine (PPQ) personnel with extensive on-the-ground experience. These recommendations and suggested best management practices should help prevent invasive species damage to the region from the military relocation on Guam and the CNMI. While the recommendations vary in specificity, they do not provide a comprehensive blueprint for implementation. How these recommendations are implemented will determine their effectiveness.

In determining biosecurity recommendations, risk assessors identified pathways which could be carriers for the introduction of invasive species and pathogens. Risk assessors evaluated current literature, visited sites, and conferred with local subject matter experts to evaluate potential risks for the introduction of invasive species and studied these risks as predicted impacts from the military relocation and build-up on Guam.

Each group of APHIS risk assessors developed a specific methodology to determine risks and recommendations for biosecurity enhancements. For many pathways and species, information for making determinative rankings for risks was limited; therefore, risk rankings for most pathways and species in the APHIS risk assessments are qualitative.

Risks were determined for a wide range of animal and plant species and pathogens. Plant propagative material may present phytosanitary risks in the Micronesia Region as either a pathway for introduction of exotic plant pests or as propagated invasive species. The introduction of many livestock, poultry, and wildlife diseases could have severe consequences to animal and human health throughout the Micronesia Region and far-reaching impacts on trade for the rest of the United States. More smuggling could mean more health and ecological risks from exotic pets and recreational animals. The potential for importation of zoonoses that pose a major public health threat warrants increased surveillance for imported wildlife.

To determine biosecurity recommendations, the assessors reviewed U.S. and Guam statutes, regulations, and procedures for prevention and mitigation of biosecurity risks for general mitigation practices for all pathways (commercial, military, and private).

While federal, territorial, and military regulations may prevent and mitigate the introduction of invasive species and pathogens, the estimated increase in population and goods with the military relocation will strain current capacity for inspection and interdiction of illegal goods, and increase the likelihood of invasive species transported throughout the region. Already mitigation resources are stretched at air- and seaports in the Micronesia Region. Ports and diagnostic laboratories do not have sufficient detection and identification equipment. Surveillance for the detection of plant pests and the brown treesnake (*Boiga irregularis*) (BTS) is routine. Rapid response capabilities are limited to BTS and lacking for even BTS in many areas.

With its broad scope and complex risks, the challenge of protecting Hawai'i and the Micronesia Region from the multitude of threats requires an overarching framework for a successfully sustained biosecurity process. This Micronesian Biosecurity Plan includes components designed to reduce biosecurity risks through prevention with educational outreach programs and through risk mitigation measures including inspection, quarantine, monitoring, surveillance, rapid response, control, and eradication.

A comprehensive biosecurity plan requires an integrated process for regular reassessment and improvement as situations change and new risks become known. An improvement planning approach from the Department of Homeland Security (DHS), *Homeland Security Exercise Evaluation Plan*, will serve as an informative reference for continual improvement in biosecurity planning. Templates are available for scheduling and conducting improvement planning events and building successful prevention and mitigation programs and can be found at https://hseep.dhs.gov/pages/1002_Exerc0.aspx.

The challenges, risks, and costs of long-term control and eradication of an established invasive species are significant. The most cost-effective approach to protecting regional human health and agricultural resources is prevention and early detection. Success in preventing the transport, introduction, and establishment of invasive species in the region will require a coordinated and comprehensive approach based on information-sharing, funding of well-planned resources, and coordinated prevention and protection programs among all biosecurity partners and stakeholders. A regionally inclusive process will engage appropriate experts and decision makers fully, build consensus and commitments, and take advantage of expertise and resources within Micronesia.

1 INTRODUCTION

In compliance with EO 12114 and according to proposed events and anticipated impacts described in the FEIS, USDA-APHIS has developed this regional terrestrial risk assessment (RA) to assist in the protection of Guam, Hawai'i, CNMI, Federated States of Micronesia (FSM), Palau and the Republic of the Marshall Islands (RMI) as well as the broader Pacific from invasion by unwanted pests and disease agents during the increased U.S. military activity (EO 12114).

The terrestrial RA provides recommendations for protecting Hawai'i, Guam and other Micronesian Region locations based on USDA-APHIS Pest Risk Assessments (PRA), USDA-APHIS regulations, and established USDA mitigation procedures. Species life histories and current biosecurity practices have identified potential means of transport of invasive species into the Micronesia Region and Hawai'i. While the primary geographic focus is Guam, the terrestrial RA considered the CNMI, the Republic of Palau, FSM, RMI, and Hawai'i with particular focus on CNMI due to proposed military training activities with trans-shipment of relocation cargo through CNMI.

The APHIS assessment task was divided among four APHIS teams based on program expertise. The Plant Health Programs of APHIS-Plant Protection and Quarantine (PPQ) provided regulatory and risk mitigation guidance. APHIS-Veterinary Services (VS) analyzed risks to livestock from disease vectors. APHIS–Wildlife Services (WS) analyzed risks to wild terrestrial vertebrate animals from wildlife disease vectors and wildlife. The Center for Plant Health Science and Technology (CPHST) of APHIS-PPQ analyzed risks from invasive plants, plant pests, and plant diseases.

1.1 ASSESSMENT DESIGN

Chapter 1: Introduction, provides an overview of the objectives, scope, design, and caveats of the terrestrial RA.

Chapter 2: Military Relocation to the Mariana Islands.

Chapter 3: Existing Mitigations, describes current policies, requirements, and methods developed by Guam, APHIS, DoD, and other authorities for phytosanitary and general sanitary practices at all Guam ports. Ports for other jurisdictions were not detailed here and therefore will be covered in the implementation plan component of the Micronesia Biosecurity Plan.

Chapter 4: Recommendations, lists APHIS recommendations for enhancing biosecurity measures and programs during and after the military relocation.

Chapter 5: Outreach Plan, describes an approach to educate local populations and organizations about potential risks from invasive species and methods to prevent, report, and control their introduction.

Chapter 6: Monitoring and Surveillance, describes strategies and methods for a coordinated monitoring and surveillance process to detect and report high-risk species rapidly.

Chapter 7: Rapid Response, describes strategies, methods, and organizations involved with control and eradication of invasive species.

Chapter 8: Terrestrial Vertebrate Species, describes the unique biosecurity requirements for terrestrial vertebrate species.

The remaining chapters include compilations of APHIS risk assessments, pathway risk analyses, quality assurance measures, and references.

1.2 OBJECTIVES OF THE TERRESTRIAL RA

- Prevention of the introduction and spread of IAS to the jurisdictions of Micronesia and Hawai'i.
- Evaluation and integration of APHIS PRA information, risk ratings, and recommendations along with appropriate APHIS regulations and policies into a comprehensive strategy for biosecurity protection and response during and after the military relocation to Guam.
- Development of an outreach and education plan to increase awareness of risks from invasive species, encourage the adoption of practices to prevent the transport of invasive species, and describe mechanisms for reporting suspected introductions.
- Development of monitoring and surveillance risk-mitigation strategies for rapid detection of high-risk species and diseases.

1.3 CURRENT RISK ASSESSMENTS

This terrestrial RA integrates the APHIS risk assessments and recommendations developed by the CPHST, PPQ, VS, and WS risk assessment teams showing potential impacts to agriculture, ecosystems, and economies throughout the Micronesia Region from the introduction of invasive species during the planned military relocation on Guam and Tinian. For the purposes of this RA, references to "invasive species" include live animal and plant species, animal pests, vectors, and infectious agents. APHIS Terrestrial Risk Assessments are included in Appendix A.

1.4 SCOPE

This RA is framed by a closely defined scope on three levels: geographic, temporal, and operational. The geographic scope describes the locations of Micronesian Region islands and Hawai'i as well as foreign ports from which personnel and supplies originate. The temporal scope describes timing and duration of all plan requirements to be completed.

The basis for understanding risks of the military relocation phase is the evaluation of all military relocation activities as described in the FEIS issued in July 2010 (U.S. Navy 2010a); identification of all potential enhanced risk due to the unintentional introduction of invasive species associated with the relocation; and the integration of the risk profile and required protection enhancements into this RA. Any changes to the military relocation plan after delivery of the final draft of this RA may not be considered in the RA document.

The operational scope analyzes potential direct and indirect impacts from military relocation activities in movement of personnel and belongings, construction, commercial development, shipping and service industries, tourism, resource utilization, resource planning, etc. The operational scope also includes prevention and protection programs; education; awareness training on Guam and throughout Micronesia for military and civilian populations; and mitigation programs of inspections, monitoring, surveillance, and emergency response.

1.5 CAVEATS

The development of risk assessments and biosecurity planning recommendations for the military relocation to Guam and Tinian and potential impacts throughout the Micronesia Region depends on processes outside the control of RA developers, and therefore, certain caveats apply. The RA presents recommendations based on methodology for assessing mitigation capabilities and determining potential impacts. The caveats are addressed in Chapter 5: USDA-APHIS Risk Assessments.

2 MILITARY RELOCATION TO THE MARIANA ISLANDS

2.1 MEASURING IMPACTS FROM THE MILITARY RELOCATION

The proposed complex military relocation includes components of the Marine Corps, Navy, and Army as well as Air Force assets already on Guam. To accommodate the three major elements of the proposed actions, a substantial increase in construction and improvements (Marine and Army base residence, aviation maintenance facilities, etc.) as well as more frequent ship berthing would be necessary. According to the DoD FEIS (U.S. Navy 2010a), implementation of the proposed military actions would result in:

- Temporarily increased population related to the construction work force
- Permanently increased number of military and civilian personnel and dependents on Guam
- Increased transient presence on Guam and Tinian
- Increased numbers and types of major equipment assets to support military personnel and operations (e.g., aircraft, ships, amphibious watercraft)
- Increased numbers and types of training activities
- Construction of new facilities
- Improvements to existing facilities
- Improvements to infrastructure (including roads and utilities)
- Acquisition of additional land (required for three of the Marine Corps Relocation-Guam actions)

The risks from invasive species to Hawai'i, Guam and other Micronesia Region islands are linked most closely with the conveyance pathways that could transport the plant and animal species. Pathways are any means that allow the entry or spread of pests. A pathway risk assessment systematically evaluates the likely ways by which exotic pests or pathogens might enter an area and become established. A number of physical animal and plant pathways may move invasive species and diseases; however, most introductions to Hawai'i, Guam and other Micronesia Region locations are likely to be by commercial and military aircraft and maritime vessels.

Military relocation activities can impact multiple pathways in diverse ways. While data may be limited, interrelationships uncertain, and future events unpredictable, estimated numbers of personnel and contract workers are available and can be used to estimate potential impacts and necessary protections required to mitigate these impacts. Estimates are also available for the increase in construction materials needed to add or improve new military and residential housing, roads, and other infrastructure.

Planning and the allocation of funds will need to be part of any military relocation to the Mariana Islands. Even a scaled back version of the build up will be overwhelming in terms of the impacts it will have on the limited infrastructure, especially inspection capabilities for contraband and invasive species.

Military relocation will increase air transportation volume to and from Guam. Most military personnel and temporary workers will travel to Guam by commercial aircraft, increasing passenger volume on air transports substantially. Related pathways to this conveyance:

- Military and civilian passengers capable of transporting infectious diseases, disease vectors, and hitchhikers (species unintentionally transported in cargo, packing material, or containers)
- Baggage of passengers and all potential risk species that could be transported therein
- Commercial air cargo
- Garbage on board aircraft and from items confiscated at port
- Imported plants, plant products, animals, and animal products
- Smuggled biological items
- Unintentional transport of terrestrial vertebrates

New Guam residents and increased military activity on Guam and Tinian will require transport of equipment and materials and other cargo by maritime vessels for infrastructure and services.

- Construction equipment and materials shipped to Guam as containerized, break bulk, and bulk cargo
- Additional homes and buildings constructed to meet the demands of new residents and businesses
- Expansion of commercial and military port infrastructure
- Garbage generated on vessels
- Imported plants, plant products, animals, and animal products

New Guam and Tinian residents will conduct activities for business or pleasure, which could impact biosecurity.

- Mail and shipments to new residents on Guam and Tinian
- Landscaping
- Cultural activities (food preferences, religious ceremonies, aesthetic pursuits, hunting, fishing, boating, and other water water and terrestrial based activities)
- Scientific activities (zoological exhibitions and scientific research)

Leisure and business travel throughout the region and beyond by new residence and/or by visitors to residents

Military Impact Estimates

According to the DoD FEIS, Guam's current population of 177,718 (World Bank, World Development Indicators 2009) will increase by about 79,178 new residents, approximately 45%, at the peak of the military relocation. The post-relocation steady state will result in 33,608 new residents, an approximately 19% increase (U.S. Navy 2010a). DoD planning as of 2013 anticipates these numbers to be lower.

The DoD FEIS estimates shipments of containerized cargo to increase and then stabilize to a post-military relocation steady state (U.S. Navy 2010a).

It should be clear that these estimates are based on information which was current in 2010 but is no longer likely to occur. Changes will take place in regards to the buildup but exactly what these changes and associated impacts will be and at what levels was still undetermined as of August 2013.

2.2 PATHWAYS AND RISK SPECIES

Invasive species and disease agents threatening biosecurity on Hawai'i, Guam and other Micronesian Region islands are linked through their life cycles to specific pathways of transport. In most cases, these animals, plants, pests, and diseases move through more than one pathway. APHIS risk assessments have evaluated each of these relationships. Table 5-1 illustrates the range of mitigation measures employed at airport and maritime port facilities. Each of the following mitigations may be applied at both the air- and seaports: 1) inspection, 2) commodity identification, 3) control, 4) quarantine, 5) treatment or disinfection, 6) review of documents (permits, health or phytosanitary certificates, etc.), 7) training, and 8) approval to handle regulated garbage.

The pathway and risk profiles described in this section are designed as snapshots of the primary risk types, risk levels, mitigation measures, and recommended mitigation upgrades based upon APHIS risk assessments. Greater detail for biosecurity mitigation measures is in Chapter 6, *Existing Mitigation*. A more detailed, comprehensive description of the biosecurity recommendations for plants and plant products, livestock and poultry, and wildlife diseases is in Chapter 7, *Recommendations*. Specific recommendations for terrestrial vertebrates are in Chapter 11, *Terrestrial Vertebrates Biosecurity Plan*.

Table 5-1: Mitigation Measures for Risk Pathways

Pathway	Pre-test/ certify	Permit or License	Monitor	Inspect	Identify	Quarantine	Treat-disinfect-decontaminate-dispose
Cargo	X	X		X	X	X	X
Wood Packing Material	X			X	X	X	X
Construction		X		X		X	X
Mail				X[a]			
Regulated garbage	X	X	X	X		X	X
Plant propagative materials	X	X		X		X	X[b]
Plant products	X	X[c]					X
Soil		X		X			X
Livestock	X	X		X	X	X[d]	X[e]
Poultry	X[f]	X		X		X	
Pet birds	X	X		X	X	X	
Dogs and cats	X[g]			X		X	X[h]
Other animals	X	X		X	X	X	
Animal products	X	X		X			X

[a] Only international mail may be inspected without a warrant.
[b] Plants from Hawai'i.
[c] Fruits and vegetables.
[d] All foreign livestock destined to Guam and associated territories would be quarantined on Hawai'i or in the continental United States.
[e] Domesticated livestock imported to the United States is subject to inspection or treatment procedures; an inspector may require disinfection of livestock and equipment as a precaution against the introduction of animal diseases.
[f] All imported hatching eggs from Exotic Newcastle's Disease-free regions must be accompanied by a veterinary health certificate as well as a USDA import permit.
[g] Dogs imported to the United States, with limited exceptions, must be accompanied by a certificate for rabies vaccination; the entry of pets from areas affected by screwworms requires a health certificate; dogs must have a rabies vaccination certificate (Guam Administrative Rules and Regulations or GARR); cats must have a certificate of immunization (GARR).
[h] Administration of two doses of rabies vaccine (GARR).

2.2.1 Aircraft

A.B. Won Pat International Airport manages hundreds of flights weekly of national and international cargo and passenger transport, with numerous flights originating or passing through major Asian and Pacific metropolitian areas. All flights are considered "foreign" for agricultural inspection purposes. During FY 2008-2009, flights into the international airport averaged 1,610/month (approximately 400/week) (Guam Airport 2009).

All aircraft pathways are considered high-risk due to their ability to transport Brown Treesnakes (BTS) and other IAS in stores, baggage, or cargo.

For military aircraft, risks were higher for conveyances departing on urgent missions, which are not delayed for BTS (or other terrestrial vertebrate) inspections.

Other factors mitigate the risk of introductions through the air transportation pathway. Most of the military personnel relocating to Guam probably will move from the United States including Hawai'i, origins with greater enforcement resources for intercepting potentially invasive species in transport. Much of Micronesia appears to be free from many high-consequence animal pathogens that affect other regions of the world (APHIS Terrestrial Risk Assessment, Appendix A), although it is difficult to substantiate this appearance without sufficient veterinary infrastructure and surveillance.

Risks from livestock are mitigated by a lack of exposure to suitable agricultural hosts. For example, mosquitoes carrying agricultural disease agents are commonly transported in conveyances, but inspection procedures and lack of susceptible hosts near ports make release of the vectors less likely. Air cargo inspection at the airline facility at the airport allows for better inspection conditions. Ticks often found in luggage or carried by humans are from countries of origin not of high risk for tick-borne exotic livestock disease to Guam.

2.2.1.1 ***Impact of the Military Relocation:*** it should be noted that the estimates expressed in this section are basic on 2010 planning projects which are no longer current.

The military relocation will cause a substantial increase in conveyance and passenger traffic to Hawai'i and the Micronesia Region. Passengers will be military personnel, temporary contract workers from foreign ports in the Philippines and China, and military and construction worker families. An estimated 9,000 permanent military personnel with 10,000 dependents will be transported to Guam by 2014 (U.S. Navy 2010a).[2] Approximately 20,000 construction workers will arrive in Guam, resulting in about 17,000 direct or induced jobs for needed services. Approximately 20,000 dependents will relocate to Guam, at least temporarily. Military families will transport baggage, household items, vehicles, and outdoor equipment. Each family is permitted up to 8,164 kg (18,000) pounds of household goods depending on rank (U.S. Navy 2010a).

The influx of the 59,000 workers and their families is likely to increase the demand for specialty ethnic items and impact the amount of plants and plant pests smuggled into the Micronesia Region.

Airport phytosanitary and general sanitary mitigation measures include inspection, permit review, control, quarantine, treatment, disinfection, and personnel training. According to military estimates, demand for airport services may increase as much as 51% during the peak of the military relocation (U.S. Navy 2010a). Therefore, these mitigation capacities may need to be evaluated to determine whether they can meet the increased demand or will require appropriate enhancements in resources and funding.

Current mitigation measures are not sufficient to protect Guam from invasive species introduction, and therefore also do not protect the rest of Micronesia nor the state of Hawai'i adequately. Recommendations that follow for improving mitigation practices should provide a suitable baseline of protection. The increased air traffic will stress the already strained inspection process on Guam. Additional resources and infrastructure improvements should be made to permit inspectors to protect

[2] Ibid, p. 2-1.

ports adequately from species introduction. Infrastructure and resources for inspection of arriving and departing aircraft should be increased to meet the expected increase in conveyance traffic to manage the influx.

2.2.2 Maritime Vessels

2.2.2.1 *Pathways and Risk Species*

Historically both commercial and military vessels have transported invasive species to new locations. Invasive species can be found in vessel passenger and crew cabins, food and garbage storage areas, and cargo holds. Cruise ships and smaller vessels like fishing and recreational craft are also potential pathways.

2.2.2.1.1 *Hitchhikers*

Maritime vessels often transport invasive species in ship interior cabins, food and garbage storage areas, and cargo holds. Passengers and crew can carry invasive species on their clothing and in baggage. High-risk species transported as hitchhikers include live plants and propagative materials, arthropods (ants, mosquitoes, ticks, bees, Khapra beetles), plant pests and diseases, small mammals (rodents and bats), reptiles (snakes), and amphibians. Historically rodents have presented substantial risks in their high populations in port cities, access to ships through mooring lines and cargo, and viability during long transports (WSTV PRA 2010).

2.2.2.2 *Garbage*

Disease-causing vectors for plants and animals could be transported in garbage stores aboard ships. Large stores of garbage also attract invasive wildlife and birds (MARPOL 2006). Vessels needs to have SOPs for safe keeping of garbage and vessels when calling to port need to be inspected by biosecurity officers to make sure garbage is in an enclosed bin and secured. How garbage is handled when removed from vessels also needs to be described in SOPs to insure that disposal methods are adequate to prevent introductions.

2.2.2.3 *Current Mitigation Measures*

Ships entering Guam waters are inspected at Guam ports; GCQA, and the GDOA Biosecurity Division and Division of Aquatic and Wildlife Resources seize products, hold animals in quarantine, and prevent illegal imports.

Vessels may need decontamination if a source of contamination or infection is found or suspected on board. Vessels may require disinfection if restricted items were not transported in leak-proof containers. Decontamination of ships may also include de-ratting under Centers for Disease Control and Prevention (CDC) regulations.

The Defense Transportation Regulation 4500.9-R, Part V (DTR 5) establishes requirements for agricultural cleaning and inspection for the military.

Current mitigation measures are not sufficient to protect Guam from invasive species. Likewise, the planning for upgrading Guam capabilities has not been adequate.

2.2.2.4 *Risk Rationale*

Contraband items, drugs, and weapons may be much higher inspection priorities for GCQA. Limited time and insufficient staffing levels prevent GCQA from inspecting all ships adequately. Most maritime cargo is allowed to proceed for inspection from the seaport to the importer's premises. This practice increases the risk of pest dissemination.

Ship rodent protections may not prevent rodent infestation adequately, and therefore ships may depart from a port with rodents aboard. Inspection for rodents and other pest species needs to be conducted for all ship arrivals.

2.2.3 Cargo

2.2.3.1 *Pathway and Risk Species*

Invasive plant propagules, seeds, plant pests, insects, amphibians, reptiles, and small mammals may be spread in cargo through inadvertent transport of contaminated or infested household items, handicrafts, or agricultural products. Other invasive species incursions occur at shipping staging and loading areas (Frank and McCoy 1995; Hawley et al. 2006; Norman and Strandberg 1997; Smith and Moore 2008; USDA-APHIS-PPQ 2010a; Whinam et al. 2005).

Invasive species can be moved in shipping containers which may be infested prior to or during loading. Movement of pest species within containers is probably less common than with break bulk items which are open to the environment throughout the loading and transportation process..

Deliberate or accidental release of imported caged birds exposes livestock and poultry to disease agent hazards and disseminates vector hazards for establishment in suitable habitats.

2.2.3.2 *Steady State Mitigation Measures*

GDAWR and the GDOA PPQ Division identify confiscated products, hold animals in quarantine, and prevent illegal imports. Any importer or exporter of wildlife must obtain a permit from the USFWS and in some instances a permit from USDA-APHIS.

Chapter 511 of the DTR 5 requires GCQA inspection of all military cargo entering Guam, regardless of origin (DTR 4500.9-R, Part V, Chapter 511). The APHIS-PPQ Manual for Agricultural Clearance (USDA-APHIS-PPQ 2013) instructs inspectors to inspect cargo of agricultural interest. Cargo inspections are conducted at designated ports unless otherwise authorized by the Director of GCQA; however, inadequate maritime port inspection facilities often cause cargo to be moved off port for inspection at the importer's premises.

GCQA requires that all DoD cargo be available for inspection upon entry to prevent the introduction of plant and animal pests or diseases. DTR 5 establishes requirements for agricultural cleaning and inspection for all military cargoes. The U.S. military is responsible for meeting all regulations for foreign host nations. Micronesian sovereign governments can insist on military compliance with appropriate regulations.

2.2.3.3 *Risk Rationale*

Because of the volume of traffic, not all containers are selected for inspection. The limited military training in invasive species can be particularly consequential for the cargo pathway. Smuggling may also become an bigger issue as the population of the region grows.

2.2.3.4 *Impact of the Military Relocation*

The risks from the re-deployment of military personnel are mitigated by the fact that most military personnel relocating to Guam probably will move from the United States, including Hawai'i. However, a large number of personal shipments of household goods would be transported.

2.2.4 Wood Packing Material

2.2.4.1 *Pathway and Risk Species*

Wood packing material (WPM) has been implicated in significant plant pest introductions worldwide. Historical interceptions include 80 families of insects from seven different orders, seven families of mollusks, and seeds of 27 plant families. Particular risks may be the introductions of ants, terrestrial mollusks, wood-boring beetles, nematodes, and fungi. Wood may contain plant propagules, seeds, soil, or a range of hitchhiking organisms (USDA-APHIS-PPQ 2010a).

2.2.4.2 *Current Mitigation Measures*

U.S. regulations and International Standard of Phytosanitary Measures (ISPM) No. 15 require either fumigation with methyl bromide or heat treatment according to specific schedules for all WPM entering the United States. Treated WPM must display a specified ISPM No. 15 stamp in a visible location to facilitate compliance checks at ports of entry. These regulations apply to WPM imported from foreign origins into Guam, Hawai'i, and the CNMI (ISPM). Movement of WPM between these U.S. jurisdictions is domestic and thus not subject to these regulations (ISPM No. 15 2009).

The USDA-APHIS MAC (USDA-APHIS-PPQ 2013) directs inspectors to check whether regulated WPM is compliant. The APHIS Miscellaneous and Processed Products Manual instructs inspectors to look specifically for timber pests, other insects, and unspecified hitchhikers (USDA-APHIS-PPQ 2012). This guidance is used by U.S. territories but may also serve as standards for other countries in the Micronesia Region.

DoD stipulates that all new WPM under DoD contracts or acquired by DoD must meet ISPM No.15 requirements for shipments both inside and outside of the United States (DSCC 2008).

2.2.4.3 *Risk Rationale*

Many species associated with WPM, if introduced, could cause severe damage to Micronesian native flora and agricultural production.

There are many challenges to measuring the risk from WPM. The diverse range of species limits the ability to predict the species that may be found on WPM.

Pests may be present in the WPM because the prescribed treatments are not completely effective against all pests, especially plant pathogens, and because WPM may be re-infested after treatment (Haack 2006; Biosecurity Australia 2006). Treatments may be applied incorrectly, and the ISPM No. 15 seal may be administered fraudulently.

Very little information is available to estimate the amount of WPM moved in trade. The quantity of WPM entering Guam and the Micronesia Region or what quantity will enter during the military relocation cannot be determined. Estimates range between 50 to 75% of maritime cargo and up to 33% of air cargo (NZ MAF 2003; Meissner et al. 2009). No data are available on the average amount of WPM present per shipment because not all containers are inspected.

Because WPM is a circulating product and routinely re-imported, its origin is not always the same as the origin of the commodity with which it is moved. Palau and the RMI are not signatories of ISPM No. 15. A percentage of military and commercial shipments containing WPM will always bypass existing regulations and guidelines (random USDA inspections revealed that about 1% of maritime shipment WPM and about 5% of the air shipment WPM arrive without the required stamp).

2.2.4.4 *Impact of the Military Relocation*

The lack of adequate inspection is expected to worsen during the military relocation. Unavailable data on the volume of WPM in cargo shipments make estimates of the increase due to the military relocation guided only by the increased volume of cargo shipments.

2.2.5 Construction Equipment and Materials

2.2.5.1 *Pathway and Risk Species*

Construction materials presenting a common pathway for the introduction of invasive species could consist of trucks, tractors, cranes, earthmovers, forklifts, and barriers, as well as packaged items and loose timber, gravel, sand, and soil. Many of the risks and recommendations for construction equipment are described in Section 5.2.3, *Cargo*. Imported construction materials are likely to be shipped in containerized, break bulk, or bulk cargo.

The source for the majority of construction materials will be the U.S. mainland, although significant portions will originate in China and Japan (Berthoud, personal communication). Some materials will be imported from the Philippines and Indonesia (Jimenez et al. 2009). Palau has been a source for wood imports (GovGuam 1995), and blocks of cement and concrete have originated in FSM (Berthoud, personal communication).

Significant introductions of invasive species may have occurred through the import of construction material. Construction projects in Micronesian island nations have been implicated as pathways of introduction for invasive snails, plants, coconut rhinoceros beetles, cogon grass seeds, and highly invasive giant African snails (Hawley et al. 2006; USDA-APHIS-PPQ 2010a).

More than 130 different species were found at U.S. ports in 394 total interceptions on quarry products and steel shipments from Asia between 2003 and 2009 (USDA-APHIS-PPQ 2010a). More than 271 interceptions occurred on general equipment, machinery, and vehicles arriving at U.S. ports of entry from 2003 through 2009 from Asia. Many of these interceptions were reportable pests, including insects, mollusks, beetles, weeds, and grasses (USDA-APHIS-PPQ 2010a).

Some invasive species may colonize environments more easily when altered by construction activities (e.g., invasive plants giant foxtail [*Setaria faberi*], redroot pigweed [*Amaranthus retroflexus*], and the highly invasive Argentine ant [*Linepithema humile*]) (Mulugeta and Stoltenberg 1997; Kennedy 1998).

2.2.5.2 *Current Mitigation Measures*

Following inspection by the GDOA PPQ Division, imports of construction equipment to Guam found to be contaminated with soil must be washed in designated areas. Those contaminated with pests must be treated or re-exported.

Saw logs with bark are prohibited from entering Guam, and debarked saw logs and lumber must be determined through inspection to be free of termites and wood-boring insects. Foreign timber must have an import permit detailing required treatment. Other Guam regulations apply to all commodities, allowing the GDOA to quarantine, inspect, fumigate, disinfect, destroy, or exclude any commodities infested with pests (GARR Title 8, Food and Agriculture).

All regulations and requirements listed for cargo apply to the import of construction material.

2.2.5.3 *Risk Rationale*

Similar to WPM, it is difficult to quantify the risk of hitchhiker pests by construction pathway. Precise information on the types and amounts of construction material and equipment entering or expected to enter Guam in the future is not available. Construction at Andersen Air Force Base (AFB) alone is estimated to require more than 1,361 metric tons (3 million pounds) of steel (PB International 2008). Overall, it is clear that imports of construction material and equipment will increase significantly as a result of the relocation and then level off after construction is complete. At this time, there is no information on whether materials will be imported from additional countries during the relocation.

On Guam, it remains unclear how consistently mitigation measures for timber, sand, and gravel are applied and how efficaciously they prevent pest entry. There are no entry requirements for other construction materials. In general, Guam inspections for construction material cargo may be inconsistent, ineffective, or non-existent. Timber may be particularly problematic for invasive species. Detection of hidden insects inside large volumes of timber is difficult, and prescribed quarantine treatments are not completely effective against all pests. These challenges and the diversity of pests with timber cause a significant risk of pest introduction to Guam through this pathway.

Because construction materials may be imported from other nations, biosecurity in those origins is important. No processes are in place for educating off-island workers about biosecurity and the potential impacts of introducing plant pests.

Construction activities disturb environments, making them more susceptible to establishment of exotic pests. Some pests preferentially invade disturbed sites (Mulugeta and Stoltenberg 1997;Kennedy 1998).

2.2.5.4 *Impact of the Military Relocation*

New housing, new utilities, municipal buildings, and roads will be constructed on Guam, and port infrastructure will be enhanced.

2.2.6 Mail

2.2.6.1 *Pathway and Risk Species*

Invasive species have been transported in domestic and international mail. Historical interceptions of mail packages sent from the Micronesia Region to Hawai'i demonstrate the possibility that pests introduced into the Micronesia Region could make their way to Hawai'i via the mail pathway (USDA-APHIS-PPQ 2010a). APHIS-PPQ has reported interceptions of various plants, high risk animal products and by-products, insects, and other invertebrate species from mail at U.S. ports, including seeds, fresh fruits and vegetables, propagative plant parts, nuts, live insects, and soil. Specific pests include a wasp parasite, bee and bumblebee colonies, nonnative nematodes, mites, disease agents, parasites, larvae of the Mediterranean fruit fly, the melon fly, the Oriental fruit fly, and the Malaysian fruit fly. Seeds are the most common type of intercepted material, demonstrating the potential for invasive plant species to be mailed into the Micronesia Region from anywhere in the world. Mailed propagative material carries the risk of introducing Huanglongbing, a serious citrus disease that has not yet reached the Micronesia Region (Gottwald et al. 2007). The impact on subsistence farmers may be significant if Huanglongbing is introduced. Betel nut pests may be of special concern, as betel nuts are frequently sent by mail.

Huanglongbing (CGD) is not currently present on Guam, Saipan, Tinian or Rota although its vector, the Asian citrus psyllid has recently been collected from Guam, Saipan and Tinian. Rota appears to be psyllid free at the moment. Most citrus in the Mariana islands is grown in residential areas, with relatively little grown by farmers. The impact of CGD would be the destruction of myriad backyard citrus trees, and the gradual decline of the few citrus orchards there are and of course the increased threat to the rest of the region. Betel nut in the Marianas is currently beset by pathogens that restrict its transport, hence the booming betel nut trade from disease free areas such as Yap to the Mariana islands.

All mail originating in the United States and most international packages destined for the Micronesia Region are processed in Honolulu, Hawai'i. Guam's Main Post Office in Barrigada processes domestic and international mail for the Micronesia Region (Murphy 1983; Jimenez et al. 2009). CNMI, RMI, Palau, and FSM receive mail processed on Guam.

2.2.6.2 *Current Mitigation Measures*

All mail originating in the United States and most international packages destined for the Micronesia Region are processed in Honolulu, Hawai'i. These parcels enter Guam as parts of the U.S. domestic first-class mail system. First-class mail in Guam and CNMI cannot be delayed or opened without either a search warrant or permission from the addressee.

While GCQA has a designated x-ray inspection area inside the post office, it is not fully functional, and the local postmaster does not always grant GCQA officers permission to access this area. Foreign origin mail cannot be opened and inspected by GCQA unless the addressee is present.

The Guam Post Office displays educational posters describing prohibited mail items, and post office clerks ask customers whether outgoing packages contain perishable items. Arriving packages stamped "perishable" are inspected by GCQA officers and sent to the Guam Plant Inspection Station when additional information or diagnostic assistance is necessary.

Military mail is handled by the Military Postal Service Agency (MPSA), the single DoD point of contact with the U.S. Postal Service (USPS), and is required to adhere to USPS rules, federal laws, and various international laws and agreements for movement of military mail. The MPSA also instructs military personnel about items prohibited in mailed packages.

2.2.6.3 *Risk Rationale*

Using interception data and mail approach rates, it is estimated that 300 plant quarantine materials along with an unknown number of animal products and byproducts arrive on Guam each week through public mail. However, specific information about the significance of the mail pathway in Guam and the Micronesia Region is scarce.

The lack of information may be due partially to the protection of mail by the U.S. Constitution (Fourth Amendment), which makes it illegal to delay mail or open it without either a search warrant or permission from the addressee (DoD 2002; USPS 2007). These protections apply in Guam and the CNMI. GCQA officers open and inspect the mail, but the addressee must be present in the facility for the parcel to be opened and inspected. The postal facility is not permitted to slow down the flow of domestic mail (USPS regulation). This restriction limits the number of packages that can be inspected with the available workforce.

Detector dogs have proved successful in establishing probable cause to obtain a search warrant for inspecting domestic mail. The USPS allows GCQA to use detector dogs in the facility after official permission has been granted to enter the facilities with canines. The permission to enter the premises for inspections is not based on processing schedules, but is granted only on a case-by-case basis. Requests from GCQA must be submitted every time canine officers want to enter the postal facilities. Many times the requests are denied. The lack of cooperation between agencies inhibits canine use in the postal facility and is recognized as a weakness in the safeguarding structure.

The increase in mail order purchases over the last several decades increases the risk of introduction by mail. Consumers are generally not aware of this risk.

All domestic mail for Micronesia is received and processed first in Hawai'i, then again in Guam, so biosecurity at Hawai'i mail processing centers is important for Guam and the entire Micronesia Region, and biosecurity at Guam's mail processing facility is important for the rest of Micronesia. It is unclear to what degree domestic mail entering Hawai'i is inspected in Honolulu because the Hawai'i Department of Agriculture recently experienced a drastic decrease in agricultural inspectors due to budget cuts.

2.2.6.4 *Impact of the Military Relocation*

The pathway traffic volume in mail cargo is expected to increase as a result of the military relocation due to demands for consumer goods by a larger population.

After the military relocation, an additional 207 plant quarantine materials are estimated to arrive in Guam through public mail each week. This is in addition to the estimated 300 plant quarantine materials arriving on Guam each week through public mail.

2.2.7 Regulated Garbage

2.2.7.1 *Pathway and Risk Species*

Garbage of agricultural concern is waste material derived in whole or in part from fruits, vegetables, meats, or other plant or animal material. Any other refuse associated with such materials is also garbage. Garbage is regulated if it has been aboard a conveyance that has been outside the United States and Canada within the previous 2-year period or if the means of conveyance has traveled within the previous 1 year between the continental United States and a U.S. territory, U.S. possession, or Hawai'i, or either directly or indirectly, to any U.S. territory or U.S. possession from any other U.S. territory or U.S. possession or from Hawai'i, or to Hawai'i from any U.S. territory or U.S. possession. Non-regulated garbage comingled with regulated garbage is also regulated. Regulated garbage must be either destroyed by incineration to ash, ground, and discharged into an approved sewage system or sterilized (heated to an internal temperature of 212 degrees Fahrenheit [°F] for 30 minutes) (7 CFR § 330.440-330.403; 9 CFR § 94.5).

Garbage as a pathway can carry diverse populations of plants, animals, and insects and other invertebrate species. Military, commercial, fishing vessels, and cruise ships generate refuse. Rejected cargo and prohibited items removed from passenger baggage at commercial and military airports and maritime ports of entry are treated as regulated garbage. Cargo shipments of garbage are common throughout Micronesia, although the importation of garbage into Guam and the CNMI is prohibited (9 CFR § 95 and 7 CFR § 330.400-403).

A wide range of potentially invasive insects, reptiles, amphibians, plant materials for plant propagation, and human and animal pathogens can be transported in garbage. Agricultural disease agents African swine fever (ASF), classical swine fever (CSF), foot and mouth disease (FMD), and swine vesicular disease

(SVD) viruses spread to swine readily through ingestion of contaminated meat, typically through garbage feeding (VS PRA 2010).

The food source and shelter of garbage attract a variety of invasive species, particularly rats and mice that could carry human and animal diseases throughout the Micronesia Region. How long disease agents remain infectious varies by agent and environmental conditions but many remain viable for weeks to months under the right conditions (e.g., *Brucella abortus*, avian influenza viruses, *Echinococcus* virus, and Exotic Newcastle's Disease [END]) (VS PRA 2010). Mice and rats are also prey items for predators such as Brown Treesnakes and the presence of such prey items in and around garbage likely increases the potential for accidently transportation of these predators.

2.2.7.2 *Current Mitigation Measures*

APHIS-PPQ and its cooperators have responsibility for monitoring regulated garbage handling at airports, caterers, cleaners, cruise ships, fixed-base operators, hauling/cartage firms, marinas, military facilities, storage facilities, and transfer stations. There are insufficient governmental resources to monitor regulated garbage activities on Guam and CNMI. Adequate on-island disposal methods for garbage, either regulated and non-regulated, do not currently exist on Tinian, the proposed site for increased military training.

The APHIS-PPQ MAC (USDA-APHIS-PPQ 2013) guides monitoring of the handling of foreign regulated garbage within U.S. territory. Entities that handle regulated garbage must be approved by USDA-APHIS and either have a compliance agreement with or be supervised directly by APHIS or APHIS cooperators. Regulated garbage must be moved by entities approved by USDA-APHIS to handle regulated garbage under the direction of an inspector to an approved garbage-handling facility. There are nine companies on Guam and Saipan authorized to handle regulated garbage under compliance agreements with USDA-APHIS. Regulated garbage is monitored to prevent the movement and dissemination of pests and plant and animal diseases. Tightly covered, leak-proof containers must be used to store regulated garbage while inside U.S. territory, which includes Guam and other locations in Micronesia. This territory extends 12 nm off the coast. Regulated garbage must be stored in the proper container to move it from a conveyance for disposal.

Regulated garbage from commercial and military aircraft must be unloaded at an airport or military base approved to handle regulated garbage. On Guam, NAVFAC Marianas at the Apra Harbor Naval Station and Pacific Environmental Resources Incorporated at Andersen AFB are approved to handle garbage. Private companies handle the off-loading of regulated garbage at A.B. Won Pat International Airport including rejected cargo from maritime vessels.

2.2.7.3 *Risk Rationale*

Non-compliant (non-containerized) regulated garbage makes this pathway prone to incursion by numerous invasive species. There is a risk of regulated garbage entering at the airport or seaport without transport to an approved processor. Private aircraft arriving at A.B. Won Pat International

Airport, military aircraft entering at Andersen AFB, and private/commercial vessels arriving at commercial seaports represent the greatest risks because of the lack of oversight.

2.2.7.4 *Impact of the Military Relocation*

The relocation is expected to bring additional people, aircraft, cargo, and commercial and military ships from foreign countries (U.S. Navy 2010a). Therefore, the military relocation is expected to increase volume of all imports proportional to the population increase, including rejected cargo and prohibited items seized from passenger baggage.

2.2.7.5 *Additional Mitigation Measures Recommended for the Military Relocation*

To mitigate the risk presented by regulated garbage, it must undergo one of three processes: 1) incineration, defined as reducing garbage to ash by burning (with policy exemptions for glass and metal); 2) sterilization, cooking at an internal temperature of 212°F for 30 minutes; or 3) grinding and discharge into an EPA- and APHIS-approved sewage system.

To handle the immediate increase in garbage generated and regulated garbage off-loaded in Guam, building a waste-to-energy processing facility to reduce the amount of debris transported to a landfill and to increase the electrical capacity of the island should be considered. Tinian government and the U.S. military should collaborate to ensure adequate facilities and resources are available to properly dispose of regulated, as well as non-regulated, garbage on-island prior to the commencement of military training. Refer to Section 6.3.10, *Garbage*, for additional information.

2.2.8 Plant Propagative Material

2.2.8.1 *Pathway and Risk Species*

Whole plants, buds, bulbs, tubers, seeds and other propagative parts present phytosanitary risks in the Micronesia Region either as pathways for the introduction of exotic plant pests or as invaders.

The movement of plant propagative material is a primary means by which plant pests and small animals invade new areas. Plant propagative material can be transported in the baggage and cargo of planes and maritime vessels, in WPM and construction materials, in soil attached to military and construction equipment, and in garbage.

Plant material hitchhikers include insects, mollusks (snails, slugs), mites, and weeds; pathogens include viruses, fungi, bacteria, and nematodes. Potential hitchhikers include the Red palm mite, *Raoiella indica* (Acari: Tenuipalpidae). At U.S. ports of entry from March 2009 to March 2010, there were 5,600 interceptions of more than 16,000 pest specimens including insects (86 families), mollusks (16 families), mites (5 families), weeds (13 families) as well as viruses, fungi, bacteria, and nematodes (USDA-APHIS-PPQ 2010a). Potential plant pathogens include banana bunchy top virus, a disease of *Musa* (banana plants) for which there is no effective treatment (Thomas et al. 1994), and the bacterium *Candidatus Liberibacter*, which causes Huanglongbing in *Citrus* species (Wang 2009). It is worth noting that banana bunchy top virus is already present in the region, specifically on Guam since at least the 1970s and was first detected in Hawai'i by University of Guam extension agent Frank Cruz.

The deliberate or accidental introduction of invasive plant propagative material may present phytosanitary risks in the Micronesia Region and Hawai'i. Examples are noxious weeds that pose ecological and economic threats, exhibit aggressive growth, and interfere with watershed functions. For example, *Miconia calvescens* (Melastomataceae), introduced to Hawai'i as an ornamental tree, is listed as a noxious weed (Loope 1997).

2.2.8.2 *Current Mitigation Measures*

For Guam the regulations for the import of foreign and domestic materials rest with APHIS and GDOA, respectively. All propagative plant materials imported into Guam, including trans-shipments to the CNMI, Palau, and FSM, are inspected at the GDOA Plant Inspection Station under agreement with USDA-APHIS-PPQ. Flowers and cut flowers are examined intensively for import violations. GDOA requires all plants entering Guam from Hawai'i to be treated with a hot water or citric acid solution drench prior to shipment and to be inspected for pests of concern to Guam.

Guam prohibits the entry of specific propagative plant materials from specified locations to prevent the introduction of pests of concern: citrus, coconut, banana, taro, and sweet potato planting materials are prohibited. Certain plants from areas infested with the European Corn Borer, *Ostrinia nubilalis* (Lepidoptera: Pyralidae) are restricted. However, the number of regulated pests is a small percentage of all pest organisms from propagative materials. Imports of plant material for landscaping on Guam are imported mainly from the United States, but other sources include Thailand, Taiwan, Philippines, Costa Rica, Ecuador, and Puerto Rico (McConnell 2010; Campbell personal communication).

2.2.8.3 *Risk Rationale*

Several factors influence risks from plant propagative materials as either hosts or carriers in Guam and the Micronesia Region. The DoD does not place restrictions on military personnel moving plants into Guam, increasing the risk of the unintentional introduction of invasive species. The current DoD landscape plan may facilitate the spread of potentially invasive plants; therefore, plants known to be invasive or to have a high invasive potential are common in Guam landscapes.

Some plant pests carried by plant propagative materials are unlikely to be detected by visual inspection because of their small size (e.g. mites). There is evidence that these pests often go undetected. Improper disposal of plants often increases the spread of plant pests from propagative materials.

There are no appropriate diagnostic tools for most plant disease pathogens feasible for plant quarantine purposes; thus, plant pathogens often are not detected unless the infected plant material expresses noticeable symptoms, often not the case. As an example, *Candidatus Liberibacter*, causative agent of Huanglongbing in *Citrus* species, can spread through infected propagative material without symptoms (Wang 2009).

No treatment requirements are in place for plants from the Caribbean and Florida, heightening the risk of introduction of plant pests from these locations.

The invasive potential of the propagative material itself is not considered in any regulation.

2.2.8.4 *Impact of the Military Relocation*

The military construction and the relocation of commerce will increase imports of plant propagative material, particularly landscape species, and may increase the risk of pests entering the Micronesia Region. These increases may well be in both volume and range of species imported.

Additionally, garden centers may increase their supply of ornamental plants to meet demands from a larger consumer base (homeowners, hotels, and commercial businesses). Garden centers may increase their supply of ornamentals, including plants that could become invasive.

Residents could demand imported home furnishings. Some plant propagative materials may also be intended as ethnic food products for foreign temporary workers on Guam.

2.2.9 Plant Products

2.2.9.1 *Pathway and Risk Species*

Plant products are commodities, foods, or other articles moved for trade or other purposes. Cut flowers and branches are fresh parts of plants intended for decorative use and not for planting. A variety of plant pests, plant disease vectors, and small exotic animals can be carried in plant products. Plant products can be transported by import in the baggage and cargo of planes and maritime vessels and through smuggling.

Christmas trees are of significant concern as potential vectors for non-native pests species. There are numerous records of non-native organisms hitchhiking to Guam and other ports as accidental passengers in Christmas tree shipments. Anticipated increases in U.S. mainland residence moving to the region will likely only increase the interest in shipping Christmas Trees and hence will also likely increase the potential for accident transport of pest species unless appropriate measures are installed throughout the region to address this pathway for invasive species.

Plant products can carry hitchhiking insects and mites and can be infected hosts for plant pathogens. Two potential plant pathogens include banana bunchy top virus, a nontreatable disease of *Musa*, and the bacterium *Candidatus Liberibacter*, which causes Huanglongbing in *Citrus* species (Thomas et al. 1994, Wang 2009).

2.2.9.2 *Current Mitigation Measures*

For Guam U.S. Federal regulations require an APHIS permit for the importation of fruits and vegetables. The APHIS-PPQ Fruits and Vegetables Import Manual guides PPQ and APHIS cooperators on fresh fruit and vegetable shipments (USDA-APHIS-PPQ 2010b). Chapter 5 of the APHIS-PPQ Treatment Manual shows the treatment schedule for fruit, nuts, and vegetables (USDA-APHIS-PPQ Treatment Manual 2008).

Cargo manifests are reviewed to determine whether cargo contains fruits and vegetables of agricultural interest. Cargo of agricultural interest must be held until cleared by PPQ or its cooperators. Clearance of fruits and vegetables may be done by an inspection of the paperwork, an inspection of the commodities, or both. Inspections may be random, routine, or targeted. Guidance for inspections is from the APHIS–PPQ Fruits and Vegetables Import Manual (APHIS Manuals).

USDA-APHIS-PPQ regulations require phytosanitary certificates for the importation of plants and certain plant products from foreign sources. GDOA may require such certificates from other parts of the United States. Risk Rationale

Of particular concern are exotic plant products imported by temporary workers relocating from origins with plant pests and diseases not found on Guam. Often these products are marketed by roadside stands outside the realm of inspection and compliance.

2.2.9.3 *Impact of the Military Relocation*

The military construction and the relocation of commerce will increase imports for plant products.

2.2.10 Soil

Movement of soil, whether intentional or unintentional, is a well-known pathway for a wide variety of potentially dangerous organisms. Soil imported for landscaping and plant propagation can be moved unintentionally on construction equipment, military equipment, other construction materials, cargo, and shoe soles.

2.2.10.1 *Current Mitigation Measures*

For U.S. jurisdictions APHIS regulations (7 CFR § 318 State of Hawai'i and Territories, Quarantine Notice, Sub-Part-Sand, Soil, or Earth, with Plants from Territories and Districts; 7 CFR § 318.60 Notice of Quarantine) describe requirements for inspecting and, if necessary, treating imported soil (7 CFR § 318, 318.60).

Guam law prohibits importation of raw soil except in small quantities for research or testing at certified soil testing laboratories (Guam Administrative Rules and Regulations 1986, USDA-APHIS-PPQ Rules and Regulations). Guam's

hardware stores and plant nurseries import large quantities of packaged potting soil and soil amendments including compost, mulch, manure, peat, and sphagnum moss from the mainland U.S. These

imported packages are a potential pathway for invasive species entering Guam. Most imported potting soil and other processed soil amendments from the U.S. Mainland are currently not inspected on arrival in Guam.

2.2.10.2 *Risk Rationale*

Movement of soil (e.g. landscaping, plant propagation, construction, military equipment, construction materials, cargo, and shoe soles) is a common pathway for a wide variety of invasive organisms.

2.2.10.3 *Impact of the Military Relocation*

Military construction and increased commerce may increase the need for plant propagative materials, particularly of landscape species. Increased sales of commercial potting soil may introduce and facilitate the spread of pests on Guam (Berringer 2010). In general, each of these increases represents an increased risk from this pathway.

2.2.11 Livestock Imports

2.2.11.1 *Pathway and Risk Species*

The livestock pathway is determined by the risk assessment to be primarily legal import of domesticated equids (horses, mules, and asses). Domestic equids can be infected hosts, contaminated with disease agents, or serve as hosts to tick vectors of disease agents. Infected domesticated equids are primary sources for the etiologic agents of African horse sickness (AHS), contagious equine metritis (CEM), dourine, equine infectious anemia (EIA), equine piroplasmosis (EP), and glanders. Through infection or as an infected host, fomite, or host to vectors, equids can transport nipah, rabies, VEE, Vesicular Stomatitis (VS) viruses, screwworms, *Echinococcus* spp., *Leishmania* spp. parasites, *M. bovis*, eastern equine encephalitis (EEE), Japanese encephalitis (JE), western equine encephalitis (WEE), West Nile viruses, ASF, CSF, and FMD viruses. Domesticated equids are hosts frequently for tick species as competent vectors for EP and less frequently for tick species as competent vectors for heartwater (VS PRA 2010; Estrada-Peña et al. 2004).

2.2.11.2 *Current Mitigation Measures*

Horses for import to Guam first must enter through ports in the continental United States for quarantine until negative results to specified tests, depending upon the country of origin, are obtained, and the horses are certified by the port veterinarian to be free from clinical evidence of disease.

Domesticated equids for import to the United States from regions affected by screwworm, CEM, and VEE are subject to inspection or treatment. Imported domesticated equids, with limited exceptions for those originating in certain countries, cannot enter the United States until they have been tested for EIA, EP, dourine, and glanders by an official test with negative results. Before a horse imported from any part of the world is released from the U.S. port of entry an inspector may require the horse and its equipment to be disinfected as a precautionary measure against the introduction of FMD or any other disease dangerous to livestock (9 CFR § 93.314).

According to GARR Title 9, Division 1, Chapter 1, no animals affected with or exposed to an infectious, contagious, or communicable disease or ectoparasite or originating in an area under state or federal quarantine shall be introduced into Guam. Horses are subject to specific mitigations to prevent the entry of EIA, EEE, WEE, and VEE viruses.

2.2.11.3 *Risk Rationale*

Risk to livestock as a result of the introduction of invasive species to Guam and the Micronesia Region is limited for several reasons. Guam has a relatively small livestock population with minimal movement of livestock on the island. No livestock have been imported in the last 5 years. This fact reduces the likelihood that any disease agent has come into contact with Guam livestock. Ticks may be carried on invasive mammals, but pre-importation and inspection procedures reduce the probability of vector release and exposure to livestock.

Imports of domesticated equids to Guam might increase as a result of the military relocation, but the steady-state import of livestock is very small. Any domesticated equids imported probably will originate in the U.S. mainland due to federal regulations on importation of livestock. The United States is free of AHS, African animal trypanosomiasis, dourine, FMD, glanders, heartwater, JE, nipah virus encephalitis, screwworm, surra, and VEE (U.S. Animal Health Report 2008). The greatest risks might be from CEM, EP, and VS due to recent outbreaks in the United States.

There has been no evidence of smuggling of livestock to Guam. Illegal transport of large agricultural animals is not feasible, and this infeasibility is not expected to change during the military relocation.

2.2.11.4 *Impact of the Military Relocation*

Traffic volume in domesticated equids to Guam might increase slightly as an indirect result of the military relocation (increased demand for recreational activities). Federal regulations governing the importation of livestock make domesticated equids for importation to Guam highly likely to originate in the continental United States, which is free of most of the hazards for which domesticated equids are primary sources. The risk of importation or interstate movement of hazards for which domesticated equids might play significant roles in transporting them to Guam is mitigated by APHIS and Guam territorial regulations.

2.2.12 Poultry Imports

2.2.12.1 *Pathway and Risk Species*

Poultry are chickens, doves, ducks, geese, grouse, guinea fowl, partridges, peafowl, pheasants, pigeons, quail, swans, and turkeys, including eggs for hatching. Poultry can transport hazards in three roles: 1) they can be infected hosts, 2) they can be contaminated with disease agents and serve as fomites, or 3) they can serve as hosts to tick vectors of disease agents.

Infected or contaminated poultry can facilitate the transmission of many etiologic agents, including avian metapneumovirus, duck virus hepatitis, fowl typhoid, pullorum, EEE, END, highly pathogenic avian influenza (HPAI), WEE, VEE, West Nile viruses, screwworms, ASF, CSF, and FMD viruses (VS PRA 2010). Game fowl, pet, and exhibition poultry may have encounters with disease-carrying ticks.

Infected bird feces and secretions spread primarily through direct contact. People, other animals, vehicles, and equipment can become contaminated with poultry feces or secretions and can carry disease agents from one location to another; END, for example, is transmitted readily on fomites.

END and HPAI are some of the most severe poultry diseases throughout the world. Animal health consequences are significant. For both diseases, morbidity and mortality rates may approach 100%, 90% in susceptible chickens (VS PRA 2010). Introduction of END, HPAI, or other high -mortality avian diseases could have a catastrophic effect, perhaps local extinction, on the very small populations of the Micronesia Region's endangered bird species.

The World Health Organization (WHO) has reported rare cases of H5N1 HPAI in humans in Asia, Africa, the Pacific, Europe, and the Near East. Indonesia and Vietnam have reported the highest number of human H5N1 cases with mortalities of up to 60%, especially in cases hospitalized late in the course of the illness (WHO 2005).

2.2.12.2 *Current Mitigation Measures*

Importation of live poultry, poultry products, and hatching eggs is restricted from regions affected by END or HPAI; several of these regions are Asia-Pacific countries. Live poultry permitted to enter the United States (except those from Canada) must be inspected, quarantined for 30 days, and tested at a quarantine facility on the U.S. mainland (9 CFR §§ 93.201, 209, and 94.6).

Birds not of U.S. origin must be accompanied by an import permit issued by APHIS. All imported hatching eggs from END-free regions must be accompanied by a veterinary health certificate as well as a USDA import permit.

Interstate commerce of a bird for the purpose of participation in a fighting venture is illegal regardless of the law in the destination state, including Guam.

Guam territorial regulations require all imported birds and hatching eggs to be accompanied by an entry permit and a health certificate approved by the chief livestock sanitation officer or a state or federal veterinarian (9 GARR 1 §1110). The health certificate must be issued within 10 days prior to shipment attesting that the bird has been found free of ectoparasites and symptoms of transmissible disease. Any animal found to be clinically affected or recently exposed to any infectious, contagious, or communicable disease or infested with ectoparasites is returned to the point of origin or destroyed.

Guam import requirements for poultry include: 1) origin from flocks and hatcheries free from pullorum disease or with a pullorum-controlled status; in the latter case birds must test to be serologically negative for pullorum disease within 30 days of entry; 2) vaccination for Newcastle disease virus (NDV) between 30 to 60 days prior to shipment; 3) no symptoms of NDV or other communicable diseases at the time of shipment; and 4) a health certificate issued by an accredited veterinarian (9 GARR 1 §1110). Requirements 2, 3, and 4 do not apply to hatching eggs and day-old poultry with an affidavit from the shipper stating that the flock of origin has not been exposed to and has been free of NDV for 60 days prior to shipment. All poultry and hatching eggs must be shipped in new (unused) containers and inspected by the territorial veterinarian or deputy prior to entry.

The USPS allows adult and hatchling poultry to be mailed with restrictions. Postal regulations prohibit mailing of hatchling (day-old) poultry vaccinated for NDV. Day-old chickens, ducks, emus, geese, guinea fowl, partridges, quail, and turkeys must be delivered to the addressee within 72 hours after hatching.

2.2.12.3 *Risk Rationale*

Illegal imports of poultry could increase temporarily as a result of the military relocation due to the popularity of cockfighting among foreign temporary workers from the Philippines. Historically, temporary construction immigration from the Philippines has increased fight attendance.

Similar to other islands in the Micronesia Region, a sizeable population of feral chickens roams freely on Guam. This feral population could facilitate the spread of poultry disease among domestic flocks.

Due to import regulations, most poultry breeding stock probably will continue to be imported from the continental United States and Hawai'i. The United States is free of ASF, CSF, END, FMD, HPAI, screwworms, and VEE; therefore, imported live poultry are unlikely to have contact with these agents and to serve as fomites for exposure of livestock to them (USDA-APHIS 2009a). Illegal traffic in live poultry, including hatching eggs, is known to occur.

The increased traffic volume that might be an indirect result of the military relocation cannot be quantified. Any significant influence on the number of imported poultry would be related most likely to the influx of foreign temporary workers.

2.2.12.4 *Impact of the Military Relocation*

The illegal import of poultry may increase temporarily from the influx of temporary workers from the Philippines. The number of live poultry legally imported to Guam or the rest of the Micronesia Region is unlikely to change as a result of the military relocation. The risk of hazard release through legal entry of live poultry to Guam is reduced by inspection and quarantine measures required by federal and territorial regulations.

2.2.13 Pet Bird Imports

2.2.13.1 *Pathway and Risk Species*

Import of pet birds for pets or for commercial trade is a common practice. Smuggling of pet birds is also common. Pet birds can be invasive species or transmit infectious diseases directly or through infected vectors. Infected bird feces or secretions spread primarily through direct contact. People, other animals, vehicles, and equipment can become contaminated with bird feces or secretions and can carry disease agents from one location to another (VS PRA 2010).

Like poultry, other birds can be infected by and serve as reservoirs for equine encephalomyelitis, END, HPAI, and West Nile viruses. Infected birds can be sources for etiologic agents of fowl typhoid and pullorum. Reports of infestation of birds with screwworms are rare. Birds that have been in contact with affected premises can spread ASF, CSF, and FMD viruses mechanically (VS PRA 2010).

Psittacines (parrots, cockatiels, parakeets, budgerigars, and other parrot-like pet birds), the most popular pet birds in the United States, are uncommon hosts for vector hazards. A variety of buntings, sparrows, finches, and weavers (families Emberizidae, Passeridae, and Ploceidae), songbirds transported in the caged bird trade, are frequent hosts for European, Asian, or African ticks (VS PRA 2010).

2.2.13.2 *Current Mitigation Measures*

For Guam birds not of U.S. origin must be accompanied by an import permit and be received and inspected by USDA personnel at an approved port of entry with quarantine facilities. Approved bird quarantine facilities are located in New York, Miami, and Los Angeles. Birds are quarantined for 30 days, during which they are tested for certain communicable diseases. USDA maintains trade restrictions on the importation of live birds from certain countries in Africa, Europe, and Asia affected by HPAI (USDA-APHIS 2009a).

Importation of exotic birds into the United States must comply with APHIS and USFWS requirements. Certain exotic birds are protected by the Convention on International Trade in Endangered Species (CITES) (www.cites.org) and the WBCA (http://www.fws.gov/international/laws-treaties-agreements/us-conservation-laws/wild-bird-conservation-act.html). U.S. Customs and USFWS enforce the international trade regulations for exotic birds. USFWS requires an importation permit, and the WBCA has set a limit of two birds per year per person, who must have resided continuously outside the continental United States for at least 1 year.

All birds entering the territory of Guam must be accompanied by an import permit and an official health certificate approved by the chief livestock sanitation officer or a state or federal veterinarian issued within 10 days prior to shipment attesting that each bird has been found free of ectoparasites and symptoms of transmissible diseases. A leg band number should identify the scientific name of the animal. Any animal found clinically affected or recently exposed to any infectious, contagious, or communicable disease or infested with ectoparasites must be returned to the point of origin or destroyed (GARR Title 9, Division 1, Chapter 1).

Under 9 GARR §§ 2101-2102 pet shops and importers are required to keep a record of each sale for at least 90 days and to make the record available to the GDOA if a quarantine is placed on the premises by the territorial veterinarian (GARR Title 9, Division 1, Chapter 1).

Guam has introduced additional quarantine requirements for the importation of all birds (poultry and non-poultry) from the continental United States to prevent the introduction of West Nile Virus. All birds must be quarantined a minimum of 7 days in an approved quarantine facility or veterinary clinic followed by 30 days of isolation in a mosquito-proof cage (Poole 2009).

Under USPS regulations, non-poultry birds cannot be mailed (USPS 2009).

2.2.13.3 *Risk Rationale*

The small number of live non-poultry birds imported to Guam may increase as a result of the military relocation due to demand in the pet trade. At least 7% of military families reported keeping a pet bird (Anderson 1985). Residents of military base housing are not prohibited from keeping non-poultry pet birds.

Most live birds moved legally to Guam during the military relocation are likely to originate from the U.S. mainland due to federal regulations on importation of live birds addressed under mitigations. The United States is free of ASF, CSF, END, FMD, heartwater, HPAI, JE, screwworms, and VEE (U.S. Animal Health Report 2008).

The risk of hazardous release through legal entry of live non-poultry birds to Guam is reduced by inspection and quarantine measures required by federal and territorial regulations. Quarantine takes place off-island as there are no APHIS-certified quarantine facilities on Guam, and import regulations are strict.

Smuggling of pet birds may increase to meet a potentially higher demand from the increased population caused by the military relocation. An increase may also occur as a result of Guam becoming a more achievable pathway to other U.S. states and territories as a result of greater flight availability into Guam from Asia. The increase is not likely to be significant due to existing regulations, but enforcement can be difficult. Most smuggled live birds seized by U.S. officials between 2004 and 2008 originated from Mexico, Central America, and South America, but smuggled birds also come from Japan, Hong Kong, and Indonesia (USDA-APHIS 2006; USDA-APHIS-PPQ 2010a). The United States is one of the largest markets for the illicit global commerce in wildlife with wild birds as major commodities, mostly for exotic pets or tourist souvenirs.

2.2.13.4 *Impact of the Military Relocation*

The small number of live non-poultry birds imported to Guam may increase along with the anticipated human population increase on Guam as a result of the military relocation. The number of birds brought to Guam through legal means should remain relatively small compared to some U.S. mainland areas but increase more than proportionally if the 7% estimate is achieved (in recent years, fewer than 12 birds annually) (VS PRA 2010).

While no reliable estimates of illegal traffic volume of live birds for the pet trade are publicly available, the demand for illegal wildlife in the United States is likely to parallel U.S. demand for legal wildlife. Illegally imported live non-poultry birds bypass mitigations intended to reduce the likelihood of release of hazards.

2.2.14 Importation of Dogs and Cats

2.2.14.1 *Pathway and Risk Species*

Domesticated dogs and cats can be infected by and serve as reservoirs for rabies and can harbor screwworms, *Echinococcus* spp., and *Leishmania* spp., and *Trypanosoma* spp. parasites. Cats and dogs are susceptible to HPAI virus and Salmonella pullorum infections. Dogs can be infected by AHS and VEE viruses, ASF, classical swine fever, or FMD. Viruses can spread mechanically by domestic dogs and cats in contact with affected premises (VS PRA 2010).

Dogs are common hosts for several tick species as competent vectors of EP and heartwater. In a few instances, hazardous ticks, specifically *Amblyomma* spp., have been found on dogs imported to the United States (VS PRA 2010).

2.2.14.2 *Current Mitigation Measures*

All pet dogs and cats arriving in Guam are subject to local quarantine requirements. The quarantine period is 120 days post-arrival for domestic dogs and cats (reduced to 30 days or less than 5 days for certain provisions made for dogs, cats, and other carnivores).

Cats and dogs imported to the United States are subject to inspection at ports of entry and may be denied entry for evidence of an infectious disease that can be transmitted to humans. Dogs imported to the United States, with limited exceptions, must be accompanied by a certificate for rabies vaccination; imported cats are not required to be vaccinated for rabies. The entry of pets from areas affected by screwworms is subject to APHIS regulations (9 CFR § 93), which require a health certificate stating that the pet was found to be free of screwworm infestation within 5 days of export (USDA 2000; USDA-APHIS 2009b).

Guam restrictions and prohibitions for the importation of cats and dogs are stricter than federal requirements, including quarantines. Cats and dogs must enter Guam through the A.B. Won Pat International Airport or the Apra Harbor maritime port. Every cat and dog must be accompanied by an entry permit, a health certificate signed by a veterinarian no more than 14 days prior to shipment, and a confirmed quarantine kennel reservation. Dogs must have a rabies vaccination certificate dated between 30 days and 1 year prior to shipment and a certificate of immunization against distemper, hepatitis, leptospirosis, parainfluenza, parvovirus, coronavirus, and bordetella. Cats must have a certificate of immunization for feline distemper, feline viral rhinotracheitis, calicivirus, panleukopenia and chlamydia (GARR Title 9, Division 1, Chapter 1). Regulations for the importation of cats and dogs into Guam require animal identification, quarantine procedures, and rabies vaccination and testing prior to arrival (GARR Title 9, Division 1, Chapter 1).

GDOA (5 GCA § 60108) regulates dog and cat imports. Title 10 Guam Code Annotated Chapter 34 Article 3 states that animals imported must complete a maximum 120 days of confinement in a commercial quarantine facility, 30 days of quarantine if they meet pre- and post-arrival requirements: administration of two doses of rabies vaccine, presence of adequate protective antibody titer, and a properly implanted identification microchip. A 5-day quarantine program is available for pets with a Fluorescent Antibody-Virus Neutralization test conducted by an eligible laboratory between 120 days and 12 months prior to entry (Guam Public 29-112). Some pets may qualify for the home quarantine option.

Animals originating from Japan, Hong Kong, Oceania, and the continental United States (except for counties on the Mexican border) can be quarantined on Guam. Animals originating from elsewhere must be quarantined in Hawai'i prior to entry. Cats and dogs originating from rabies-free areas, Hawai'i, New Zealand, Australia, and the United Kingdom, are exempted from quarantine if they comply with all other requirements.

All cats and dogs originating from Africa, Asia, or islands of the Pacific Ocean (except Australia, Hawai'i, and New Zealand) must have a certificate from the national chief livestock sanitation officer stating that the animals originated in a state, country, or political subdivision officially declared free of surra, animal African trypanosomiasis, and leishmaniasis.

Cats and dogs that do not comply with regulations may be declared ineligible to enter and remain in the custody of the carriers at a designated inspection area at the port of entry until sent back.

2.2.14.3 *Risk Rationale*

Most pet dogs and cats will be imported through legal channels. Total imports of dogs and cats may be limited due to import restrictions and costs. Most imported pets will come from the United States and Hawai'i with a few animals imported from Japan and the CNMI (VS PRA 2010). Temporary workers and tourists are unlikely to bring pets due to their nonpermanent status on Guam and the regulatory requirements of import.

Because Chagas disease is endemic in parts of the continental United States and the majority of pet dogs and cats will come from the United States, this disease agent must be considered a risk. Leishmania presents a similar concern.

2.2.14.4 *Impact of the Military Relocation*

Traffic volume (10 to 100 annually in domestic cats and dogs to Guam is likely to increase as result of the military relocation). Most domesticated cats and dogs intended for importation to Guam are likely to originate in the continental United States, which is free of most of the hazards for which domesticated cats and dogs are epidemiologically significant sources.

The risk of importation or interstate movement of hazards for which domesticated cats and dogs might play significant roles in transporting them to Guam is mitigated by U.S. military and Guam territorial regulations.

2.2.15 Importation of Exotic Animals

2.2.15.1 *Pathway and Risk Species*

Exotic species of animals are often imported for pets, cultural or scientific purposes, or zoological exhibition. These animals can be invasive species and can transport disease agents or vectors for native species. Worldwide, illegal trade in these animals is substantial and profitable, and the U.S. is the leading import market. There may be an increase in breeding of socially popular species which could have impact on Guam's environment.

Members of the genera *Amblyomma*, *Dermacentor*, *Haemaphysalis*, *Hyalomma*, and *Ornithodoros* frequently parasitize reptiles, particularly terrestrial chelonians, snakes, and lizards, in tropical regions (VS PRA 2010). Numerous ticks, primarily exotic species of *Amblyomma* and *Hyalomma*, have been found on reptiles imported to the United States. Exotic ticks introduced with imported reptiles could be infected with organisms pathogenic to domestic livestock populations; *E. ruminantium*, the causative agent of heartwater, was detected in *Amblyomma sparsum* ticks collected from imported tortoises (Burridge et al. 2002).

2.2.15.2 *Current Mitigation Measures*

Importation of zoo, fur-bearing, and other wild animals to Guam requires a permit in advance from the Director of Agriculture of Guam. USFWS designates Agana, Guam, as a special port for importing certain kinds of wildlife (including animal parts and products with a final destination of Guam). The GDAWR and the GDOA PPQ Division identify and hold animals in quarantine. Any importers or exporters of wildlife must obtain a license from USFWS.

2.2.15.3 *Risk Rationale*

The U.S. live animal trade in small mammals, reptiles, and amphibians has grown significantly since the 1990s, driven in part by the increasing popularity of exotic pets and demand for traditional foods and medicines. Worldwide, illegal trade in these animals is substantial and profitable, and the United States is the leading import market.

2.2.15.4 *Impact of the Military Relocation*

The larger human population resulting from the military relocation will increase demand for exotic pets and for traditional foods and medicines, and therefore, increase pathway traffic volume in small mammal, reptile, and amphibian species.

2.2.16 Animal Product Importation

2.2.16.1 *Pathway and Risk Species*

Animal products are defined as of animal origin, including meat, milk, blood and their products, skins, feathers, wool, hair, and animal feed containing products of animal origin.

Milk, eggs, meat, blood, and other tissues can serve as disease agent sources. While the probability of transmission through animal products is low, several high-risk disease agents may be transmitted, including FMD, bovine spongiform encephalopathy, END, classical swine fever, ASF, HPAI, and swine vesicular disease.

2.2.16.2 *Current Mitigation Measures*

GCQA is responsible for the inspection, of the import of animal products and by-products. GDOA monitors animal products found on wholesale and retail shelves.

2.2.16.3 *Risk Rationale*

Although many disease agents have demonstrated the capability to survive in animal products for months to years and under a variety of environmental conditions (e.g., ASF, CSF, FMD, SVD, and Bacillus anthracis spores) (WS Diseases PRA 2010), there is a low probability of transport of disease agents to the Micronesia Region through this pathway, i.e., the legal importation (many of the potential disease agents are spread primarily through routes other than direct exposure to contaminated animal products).

Most animal product imports originate in the continental United States (75 to 98%), a low-risk area for diseases of concern, and there are strict regulations for the importation of animal products and by-products (VS PRA 2010). Other foreign imports originate from New Zealand and Australia. Limited veterinary services and lack of slaughter facilities throughout Micronesia limit commercial trade in locally produced meat, eggs, and milk.

The increase in foreign temporary workers may result in smuggling of animal products from their home countries, or Guam retailers may carry products to meet the demand. Preventive regulations are in place, but enforcement can be difficult.

2.2.16.4 *Impact of the Military Relocation*

Pathway traffic volume in animal products will increase as a result of the military relocation due to demands for animal products by a larger population.

2.2.17 Other Activities on Guam

2.2.17.1 *Pathway and Risk Species*

Imported or smuggled materials for animal fighting, game hunting, religious ceremonies, research, or aesthetic pursuits may increase proportionally according to the population increase, especially for cultural preferences of temporary foreign workers.

Species can include the full range of biological commodities and exotic animals. High-probability items are poultry (animal fighting); amphibians, reptiles, birds and insects (pets, religious ceremonies); animal and plant products (foods, furnishings); and feral animals (game). Various animals could be for biocontrols and scientific research.

2.2.17.2 *Current Mitigation Measures*

Legal imports to Guam must follow all APHIS and Guam regulations for permits, inspections, quarantine, etc. for each plant and animal type (see above pathways or Chapter 6, *Existing Mitigations*).

2.2.17.3 *Impact of the Military Relocation*

Imports of plants and animals and their products are likely to increase proportionally to the increase of population, particularly that of foreign temporary workers and their families.

2.3 APHIS RISK RATINGS

Tables 5-2 to 5-4 list qualitative risk ratings for the various potential pathways for introduction of invasive species to Hawai'i, Guam and other Micronesian Islands. Each risk rating is specific to an APHIS risk assessment team, and each team developed a risk rating methodology suited to the types of risks evaluated. Additional information on the rating methodology and risk ratings justification is in each APHIS Terrestrial Risk Assessment report (Appendix A).

Table 5-2: APHIS-VS Risk Ratings

Pathway	APHIS Risk Ratings				
	Release Assessment Legal	**Release Assessment Illegal**	**Exposure Assessment**	**Consequence Assessment**	**Overall Risk**
Conveyance–Aircraft	Very low	N/A	Medium	Guam and Micronesia: Very low United States: Very low	Very low
Conveyance–Maritime vessels	Very low	N/A	Medium	Guam and Micronesia: Very low United States: Very low	Very low
People	Negligible	Negligible	N/A	N/A	Negligible
Livestock	Negligible	Negligible	N/A	Guam and Micronesia: N/A United States: N/A	Negligible
Poultry	Negligible	Very low	Medium	Guam and Micronesia: Low United States: Medium	Low
Non-poultry birds	Negligible	Very low	Medium	Guam and Micronesia: Very low United States: Very low	Very low
Cats and dogs	Negligible	Negligible	N/A	Guam and Micronesia: N/A United States N/A	Negligible
Animal products	Negligible	Low	Medium	Guam and Micronesia: Low United States: Medium	Low

Pathway	APHIS Risk Ratings				
	Release Assessment Legal	Release Assessment Illegal	Exposure Assessment	Consequence Assessment	Overall Risk
Garbage	Negligible	Very low	Medium	Guam and Micronesia: Low United States: Medium	Low
Other cargo	Very low	N/A	Medium	Guam and Micronesia: Very low United States: Very low	Very low

Table 5-3: USDA-APHIS-WS Terrestrial Vertebrates Risk Ratings

Pathway	APHIS Risk Ratings			
Conveyance–Aircraft	HIGH RISK			
Conveyance–Maritime vessels	HIGH RISK			
Cargo	HIGH RISK			
Construction	HIGH RISK			
Plant products	HIGH RISK			
WPM	HIGH RISK			
Garbage	HIGH RISK			
INTENTIONAL	**Importation**	**Establishment**	**Hazard**	**Total Risk**
Pet trade	3	3	3	9 HIGH
Aesthetic releases	3	2	3	8 HIGH
Food use	3	3	3	9 HIGH
Animals for entertainment	2	2	3	7 MODERATE
Game hunting	1	2	3	6 MODERATE
Biocontrol	1	3	2	6 MODERATE
Scientific research	1	3	3	7 MODERATE
Religious ceremonies	I1	1	2	4 LOW
Bioterrorism	1	1	3	5 LOW

Table 5-4: USDA-APHIS-WS Wildlife Diseases Risk Ratings

Pathway	APHIS Risk Ratings			
	Probability of Infection	Alternate Probability	Impact of Infection	Alternate Impact
Hantavirus	Moderate	-	Low	-
Rabies virus	Minimal	-	Low	-
West Nile Virus	Minimal	-	High	-
HPAI	High	-	Moderate	Moderate

Japanese Encephalitis Virus	High	-	Minimal	Low
Avian Malaria Parasites	High	Minimal	Moderate	Moderate
Henipaviruses	Minimal	High	Moderate	Moderate
NDV	Minimal	High	Moderate	Moderate
Yersinia pestis	Minimal	-	Low	-
Tick-Borne Encephalitis	High	-	Low	Moderate

2.4 HIGH-RISK SPECIES AND VULNERABLE MICRONESIAN LOCATIONS

Guam receives visitors and imports of commodities from multiple countries. Guam is also served by multiple shipping lanes; east/northeast waterways connect with Hawai'i, and the continental United States waterways running north and west connect to CNMI and Asian ports.

In 2002, Guam imported agricultural commodities primarily from Australia, Asia (China, Korea, Hong Kong, Japan, Malaysia, the Philippines, Singapore, Taiwan, and Thailand), the rest of Micronesia (Chuuk, CNMI, Palau, Pohnpei, and Yap), New Zealand, and the United States. Most visitors travel by air from Japan or Korea (WS Diseases PRA 2010). Most arrivals to CNMI in 2002 and Palau in 2007 demonstrated a similar trend. Most visitors to FSM arrived by air from the United States followed by Japan and Europe (WS Diseases PRA 2010). It should be noted that information from 2002 and perhaps from 2007 may well be outdated. More updated information should be considered.

Of particular concern is the introduction of invasive species from China, Korea, Hong Kong, Thailand, Malaysia, and the Philippines. The USDA-APHIS publication *Combined Animal and Plant Health Risk Ratings for Countries*, October 2010, lists each of these in the top 25 countries presenting the highest combined risk for animal and plant diseases and pests (USDA-APHIS-PPQ 2010c). China ranks as the highest risk country, and Thailand is third highest. Countries linked to Guam by trade include Japan (ranked 7th), Republic of South Korea (ranked 15th), and Indonesia (ranked 22nd). (See APHIS-Terrestrial Risk Assessments in Appendix A for more detail.)

International airports are located in the State of Hawai'i and the U.S. territory of Guam, the CNMI islands of Saipan (71% commuter, 18% commercial), Tinian (99% commuter, 1% commercial), and Rota (72% commuter, 27% commercial), the Republic of Palau, the FSM, and the RMI (CPA 2007a, b, c). Commercial air transportation traffic may increase among these islands, evidenced by the scope of improvements underway at airports on Saipan, Tinian, and Rota.

The complete list of invasive species presenting potential biosecurity threats to Hawai'i, Guam and other Micronesian Region islands is far too large for detailed descriptions in this plan. Greater detail on risk species is in the APHIS Terrestrial Risk Assessments (Appendix A). These species could produce significant impacts if introduced to Hawai'i, Guam and other Micronesian Region locations.

Chapter 7, *Recommendations*, recommends enhanced mitigations for Hawai'i, Guam and other Micronesian Region locations based upon risk assessments by PPQ-Center for Plant Health Science and Technology (plants, plant products, and plant pests), VS (livestock, poultry and pets), and WS (wildlife diseases). Recommendations for Terrestrial Vertebrates are in Chapter 11, *Terrestrial Vertebrates Biosecurity Plan*.

3 EXISTING MITIGATION

3.1 INTRODUCTION TO MITIGATION AND PREVENTION STRATEGY

Biosecurity measures prevent and mitigate risks posed by invasive species and incorporate a wide range of preventive activities including public awareness, training, inspection, monitoring, detection, and eradication. Some of these measures may take place before conveyances arrive at the border. Determination of entry status, inspection, and treatment are usually conducted at the border. Post-border activities include control and eradication efforts for introduced species, public awareness programs, agreements with local businesses, and habitat improvement projects.

3.2 ORGANIZATIONS INVOLVED IN PHYTOSANITARY AND SANITARY PROTECTIONS FOR GUAM

Numerous organizations contribute to phytosanitary and general sanitary protections on Hawai'i, Guam and other Micronesian Region locations.

Each organization may have responsibility for a portion of the mitigation processes as described in Table 6-1. The following entities play significant roles in Guam mitigation activities:

Table 6-1: Biosecurity Organizations

Organization	Description
Aquatic Nuisance Species Task Force	The Aquatic Nuisance Species Task Force collaborates with the NISC Prevention Committee as the Pathways Work Team in support of the NISC Management Plan (NISC 2008).
CEQ	Coordinates federal environmental efforts with agencies and other White House offices in the development of environmental policies and initiatives (40 CFR §§ 1502.09 and 1502.20)
GCQA	GCQA clears aircraft, passengers, baggage, and cargo at airport and maritime ports, both civilian and military. Responsible for border inspections and monitoring regulated garbage handling at the ports of entry.
GDOA	A Biosecurity Task Force has been approved legislatively to unify GCQA and GDOA activities conducted under the direction of USDA-APHIS-PPQ and GCQA. Members will be available to respond to of invasive species reports. Foreign agricultural import inspections are overseen by USDA-APHIS-PPQ and GDOA. GDOA also permits the importation of certain animal products and live animals including zoo, fur-bearing, and other wild animals. GDOA works with the University of Guam, USDA-APHIS-WS, and USFWS to manage invasive species. GDOA and PPQ identify confiscated agricultural products, hold animals in quarantine, and prevent illegal imports. A Biosecurity Task Force has been approved legislatively to help coordinate GCQA and GDOA activities conducted in cooperation with USDA-APHIS-PPQ. Members will be available to respond to invasive species reports and incursions. Foreign agricultural import inspections are overseen by USDA-APHIS-PPQ while domestic imports are under the jurisdiction of GDOA's Biosecurity Division. GDOA also permits the importation of

Organization	Description
	certain animal products and live animals including zoo, fur-bearing, and other wild animals. GDOA works with the University of Guam, USDA-APHIS-WS, and USFWS to manage invasive species. GDOA and PPQ identify confiscated agricultural products, hold animals in quarantine, and prevent illegal imports.
GDAWR	A division of the GDOA, GDAWR identifies confiscated aquatic, marine, and wildlife products, holds animals in quarantine, and helps prevent illegal imports of such items.
Guam Invasive Species Council	Aligned with the Western Micronesia Regional Invasive Species Council, provides guidance when invasive species are detected, liaises to coordinate activities of Guam government agencies.
Guam Invasive Species Advisory Committee	Provides specialists to identify invasive species and determine distribution, identifies mitigation options, prepares cost/benefit analysis for mitigation options, and recommends emergency response actions to Guam Invasive Species Council.
JGPO	Serves as the NEPA proponent of proposed actions. The JGPO coordinates federal agencies having either jurisdiction over or technical expertise for certain components of proposed actions or a potentially affected resource.
NISC	The NISC Prevention Committee and Aquatic Nuisance Species Task Force collaborate as the Pathways Work Team in support of the NISC Management Plan (NISC 2008).
Quarantine Policy, Analysis and Support (QPAS)	An APHIS-PPQ program unit providing assistance on regulatory issues related to port inspection requirements and quarantine events. QPAS works closely with the PPQ Veterinary Regulatory Support (VRS) unit, which is dedicated to performing the same functions for animal products and by-products and regulated garbage.
University of Guam	The University of Guam conducts research and survey activities on invasive species, including plant disease and botanical identification in collaboration with GDOA and USDA-APHIS–PPQ.
USDA-APHIS-PPQ	PPQ oversees foreign agricultural import inspections as well as regulated garbage handling activities and handles invasive species events. PPQ Plant Inspection Station identifies plant products and plant pests seized in port inspections.
USDA-APHIS-WS	Conducts all BTS canine inspections, undertakes extensive BTS management efforts (trapping, fence line searches, and rapid response) and provides public outreach.
USFWS	Enforces international trade regulations on exotic birds and other wildlife. Any importers or exporters of wildlife must obtain a license from USFWS. USFWS designates the Agana, Guam port for importing certain kinds of wildlife (including animal parts and products with a Guam final destination).

Organization	Description
USGS BTS Rapid Response Team	USGS has a coordination office in the region which supports management agencies and NGOs involved in invasive species throughout all the jurisdictions covered by the MBP as well as the US Mainland. Support includes training courses for ED and RR, capacity building activities, community outreach, and coordinating ED and RR actions throughout the region. The RRT is manned by team members from all jurisdictions covered by the MBP as well as the US Mainland. Team members generally work for local, territorial, state, federal and private agencies and groups and in exchange for training are available to support field actions throughout Micronesia and Hawai'i as needed. The coordination office works with the governments throughout the region and supports their request for assistance. The USGS response coordination office also mans a 24/7 regional alien snake reporting hotline (671-777-HISS). The USGS response coordination office also supports other biosecurity and invasive species issues within the region when feasible, including servicing as a clearing house for information, facilitating linkages between locations, agencies, and experts and assist when possible with other taxa (other than snakes) response efforts.USGS has a BTS rapid response team capability on Guam. As of March 2013 the USGS coordination office has been vacant but capacity within the region for ED and RR still exists.
U.S. Marines	Relocation of force to Guam and training on Tinian.
U.S. Navy/NAVFACPAC	Relocation of force to Guam.
U.S. Transportation Command	Oversees the movement of military personnel and equipment. The U.S. Air Force Air Mobility Command supports strategic and tactical military operations by airlifting personnel and cargo. Military cargo not consigned to commercial carriers would be transported by Air Mobility Command aircraft.
Veterinary Regulatory Support (VRS)	An APHIS-PPQ program unit providing assistance on regulatory issues related to port inspection requirements and quarantine events related to animal diseases. PPQ, Agricultural Quarantine Inspection (PPQ-VRS-AQI) provides regional support for animal product/by-product import inspections as well as regulated garbage handling activities
VS/National Center for Import and Export Technical Trade Services Staff	A program unit within APHIS-VS which is responsible for the import regulations and policy with respect to live animals and animal products. Provides import permits for imported and transiting commodities.

3.3 PROCEDURES

3.3.1 Safeguarding Standard Operating Procedures

Government agencies with safeguarding authority have developed SOPs for protecting pathways, ports, and mainland areas within the Micronesia Region and for mitigating the accidental or intentional introduction of infective or invasive species. SOPs for Guam and CMNI, developed in harmony with U.S. and international standards, are for monitoring, surveillance, and rapid response functions for plant pests. ERPs exist for all jurisdictions covered by the MBP (except Guam) for alien snake incursions.

These were created by each jurisdiction in coordination rapid response team coordination office (Stanford, personal communication). The FSM, RMI, and Palau all have ERPs for bird flu which SPC helped develop. Yap has an ERP for coconut rhinoceros beetles which was developed by RISC and their technical supporters. Other ERPs which generally include SOP language may also exist for other organisms and/or situations through the region and the state of Hawai'i. .

3.3.2 Port Infrastructure

Biosecurity planners evaluate the types of infrastructure required to monitor pathways so resources are available to detect and mitigate the introduction of plant and animal health risks on arrival. These facilities include having sufficient equipment and personnel at all ports and designated cargo handling stations during surge conditions as anticipatedfor the military relocation to Guam. While Guam has the best-equipped airport and maritime port locations in the Micronesia Region, certain deficiencies in the ports' infrastructure require the following improvements:

- Port staging areas
- X-ray equipment, detector dogs, and other inspection resources
- On-site decontamination/treatment areas
- On-site quarantine facilities
- Dedicated inspection facilities within the port environs
- Barriers to separate potentially invasive from native species
- Regulated garbage disposal equipment/facilities
- Information technology and necessary equipment

3.3.3 Port Operations (inspection, permit/certificate enforcement, and treatment)

Essential biosecurity components are capabilities for inspection, enforcement of regulatory requirements, and operable equipment and materials. In conjunction with their own policies and procedures, Guam and CNMI authorities utilize procedures from the APHIS MAC and individual animal product and plant port of entry manuals (USDA-APHIS-PPQ 2013). USDA-APHIS-WS is responsible for BTS inspections upon port departure (export) from Guam. It should be clearly understood that BTS inspections conducted by USDA on Guam for departing cargo and planes are not required by law but rather are conducted on a volunteer basis. Additionally, it should also be clear that these inspections are conducted only for BTS and are only conducted on Guam (no other jurisdiction has this type of program and the volunteer departure program on Guam is only for BTS detection, no other organisms are specifically searched for). Shipments from other areas of Micronesia are inspected upon arrival according to local regulations and policies. GDOA issues import permits for various commodities including eggs for consumption, live animals, and various plant materials.

3.3.4 Interdiction Procedures

3.3.4.1 *Guam*

GCQA clears aircraft, passengers, and cargo at the airport, seaport, and mail facility. There are approximately 120 GCQA inspectors stationed at these locations (based on 2009 figures). There are currently four trained agriculture detector dogs stationed on Guam primarily for air passenger clearance. The airport has three shifts for clearing international flights.

USDA-APHIS-PPQ and GDOA oversee propagative plant inspections at the Plant Inspection Station. The University of Guam (UOG), GDOA, USDA-APHIS-WS, and USFWS are tasked with handling invasive species issues.

A Biosecurity Task Force has been legislated, coordinating GCQA and GDOA activities in cooperation with USDA-APHIS-PPQ. Members would be available to respond to invasive species reports and incursions. Guam also has the Guam Invasive Species Council, which includes the Guam Invasive Species Advisory Committee to provide it with scientific recommendations. USDA-APHIS-WS has an active BTS trapping, hand capture, and dog detection program on Guam available at all times.

GDAWR and the GDOA Biosecurity Division identify confiscated products and pests, hold animals in quarantine, and prevent illegal imports. Any importer or exporter of wildlife must obtain a license from USFWS and in some instances a permit from USDA-APHIS.

All pet dogs and cats arriving at Guam are subject to local quarantine requirements. The quarantine period is 120 days post-arrival for domestic dogs and cats (reduced to 30 days or less than 5 days if certain provisions are made for dogs, cats, and other carnivores).

Importation of zoo, fur-bearing, and other wild animals requires a permit in advance from the Guam Director of Agriculture. USFWS has designated Agana, Guam, as a special port for importing certain wildlife (including animal parts and products with a Guam final destination).

BTS presents a unique biosecurity circumstance, especially to Guam and CNMI (Saipan, Tinian, Rota), due to the military impact on these islands. Accidental transport of BTS from Guam is also a significant concern to all of Guam’s trade partners, which include the islands of the CNMI, the U.S. State of Hawai’i, the Republic of Palau, The Republic of the Marshall Islands, and the Federated States of Micronesia including the four states: Chuuk, Kosrae, Pohnpei, and Yap. Whereas most customs and quarantine inspections occur upon arrival and importation of goods, BTS inspections take place upon departure and export of goods, cargoes (e.g., vehicles, military field gear) and aircraft (i.e., military, commercial, private) as well as in staging areas. For most purposes, these pre-departure inspections are voluntary in nature.

3.3.4.2 *Commonwealth of the Northern Mariana Islands*

The CNMI is funded through the Office of Insular Affairs to conduct BTS interdiction work in Saipan, Rota, and Tinian. BTS interdiction efforts on Guam are conducted by USDA-WS. These inspections are a critical step in preventing off-island dispersal of BTS. Work done at the receiving ports in the CNMI or elsewhere is typically a second-line of defense but is considered equally important and in fact at times primary inspections are only conducted at receiver ports for items which miss the voluntary inspections conducted on Guam by USDA-WS .

3.3.4.3 *Saipan*

Airport operations are 7 days a week and run from 0300 hours to 2200 hours. On October 1, 2011, austerity measures (32-hour work week) were implemented resulting in an inspection rate of 40%, which is well below the 90% measure of effectiveness. Also, overtime was not authorized. As of mid-April 2012, the BTS program has been given approval to work up to 40 hours and limited overtime on a weekly basis to provide the program with the flexibility to cover most arrivals (about 70%); however, most flights are done visually instead of with canines. A new canine handler is awaiting Airport Operations Area certification and can then start clearing arrivals at Saipan International Airport, which may further boost inspection percentages.

About 46 BTS traps are currently deployed at the airport with an additional 40 at the seaport. The CNMI has an on-going public relations campaign "28-SNAKE, Don't give snakes a break" to raise awareness of the BTS threat and includes a central reporting system for snake sightings. Saipan currently has five employees working on BTS intervention, including one canine trainer; three canine handlers (one undergoing training, with previous canine handling experience with USDA-WS in Guam); and one trapper with no canine experience. The intent is to have this person trained as a handler.

3.3.4.4 *Rota*

Inspections for BTS are currently conducted by a single individual who has been trained for visual inspections, trap lining, and early detection and rapid response capacities. This individual has a canine to assist with BTS inspection work.CNMI Quarantine officers also may assist at times with the clearance of arrivals from Guam for BTS, but it is not their priority.

3.3.4.5 *Tinian*

Inspections for BTS are currently conducted by a single individual who has been trained for visual inspections, trap lining, and early detection and rapid response capacities. This individual has a canine to assist with BTS inspection work. Tinian has a BTS quarantine area at the seaport where suspect cargo can be held until appropriately inspected. The BTS inspector is stationed at the seaport. Aircraft Inspection

GCQA officers collaborating with USDA-APHIS to enforce federal animal and plant health regulations have the authority to board all military aircraft and maritime vessels. USDA-APHIS provides guidance, information, and training to DoD for pre-clearance inspections. However, because GCQA has not authorized the DoD to conduct inspections on its behalf, pre-cleared DoD shipments are still subject to routine inspection upon arrival. The USDA-PPQ MAC contains information on the inspection of aircraft and maritime vessels for plant and animal health concerns by APHIS collaborators (USDA-APHIS-PPQ 2013). Military regulations (OPNAVINST 6210.2 06) designed to prevent the introduction and spread of disease agents (human, animal, and plant), arthropod vectors, and pests of health or agricultural importance comply with regulations of the U.S. Departments of Health and Human Services, Agriculture, Treasury, DHS, Interior, and Commerce (OPNAVINST 6210.1; OPNAVINST 6210.2).

Current biosecurity inspections are the same for military and commercial aircraft upon arrival. Military aircraft are subject to agricultural quarantine inspections for animal and plant pests as well as invasive species, but are exempt from customs regulatory enforcement; however, passengers, cargo, and equipment are subject to both. Military aircraft departing Andersen AFB typically undergo canine inspection by APHIS-WS personnel for BTS to "the maximum extent possible," with some exceptions for medical emergency missions (U.S. Navy 2005a; b). Since inspections of any aircraft departing Guam, commercial or military, are primarily to detect BTS (BTSCC 1996; U.S. Air Force 2007), other species not specifically targeted may be missed or overlooked. Arriving aircraft, military or commercial, are not usually inspected by APHIS-WS or GCQA for terrestrial vertebrates but are subject to inspections for other agricultural purposes.

APHIS-WS inspects the exteriors of planes that are not "quick turns" (on the ground for less than 3 hours) using both canine teams and visual inspections by personnel. Cargo contents are inspected generally within 2 hours of loading. Contents vary, and chartered planes not on regular commercial flight schedules require much more ongoing inspection coordination. APHIS-WS and GCQA very rarely inspects planes internally for BTS or for animal and plant health concerns. If a plane is down for extended service and its hatches, doors, or exterior compartments are open for extended periods, an internal inspection for BTS may be done. Military aircraft are exempt from inspection if the process could jeopardize national security.

3.3.5 Maritime Vessel Inspection

For maritime transportation, CFR Title 7 regulates articles from Hawai'i and the territories, Title 9 regulates movement of animals and animal parts, and Title 42 governs public health. Title 7 regulates plants and plant products (Subtitle B, Volume 5, Chapter 3, Parts 318.13-9 and 330.111) and requires notification to inspectors prior to ship departures or arrivals on Guam. Title 9 (Volume 1, Chapter 1, Subchapter D, Part 93) permits inspection of any ship from foreign locations without a warrant to determine whether it carries any animal or animal part subject to safeguard or disposal to prevent the spread of disease. Title 9 (Volume 1, Chapter 1, Subchapter D, Part 95) requires disinfection of ships transporting restricted items not in leak-proof containers.

Titles 7 and 9 permit the inspection of any ship for agricultural risk of animal diseases, plant pests or diseases, and animal or plant products, including ship infrastructure, stores, cabins, and equipment.

Information in the USDA-APHIS MAC on the inspection of ships details procedures for ship infrastructure, stores, and cargo (USDA-APHIS-PPQ 2013).

Agricultural clearance of commercial ships includes inspection of deck areas, ship stores, and crew quarters and may include cargo. Pets of crew members transported must be quarantined on board.

Hitchhiking pests or animals of agricultural risk must be removed or destroyed. If pests are found on fruits and vegetables in ship stores, the products are either sealed on board while in port or removed for destruction.

U.S. military ships are subject to inspection for agricultural concerns. In the United States, military personnel are trained to assist and expedite in completing ship inspection forms and spot-inspecting ship stores. GCQA and DoD are responsible for developing local policies to maintain these requirements for incoming vessels.

The Armed Forces Pest Management Board published Technical Guide Number 31 (AFPMB 2004) to describe cleaning and inspection procedures for retrograde washdowns.

NAVMED P-5010-8, *Naval Manual of Preventative Medicine, Chapter 8, Navy Entomology and Pest Control Technology*, covers the use of preventive measures and bait station anticoagulants for rodent control. NAVMED P-5052-26, *U.S. Navy Shipboard Pest Control Manual*, explains inspection and de-ratting procedures for ships. MIL-STD-904B guides detection and prevention of pest infestations (MIL-STD-904B).

3.3.6 Passengers and Baggage

Civilian and military passengers and their baggage arriving in Guam are subject to inspection by GCQA regardless of conveyance. Passengers are interviewed upon arrival to determine whether they have prohibited or restricted commodities. Limited time, inadequate inspection facilities, inoperable or absent x-ray equipment, and insufficient staffing levels prevent GCQA from inspecting all incoming passengers and their baggage. Four trained agriculture detector dogs are available, but current resources are far below what is needed to staff air arrivals fully. All arriving passengers are considered “foreign” and subject to the same agricultural restrictions regardless of their travel origins. For example, passengers arriving from Hawai’i undergo the same inspection procedures as those from Japan. Passengers transiting to other countries, including those in the Micronesia Region, are not inspected by GCQA.

3.3.7 Cargo

Container shippers are responsible for keeping containers and loading areas free of vectors, reservoirs of disease and contamination, and invasive pest species during the packing process. This type of shipping is a risk for the transport of insect pests and other wildlife as hitchhikers and in WPM for the cargo.

Air cargo shipments are of particular risk due to the speed of shipping. Fruits and vegetables for consumption, flowers and decorative plants, and propagative plants may present a greater risk in the introduction and establishment of plant pests and diseases.

While the movement of cargo from the United States to Guam is interstate, under CFR Title 7 (Subtitle B, Volume 5, Chapter 3, Parts 318.13-8 and 318.13-10) cargo moving between Guam, CNMI, Hawai’i, and the continental United States is subject to agricultural inspection for plant pests and diseases. There are no such restrictions on cargo containing animal products moving between Guam, CNMI, Hawai'i, and the continental United States. All cargo originating in foreign countries is subject to inspection by GCQA. Cargo and passengers entering Hawai'i and the continental United States are inspected by DHS-CBP. The GOA authorizes GCQA to inspect cargo from the continental United States.

Parcels shipped through private mail (express courier operations) are regulated and inspected as cargo. GCQA has authority to inspect these packages without a search warrant. Privately shipped mail by commercial express courier operations (except diplomatic parcels) is inspected by GCQA through visual evaluation of the parcel and the declaration label. No x-ray equipment is available at the express courier operations and the inspection area is lacking equipment and lighting.

3.3.7.1 *Construction Equipment and Materials*

Following inspection, imports of construction equipment contaminated with pests or soil must undergo approved remedial treatment (if available) or re-export is required. The vast majority of problems with construction equipment are contamination with soil that can be washed away in areas designated for approved collection or drainage of the effluent, as into a system that treats sewage. There may be a plan for improvements, including additional inspection of imported construction materials and a military inspection site. On Guam, it is unclear how consistently mitigation measures for timber, sand, and gravel are applied and how well they prevent pest entry. There are no entry requirements for other construction materials.

Safeguarding measures prevent the spread of pests by timber. Saw logs with bark may not enter Guam, and de-barked saw logs and lumber must be inspected for termites and wood-boring insects. Foreign timber must have an import permit detailing required treatment. Other regulations authorizing the GDOA to quarantine, inspect, fumigate, disinfect, destroy, or exclude any commodities infested with pests are found in GARR Title 8-Food and Agriculture, Division 2-Plant Industry, Chapter 10, Importation of Plants and Plant Products.

3.3.7.2 *Propagative Material*

Guam inspectors employ extensive phytosanitary measures inspecting propagative plant shipments and cut flowers for plant pests and diseases and for import permit violations. Plants imported into CNMI arrive via Guam from California or Hawai'i for entry clearance by PPQ. Because of concerns about smuggling, every large bag or box brought into CNMI by foreign passengers is inspected visually.

Plant material for landscaping on Guam is imported primarily from the U.S., but Thailand, Taiwan, the Philippines, Costa Rica, Ecuador, and Puerto Rico are other sources. All imported propagative plant material, including transshipments to the CNMI, Palau, and FSM, is inspected at the GDOA/USDA Plant Inspection Facility.

GDOA requires treatment prior to shipment of all plants entering Guam from Hawai'i with a hot water or citric acid solution drench and inspection for pests of concern (by GCQA), primarily the coqui frog.

Guam prohibits entry of citrus, coconut, banana, and taro propagative plant materials from specified locations to prevent the introduction of specific pests of concern, and sweet potato planting materials are highly restricted. Importation of certain plants from areas infested with the European Corn Borer, *Ostrinia nubilalis* (Lepidoptera: Pyralidae) is also restricted (GDOA). Parts of this Guam regulation have been superseded by the Federal Plant Protection Act of 2000 (R. Campbell, Personal Communication).

3.3.8 Plant Products

GCQA conducts extensive inspections of incoming fruits and vegetables at several designated facilities on the island. Because these items are for consumption, they are of high priority for clearance. These very large shipments (consisting of many containers) necessary to supply the population of Guam occur very regularly via both air and maritime transport.

The APHIS-PPQ Fruits and Vegetables Import Manual guides PPQ inspectors and cooperators on shipments of fresh fruits and vegetables (USDA-APHIS-PPQ 2010b). Chapter 5 of the APHIS-PPQ Treatment Manual shows the treatment schedule for fruit, nuts, and vegetables (USDA-APHIS-PPQ 2008).

Clearance of fruits and vegetables may be by inspection of both the paperwork and the commodities if indicated. Inspections may be random, routine, or targeted.

Title 7 Part 319 of the CFR governs the importation of fruits and vegetables. All must have an APHIS import permit.

GARR Title 8, Division 2, Chapter 10 governs the importation of plants and plant products (GDOA 1997). Import permits and phytosanitary certificates are required to ship regulated articles into Guam.

3.3.9 Garbage

Garbage has been implicated in various animal disease outbreaks around the world (CRS Report 2001). Regulated garbage is monitored to prevent the movement and dissemination of pests and plant and livestock diseases. Sections in Titles 7 and 9 of the CFR state requirements for the handling and movement of regulated garbage (7 CFR, 9 CFR). Garbage is defined in 7 CFR § 330.400-330.403 and 9 CFR § 94.5 as waste material derived in whole or in part from fruits, vegetables, meats, or other plant or animal material. Any other refuse associated with such materials is also garbage. For purposes of this plan, trash is any waste material not in contact or associated with garbage and unregulated by APHIS for animal and plant disease concerns. Both trash and garbage are subject to EPA and local Micronesian regulations and restrictions (EPA 2013).

APHIS regulates garbage if the conveyance moving it has been outside the U.S. and Canada within the previous 2 years. Garbage on or removed from a means of conveyance is also regulated garbage, if at the time the garbage is on or removed from the means of conveyance, the means of conveyance has moved during the previous 1-year period, either directly or indirectly, to the continental United States from any territory or possession or from Hawai'i, to any territory or possession from any other territory or possession or from Hawai'i, or to Hawai'i from any territory or possession. These regulations apply to Guam and CMNI. Regulated garbage may not be moved between the continental United States and U.S. territories, U.S. possessions or Hawai'i nor may regulated garbage be imported or discharged in any form into U.S. territorial waters (within 12 nm of the coastline).

Tightly covered, leak-proof containers must store regulated garbage within U.S. territorial waters. Garbage must be stored properly to move it from a conveyance for disposal. Regulated garbage can be moved under the direct supervision of a USDA-APHIS-designated inspector (e.g., GCQA or CMNI quarantine personnel) or by an entity operating under a compliance agreement with APHIS to an approved garbage handling facility. There are seven compliance agreements for regulated garbage handlers in Guam and five in Saipan. Approximately, 680,389 kg (1.5 million pounds) of regulated garbage was destroyed from 1 February 2009 to 1 February 2010 (Brown 2010). Ports without the capability to handle and process regulated garbage may not allow its removal from conveyances.

To mitigate the risk presented by regulated garbage, it must undergo one of three processes: 1) incineration, defined as reducing garbage to ash by burning (with policy exemptions for glass and metal); 2) sterilization, cooking at an internal temperature of 212°F for 30 minutes; or 3) grinding and discharge into an EPA- and APHIS-approved sewage system.

Garbage from commercial and military aircraft must be unloaded at an airport or military base approved to handle it. On Guam, NAVFAC marinas at the Apra Harbor Naval Station and Pacific Environmental Resources Incorporated at Andersen AFB are both approved to handle garbage. Regulated garbage from A.B. Won Pat International Airport is processed at the local aircraft catering company. Saipan International Airport has an incinerator owned and operated by the Commonwealth Ports Authority to handle regulated garbage. Site visits to Guam and Saipan noted multiple deficiencies on the premises of some compliance agreement holders (Jimenez et al. 2009).

Tinian has no functional equipment for the disposal of regulated garbage. The local landfill has been cited for multiple violations by the Saipan Division of Environmental Quality, and the EPA and the military's plan to move garbage generated on Tinian during training operations to Saipan or Guam for disposal until that time when and if a new landfill is complete violates APHIS regulations. Tinian has not repaired the equipment for processing regulated garbage and, according to the Saipan Tribune, the new Tinian landfill will be built within the area leased by the U.S. military (as of 2013 information on this remains vague), but will be closed during construction and training exercises. A transfer station will be built to store garbage generated by civilians during training exercises (Saipan Tribune 2010).

APHIS-PPQ has responsibility for monitoring garbage handling activities of airports, caterers, cleaners, cruise ships, fixed-base operators, hauling/cartage firms, marinas, military facilities, storage facilities, and transfer stations in U.S. locations; however, there are only two PPQ officers for Guam and CNMI. In Guam, GCQA assists with this effort.

The APHIS-PPQ MAC guides handling of regulated garbage. The APHIS-PPQ MAC also instructs inspectors to monitor regulated garbage handling on aircraft and ships in port as well as at land-based facilities

(USDA-APHIS-PPQ 2013). The Quarantine Regulations of the U.S. Navy require garbage handling in compliance with APHIS regulations (OPNAVINST 6210.2).

Other practices related to garbage present additional risks. Garbage not on a conveyance outside of U.S. locales and Canada may be regulated if fed to swine. Some local pigs are fed garbage collected in restaurants and perhaps from boats; however, pig owners are not licensed to feed this type of garbage (Poole 2009). CFR Title 9 § 166.1–166.2 states that only personal household garbage may be fed to pigs and that the farmers must be licensed to feed them other types of garbage.

3.3.10 Mail

Mail is a high-risk pathway for the movement of agricultural commodities and invasive species. GCQA monitors mail and seizes items of phytosanitary concern. Both GCQA and the local postmaster recognize domestic and foreign mail as a pathway for smuggling all types of commodities (Jimenez et al. 2009). Foreign mail may be inspected without a warrant only at the first port of arrival, after which it is considered domestic mail. Approximately 95% of the mail arriving on Guam comes directly from the U.S. or is international mail processed in Hawai'i. All (100%) of the international mail entering Honolulu destined for Guam is inspected by CBP.

The remaining 5% of mail arrives directly from foreign countries, primarily Japan and the Philippines. In 2008, 1.9 million parcels/pieces of mail came through the Guam Post office (Jimenez et al. 2009). Mail arriving in Guam destined to the CNMI is inspected in Guam.

First-class mail sent via the USPS is legally protected under the Fourth Amendment to the U.S. Constitution, making it illegal to delay or open such mail without either a search warrant or permission from the addressee. These protections apply also in Guam and the CNMI. GCQA officers open and inspect the mail, but the postal inspector and the consignee must be present. The postal facility legally may not slow down the flow of domestic mail, which limits the number of packages that can be inspected with the available workforce. The facilities are inadequate, and the x-ray machine is not fully functional (Jimenez et al. 2009). In addition, the present postmaster makes the use of detector dogs inside the postal facility very difficult. Using detector dogs inside the postal facility would facilitate the inspection process and reduce risks.

The USPS allows adult and hatchling (day-old) poultry to be mailed with restrictions. Postal regulations prohibit mailing of hatchlings vaccinated for NDV. Day-old chickens, ducks, emus, geese, guinea fowl, partridges, quail, and turkeys must be delivered to the addressee within 72 hours after hatching. Per USPS regulations, non-poultry birds may not be mailed (USPS 2009). Poultry from Hawai'i are transported on United Airlines as domestic mail (Jimenez et al. 2009).

The Guam Post Office displays educational posters describing prohibited mail items, and while currently not occurring as a common practice, post office clerks are encouraged to ask customers whether outgoing packages contain perishable items. When packages stamped "perishable" arrive on Guam, GCQA officers inspect them and, when necessary, forward them to the Guam Plant Inspection Station for additional inspections or diagnostic assistance.

Military mail is handled by the MPSA, the single DoD point of contact with the USPS, which is required by military regulation to adhere to USPS rules, federal laws, and various international laws and agreements for movement of military mail. The MPSA also educates military personnel about items prohibited in mailed packages (Ericksen personal communication). Military mail may not be inspected by GCQA.

The USDA APHIS MAC provides direction for inspections at U.S. postal facilities receiving international mail (USDA-APHIS-PPQ 2013).

Information from GCQA and the USPS indicates that the mail flow will increase with the military relocation (Jimenez et al. 2009).

3.3.11 Wood Packing Materials

U.S. regulations and the ISPM No. 15 (ISPM No. 15 2009) require either fumigation with methyl bromide or heat treatment according to specific schedules for all WPM entering the country for use in commerce. Treated WPM must display a specified ISPM No. 15 stamp in a visible location for compliance checks at ports of entry.

These regulations apply to WPM imported from foreign origins into Hawai'i, Guam, and CNMI. Movement of WPM between these same locations is domestic and not subject to these regulations. Because the majority of cargo entering Guam is from domestic locations, this fact represents a potentially significant safeguard gap. FSM, Palau and RMI have no existing regulations to mitigate the pest risk from the importation of WPM. It is likely that a certain percentage of WPM always bypasses mitigation and sometimes live pests are found in properly marked WPM. In these cases for U.S. locations when an issue is detected, APHIS-PPQ determines either that the shipment was treated improperly or that ISPM No. 15 stamps were applied fraudulently, without treatment. Inspections of WPM with its cargo for pests and the required marking have detected wood pests in both stamped and unstamped WPM. There are obvious gaps in this process .

The USDA MAC directs inspectors to check whether regulated WPM is compliant or non-compliant (APHIS MAC). Guidance from the APHIS Miscellaneous and Processed Products Manual on this topic applies to Hawai'i, Guam and the CNMI (USDA-APHIS-PPQ 2012). Inspectors are instructed to look specifically for timber pests, other insects, and unspecified hitchhikers.

3.3.12 Livestock, Poultry, and Non-poultry Birds

For purposes of this terrestrial risk assessment, livestock and poultry are defined per APHIS regulations:

- **Livestock**–Domesticated ruminants (cattle, carabaos, sheep, and goats), domesticated swine (including feral swine), and domesticated equids (horses, mules, and asses).

- **Poultry**–Chickens, doves, ducks, geese, grouse, guinea fowl, partridges, peafowl, pheasants, pigeons, quail, swans, and turkeys, including eggs for hatching (9 CFR § 93.100).
- **Non-poultry birds**–Birds other than those listed above susceptible to communicable poultry diseases or capable of carrying those diseases or their arthropod vectors (9 CFR § 92.1). This definition includes wildlife species.

APHIS regulations (9 CFR § 92) refer to all species of the animal kingdom except humans, including: cattle, sheep, goats, other ruminants, swine, horses, asses, mules, zebras, dogs, poultry, and birds susceptible to communicable livestock and poultry diseases or capable of carrying those diseases or their arthropod vectors. APHIS regulations governing the importation of domesticated livestock, poultry, and non-poultry birds in 9 CFR § 93 pertain to movement of cattle, sheep, goats, pigs, horses, mules, asses, other livestock species, poultry, and other non-poultry birds from foreign countries into any of the 50 U.S. states, the Commonwealth of Puerto Rico, the CNMI, the District of Columbia, and any territories and possessions of the United States. Domesticated livestock for importation into the United States from any part of the world must be shipped directly to an approved port and be quarantined there until negative results to specified tests, depending upon the country of origin, are obtained and the animals are certified by the port veterinarian to be free from clinical evidence of disease. In special cases the APHIS Administrator may designate unapproved ports as quarantine stations. No ports on Guam are approved for importation of livestock, poultry, or non-poultry species; therefore, at this time these species for import to Guam first must enter through ports in the continental United States.

APHIS regulations on the interstate movement of domesticated livestock, poultry, and non-poultry birds in 9 CFR § 71-89 generally prohibit animals, including domesticated livestock, affected with any communicable disease from interstate movement.

In 2002, an amendment to the AWA made the import or interstate commerce of a bird or animal for the purpose of participation in a fighting venture illegal regardless of the law in the destination state, including Guam (APHIS-VS 2003). This amendment does not restrict the possession of poultry or dogs for breeding or as show animals.

GARR import requirements for live animals, organisms, and vectors require any animal found to be clinically affected or recently exposed to any infectious, contagious, and/or communicable disease or infested with ectoparasites to be returned to its point of origin or destroyed (9 GARR 1 § 1100-1113).

3.3.12.1 *Livestock*

U.S. and Guam territorial regulations impose livestock requirements for horses and other livestock moving interstate or imported into Guam. Horses are subject to specific mitigations to prevent the entry of EIA, EEE, WEE, and VEE viruses (9 CFR § 75 and 9 GARR 1 § 1104).

3.3.12.2 *Poultry*

Federal regulations restrict importation of live poultry, poultry products, and hatching eggs from regions affected by END or HPAI; several of these regions are Asia-Pacific countries (9 CFR § 93.201, 9 CFR §

94.6, and 9 § CFR 95.30). Live poultry permitted to enter the United States (except those from Canada) must be inspected, quarantined for 30 days, and tested at a quarantine facility on the U.S. mainland (9 CFR § 93.209). The importation of hatching eggs is restricted from countries affected by END and HPAI, including the Philippines and several other Asia-Pacific countries (9 CFR § 93.201 and 9 CFR § 93.209).

In addition to applicable APHIS regulations, Guam territorial regulations require an entry permit and a health certificate approved by the chief livestock sanitation officer or a state or federal veterinarian as well as serological testing and vaccination for poultry diseases of concern (9 GARR 1 § 1110). Poultry must be identified individually with a numbered leg band with the number indicated on the health certificate. (9 GARR 1 § 1110). Hatching eggs and day-old poultry require only an affidavit from the shipper stating that the flock of origin is free of NDV and has not been exposed to it within 60 days prior to shipment for import. All poultry and hatching eggs must be shipped in new (unused) containers and inspected by the territorial veterinarian or deputy prior to entry into Guam.

3.3.12.3 *Non-poultry Birds*

Federal regulations state birds not of U.S. origin must be accompanied by an import permit and inspected by USDA personnel at an approved port of entry with avian quarantine facilities. USDA imposes trade restrictions on the importation of live birds from countries affected by HPAI, including certain countries in Africa and Asia (USDA-APHIS 2009a).

Importation of wild or exotic birds into the United States must comply with APHIS and USFWS requirements. Certain exotic birds are protected by the CITES and the WBCA.

All birds entering Guam must be accompanied by an import permit and an official health certificate approved by the chief livestock sanitation officer or a state or federal veterinarian. Birds must be identified individually with a numbered leg band with the number indicated on the health certificate (9 GARR 1 § 1110).

Regulations for the importation of pet birds (all birds except poultry) under 9 GARR §§ 2101-2102 require pet shops and importers to keep a record of each sale made for at least 90 days and to make the record available to the GDOA if a quarantine is placed on the premises by the territorial veterinarian (9 GARR §§ 2101-2102).

Guam has introduced additional quarantine requirements for all birds (poultry and non-poultry) arriving from the continental United States to prevent the introduction of West Nile Virus requiring a 7-day quarantine in an approved facility or veterinary clinic followed by 30 days of isolation in a mosquito-proof cage.

3.3.12.4 *Dogs and Cats*

Under CDC regulations, 42 CFR § 71.51, dogs imported to the United States, with limited exceptions, must be accompanied by a certificate of rabies vaccination; imported cats are not required to be vaccinated for rabies (42 CFR § 71). The entry of pets from areas affected by screwworms is subject to

APHIS regulations (9 CFR § 93), which require a health certificate stating that the pet was examined and found to be free of screwworm infestation within 5 days of export (USDA 2000; USDA-APHIS 2009b).

The GDOA regulates importation of pets to Guam (5 GCA § 60108). Guam restrictions and prohibitions for the importation of cats and dogs are stricter than federal requirements. Cats and dogs must enter Guam through the A.B. Won Pat International Airport or the Apra Harbor maritime port. Every cat or dog must be accompanied by an entry permit, a health certificate signed by a veterinarian no more than 14 days prior to shipment, and a confirmed quarantine kennel reservation. Dogs must have a rabies vaccination certificate dated between at least 30 days and 1 year prior to shipment and a certificate of immunization against various canine diseases. Cats must have a certificate of immunization for multiple feline diseases. Regulations for the importation of cats and dogs into Guam require animal identification, quarantine procedures, and rabies vaccination and testing prior to arrival.

Title 10 GCA Chapter 34 Article 3 states that animals imported must complete a maximum of 120-day confinement in a commercial quarantine facility. Animals may undergo shorter quarantines under specific testing schemes for rabies and some pets may qualify for the home quarantine option.

Animals originating from Japan, Hong Kong, Oceania, and the continental United States (except for counties on the Mexican border) can be quarantined on Guam. Animals originating elsewhere must be quarantined in Hawai'i prior to entrance into Guam. Cats and dogs originating from rabies-free areas, Hawai'i, New Zealand, Australia, and the United Kingdom, may be exempted.

Import regulations for cats and dogs in 9 GARR 1 § 1109 include additional requirements for cats and dogs from other countries. Cats and dogs that do not comply with regulations may be declared ineligible to enter and remain in the custody of the carriers at a designated inspection area at the port of entry until sent back.

Military regulations for the import of dogs and cats published in the Quarantine Regulations of the Armed Forces (QRAF) comply with federal and state requirements. General requirements for the admission of cats and dogs include the following: 1) all animals arriving in the United States are subject to inspection by a public health or military quarantine officer; 2) animals will require testing and confinement when they appear to be not in good health or when they have been exposed during shipment to a sick or dead animal suspected to have a communicable disease; 3) unsanitary cat and dog containers arriving in the United States must be cleaned and disinfected before the animals can be admitted; and 4) a valid rabies certificate is required for dogs. The military requires dogs to be vaccinated for rabies and inspected at the port under quarantine regulations. All pets belonging to military personnel must meet the requirements for importation into Guam.

One of at least four private veterinary clinics on Guam maintains a quarantine facility for imported cats and dogs. The military has one veterinary clinic and a boarding and quarantine facility at Andersen AFB and another veterinary treatment facility at the Navy base. The Andersen facility maintains 14 canine kennels and six feline quarantine kennels. The Navy will construct a new facility with space for 10 military working dogs, a veterinary examination area, an outdoor dog wash, and four quarantine runs.

In recent years, effective mitigations have drastically reduced the risk of infectious disease in military dogs stationed overseas.

3.3.13 Wildlife

Importers or exporters of wildlife, wildlife parts, or products must obtain a license from USFWS and importers may be required to secure an import permit from APHIS or the CDC and subjected to additional APHIS and CDC regulations depending on the species (9 CFR § 93, 9 CFR § 95, 42 CFR § 71.52-71.56). Guam also requires permits for the import of zoological or menagerie animals, inspection by the territorial veterinarian, and any necessary quarantine conditions.

GCQA must notify the territorial veterinarian of the arrival of live wildlife. GDAWR assists GCQA in identifying confiscated animal products.

Routine activities to monitor the movement of vertebrate wildlife are limited to BTS. APHIS-WS is responsible for surveillance and monitoring.

3.3.14 Military Mitigation

DoD maintains customs and border clearance policies and procedures for wildlife, agricultural and animal products, pets, plants, and plant products. By mandate of the Military Customs Inspection (MCI), all passengers, crew members, accompanied baggage, and equipment boarding any DoD-sponsored ship or aircraft departing an overseas area for the Customs territory of the United States (CTUS) must meet all U.S. entry requirements. All personnel on military aircraft must complete a U.S. Customs Accompanied Baggage Declaration (DD Form 1854), and civilian crew members must complete Customs Form 5129. The MCI program does not extend to Guam because GCQA has not authorized inspections by DoD personnel on its behalf.

A DoD memorandum designates Navy personnel with authority to inspect and to issue ship sanitation certificates for Navy, Army, Military Sealift Command, Coast Guard, and National Oceanic and Atmospheric Administration vessels. This memo requires adherence to standard procedures and policy–IAW Article 39 of the International Health Regulations 2005–certificate (valid for 6 months) (WHO 2005).

AFJI 48-104, Quarantine Regulations of the Armed Forces, incorporates regulations to mitigate the risk of introduction and dissemination of arthropod vectors by movements of vessels, aircraft, and other Armed Forces transport arriving at or leaving U.S. and foreign ports, installations, or other facilities where arthropod vector-borne diseases exist. This requirement is included in the Military Entomology Operational Handbook.

3.3.14.1 *Military Aircraft*

Military aircraft departing Guam should be screened by USDA-APHIS-WS canine inspection teams prior to departure. Military aircraft that arrive at Guam from Asian ports in Japan, China, and Korea should be inspected for insects, mice, birds, and amphibian and reptile species trapped within cabin and cargo compartments or hitchhiking externally in wheel-well compartments.

3.3.14.2 *Vessels*

DoD rodent control on ships to guard or separate gangways from the shore extend to cargo nets and other devices in port and fit connecting lines with rat guards. Cargo found free or treated for rats must be loaded. Ships must be inspected for rats and fleas prior to departure.

3.3.14.3 *Military Personnel*

The DoD relies on individual military personnel to clean and inspect their clothing and personal property to prevent the introduction of plant pests. Military personnel undergo limited training in biosecurity for agriculture. They are not trained in pest detection and receive no comparable information about the risks of moving plant pests into Guam and around the Micronesia Region. Military personnel are informed about the risks of spreading BTS from Guam. No oversight, compliance checks, or quality control processes are in place to ensure that biosecurity procedures for personnel are effective.

3.3.14.4 *Cargo*

All DoD cargo must be available for inspection by CBP upon entry into the United States except for areas outside CTUS, such as the Micronesia region. GCQA and CMNI Quarantine are responsible for agricultural inspections on behalf of APHIS in their respective territories. DTR 4500.9, Part V includes agricultural cleaning and inspection requirements and indicates that DoD personnel will be assigned as agricultural and customs inspectors for pre-clearance programs (DTR 4500.9). USDA-APHIS provides DoD with guidance, information, and training for pre-clearance inspections. According to the agricultural cleaning and inspection requirements (Part 5, Chapter 505), no cargo may be loaded in a foreign country unless free from plant and animal contamination or pest infestations.

Chapter 511 of DTR 5 states that all cargo entering Guam, regardless of origin, is subject to inspection by GCQA. OPNAVINST 6210.2 authorizes USDA-APHIS-PPQ personnel to inspect cargo to prevent the introduction of plant and animal pests or diseases.

3.3.14.5 *WPM*

DoD stipulates that all new WPM under DoD contracts or acquired by the DoD must meet ISPM No. 15 requirements. Companies supplying WPM to DoD must comply with a quality control program administered by the American Lumber Standard Committee (ALSC) through an agreement with APHIS auditing for proper treatment and record-keeping practices. However, DoD may use old WPM not compliant with ISPM No. 15. Whether any of this noncompliant WPM is shipped to Guam is not known.

3.3.14.6 *Propagative Material*

The DoD Personal Property Consignment Instruction Guide Online system, which provides guidance to military and DoD civilian personnel assigned to foreign duty stations, states incorrectly that there are “No restrictions identified” for plant movement into Guam.

3.3.14.7 *Mitigation Regulations and Requirements*

Table 6-2 presents pertinent regulations for Guam inspections, quarantine, and treatment. Tables 6-3 and 6-4 detail other biosecurity guidance and the military regulations and requirements for biosecurity.

Table 6-2: Biosecurity Regulations and Requirements

Statute, Regulation or Requirement	Description
Animal Health Protection Act (AHPA)	The AHPA purpose is to prevent, detect, control, and eradicate diseases and pests of animals to protect animal health, the health and welfare of the people of the U.S., the economic interests of U.S. livestock and related industries , the U.S. environment , and U.S. interstate and foreign commerce in animals and other articles.
Animal Welfare Act (AWA)	A modification to the AWA, the Animal Fighting Enforcement Act of 2007, made interstate commerce of a bird for the purpose of participation in a fighting venture illegal regardless of the law in the destination state, including Guam.
National Defense Authorization Act, Public Law 110–181, Section 314	Requires prohibition on the transport and spread of BTS via aircraft.
National Environmental Policy Act (NEPA)	NEPA, 42 U.S. C. § 4321 as amended, of 1969.
Non-Indigenous Aquatic Nuisance Prevention and Control Act of 1990	Authorizes a cooperative program to control BTS outside its historic range.
Plant Protection Act (PPA)	The PPA consolidates all or parts of 10 USDA plant health laws into one comprehensive law, including the authority to regulate plants, plant products, certain biological control organisms, noxious weeds, and plant pests.
Title 8 Guam Administrative Rules and Regulations (GARR)	Division 2–Plant Industry, Chapter 10 regulates Food and Agriculture, Importation of Plants and Plant Products.
Title 9 GARR 1997	Division 1, Chapter 1 of the GARR regulates the importation of live animals.
	Section 2 of § 1103 (GARR) states that under no circumstances shall any animal be turned loose at the port and that hogs and sheep may be confined in temporary pens or crates, cattle and horses may be tied, and dogs and cats shall be confined in crates.
	Title 9 GARR, Division 1, Chapter 1, § 1109 requires that all cats and dogs originating from Africa, Asia, or islands of the Pacific Ocean (except Australia, Hawai'i, and New Zealand) have a certificate from the national chief livestock sanitation officer stating that the animals originated in a state, country, or other political subdivision officially declared free of surra, animal African trypanosomiasis, and leishmaniasis.
	Title 9 GARR 1 § 1110 requires all imported birds and hatching eggs to be accompanied by an entry permit and a health certificate approved by the chief livestock sanitation officer or a state or federal veterinarian.

Statute, Regulation or Requirement	Description
	Subchapters §§ 2101 and2102 regulate the importation of pet birds (all birds except poultry).
Title 10 GDOA 5 GCA § 60108	The GDOA regulates the importation of pets to Guam. Title 10 Guam Code Annotated Chapter 34 Article 3 states that animals imported must complete a maximum of 120-day confinement in a commercial quarantine facility.
Wild Bird Conservation Act (WBCA)	Certain exotic birds are protected by the CITES and the WBCA. Importation of exotic birds into the U.S. must comply with APHIS and USFW requirements.

Table 6-3: Other Biosecurity Guidance

Other Guidance	Description
Animal Product Manual	Guidelines based upon the regulation governing the importation of specific animal products and by-products.
Combined Animal And Plant Health Risk Ratings for Countries	USDA-APHIS analysis of relative risks presented from other countries as a result of animal and plant diseases inside their borders (CPHST, VS Center for Epidemiology and Animal Health, October 2010).
Fruits and Vegetables Import Requirements (FAVIR) Online Reference	www.aphis.usda.gov/favir/
Manual of Agricultural Clearance	The APHIS MAC provides comprehensive guidance for practices required for safeguarding imported products and articles and handling regulated garbage. Safeguarding is a preventive action for handling, maintaining, or disposing of prohibited or restricted products and articles to maintain cargo control and eliminate the risk of plant and animal pest and disease dissemination. Nursery Stock Restrictions (M319.37–A & B)
USDA-APHIS-PPQ Manuals	Guidelines for regulating the importation and interstate movement of specific plants and plant products.

Table 6-4: Military Biosecurity Regulations and Requirements

Regulation or Requirement	Description
AFJI 48-104, Quarantine Regulations of the Armed Forces	Incorporates regulations to mitigate the risk of introduction and dissemination of arthropod vectors by movement of vessels, aircraft, and other Armed Forces transport arriving at or leaving U.S. and foreign ports, installations, or other facilities.
AFPMB Tech. No. 31 (2004).	Delineation of responsibilities for the military meeting USDA-APHIS requirements for internal and external inspections for terrestrial vertebrate species, insects, and plant species.
COMNAVMAR INST 5090.10a	Navy instruction for BTS training for military personnel.
DoD Memorandum	DoD Memorandum designates Navy personnel with authority to inspect and to issue ship sanitation certificates (ship sanitation control exemption certificate and ship sanitation control certificate) for Navy, Army, Military

Regulation or Requirement	Description
	Sealift Command, Coast Guard, and National Oceanic and Atmospheric Administration vessels to adhere to standard procedures and policy–IAW Article 39 of the International Health Regulations (WHO 2005)–certificate (good for 6 months) with section for observed rodent infestations.
DoD SDDC PPCIG 2010 Personal Property Consignment	The DoD Personal Property Consignment Instruction Guide Online system, which provides guidance to military and DoD civilian personnel being assigned to foreign duty stations, states that there are "No restrictions identified" for plant movement into Guam.
Guam and CNMI Military Relocation EIS/OEIS	The Guam and CNMI Military Relocation EIS/OEIS describes military relocation plans, schedules, impacts, and mitigations.
Naval Supplemental Publication Number 486, Volume 1	Naval policy contains information regarding APHIS requirements for foreign garbage.
NAVMED P–5010–8	Naval Manual of Preventative Medicine, Chapter 8, Navy Entomology and Pest Control Technology: Navy procedures for the eradication of animals.
OMNAVMARIANA SINST 5090.10A	Requirements for setting barriers for BTS.
OPNAVINST 6210.2	USDA-APHIS-PPQ personnel may inspect cargo to prevent the introduction of plant and animal pests or diseases.
Quarantine Regulations of the Armed Forces	The Quarantine Regulations of the Armed Forces state that cargo is subject to inspection by a USDA representative to prevent the introduction or spread of animal and plant diseases or pests (DoD 1992). For the purposes of these regulations, Guam is part of the U.S. DoD maintains customs and border clearance policies and procedures for wildlife, agricultural and animal products, pets, plants, plant products, and regulated garbage.
SECNAVINST 6210.2A AFR 161–4, DoD, 1992, Section 9	Outlines procedures for the use of rat guards at ports with known rodent infestations.
Subsistence Manual COMDTINST M4061.3C	Waste Disposal Requirements.

4 RECOMMENDATIONS

APHIS risk assessment teams from PPQ-CPHST, VS-Center for Epidemiology and Animal Health, and WS have developed phytosanitary and general sanitary recommendations for enhanced biosecurity necessary to protect Hawai'i and the Micronesia Region during and after the military relocation to Guam and Tinian. Recommendations are based on the specific pest risk assessments of each APHIS team and observed deficiencies in mitigation capabilities.

The primary focus of the MBP is to describe recommendations for additional biosecurity measures for Guam, Hawai'i, CNMI, FSM, RMI,, and Palau. Each of these jurisdictions has reason to be concerned about many of the same challenges related to the introduction of invasive species and the lack of resources for sanitary and phytosanitary protections. In general these islands have limited staffing, funding, infrastructure, and/or capabilities for airport and seaport border inspections; agricultural quarantine inspection programs; plant and animal pest and disease surveillance; control and eradication; and early detection and rapid response programs.

Several biosecurity infrastructure needs are common at each Micronesian location. Adequate x-ray capability for baggage screening and inspection must be improved at each commercial port, either by ensuring operability or adding additional equipment. The CNMI, FSM, RMI, Guam, Hawai'i, and Palau should expand their inspection capabilities for air and sea containers. Permanent operational wash racks for inspection and cleaning of soil-contaminated vehicles and equipment must be constructed and maintained, especially for construction vehicles arriving via water to Guam, Saipan, Tinian, and Rota.

In addition, a Micronesian Region monitoring and surveillance program for the occurrence of foreign animal and plant introduction should be established to improve communications of survey results among all island mitigation programs. Special surveillance programs should be established for plant pests and diseases; exotic fruit flies, Khapra beetle, Rhinoceros beetle, and tropical wood pests should be trapped. All Micronesian Region islands and Hawai'i should improve early detection and rapid response capabilities.

Other biosecurity measures are recommended for specific Micronesian Region islands and Hawai'i, including additional inspectors, legislatively approved user fees, electronic systems for tracking manifests, container scanners, and a training and outreach program (see Appendix A for more detail).

4.1 GENERAL RECOMMENDATIONS:

It is worthwhile to note that many of the recommendations within this risk assessment refer directly to Guam but that many of these same concepts can be applied to the other jurisdictions covered by the MBP. Additional recommendations and details will be provided in the SIP.

4.1.1 Infrastructure

4.1.1.1 *Funding*

Increase funding for regional biosecurity so necessary efforts to prevent, control, and eradicate animal and plant pests and diseases throughout the region are effective. A centralized regional group with representatives from each country within the Micronesia Region should develop sustainable funding streams for efforts to manage interrelated risks that cross political boundaries. There should be sufficient funds to conduct routine surveillance, implement response plans, and provide outreach and education, in addition to port of entry exclusion activities and training for inspectors.

Ensure sufficient funding for agriculture and wildlife disease and pest exclusion activities by developing legislation to create a user fee structure similar to that employed by the DHS and USDA. Review penalty assessment structure for noncompliance with regulations covering animal and plant health as a source of additional funding. Military presence in the region calls for long-term allocation and ongoing management of biosecurity funds. Current funding for regional biosecurity is distinctly inadequate for the magnitude of the existing and emerging challenges posed by the military relocation to the current exclusion and control systems. In particular, a main challenge to an agency with the all-inclusive mission of GCQA is sustainable financial support and subsequent accountability. A reasonable solution would be user fees. User fees are assessed by the government to recover the costs of goods or services. USDA-APHIS levies user fees through statutory authority 7 CFR § 354.3 and 9 CFR § 130. In 2010, GCQA levied a $6.36 per passenger combined Customs and Agriculture user fee to cover passenger and baggage inspections compared to $10.50 per passenger fee for international arrivals to the rest of the U.S. ($5.50 for Customs inspection collected by the CBP and $5.00 for agricultural inspection services by CBP on behalf of USDA). There is an additional fee for immigration services. User fees are not charged for military passengers or conveyances. User fees cover inspection of commercial aircraft and maritime vessels as well as commercial maritime vessels or aircraft carrying military cargo. If passenger arrival totals remain at current levels, increasing the user fee to the same as that of USDA/CBP would represent an approximate 40% increase in revenues.

Ensure adequate long-term military funding is available for biosecurity efforts. The military must participate in regional biosecurity efforts.

Create community funding sources for local programs to promote environmental awareness and stewardship through local training, education, and eradication efforts

Ensure adequate long-term funding is available for equipment and infrastructure.

4.1.1.2 *Staffing and Resources*

Ensure sufficient staffing (inspectors, plant health safeguarding specialists, and surveyors) to accomplish all necessary inspection and quarantine activities in the Micronesia Region. Develop a staffing model that addresses all activities for inspection and quarantine. Already insufficient staffing levels will be strained further by the military relocation as the workload at airports, maritime ports, the mail facility, and the Plant Inspection Station increases. Quarantine officers with agriculture expertise should be on duty to clear cargo and conveyances whenever aircraft or maritime vessels arrive. Quarantine officers must be trained adequately in all aspects of their work and should receive periodic refresher training.

Activate the Guam Biosecurity Task Force. The Biosecurity Task Force has been approved by the Guam Legislature as a way to increase effective prevention of the importation of IAS. The source of funding is undetermined. This task force will have a total of 30 officers; 15 from GCQA and 15 from GDOA. The task force, a major step towards increased agriculture quarantine inspections and early detection efforts, should be funded fully for the success of the program.

Establish an MCI-excepted program on Guam. The program would include USDA-APHIS-trained military personnel to augment, conduct, and coordinate with GCQA agricultural inspections of foreign military arrivals. This program would augment and improve the import process to inspect all military maritime vessels in compliance with USDA and Guam statutory regulations and authorities. These MCI personnel could receive instruction from WS to recognize invasive species. The MCI program should be initiated on Saipan and Tinian as well.

Ensure availability of necessary equipment. Equipment necessary for effective safeguarding, hand lenses, microscopes, and computers, etc., must be available to quarantine officers. X-ray machines and other appropriate scanning technology and cleaning equipment must be provided where needed. A sufficient number of cranes must be available for sea cargo container inspections. All equipment must be maintained in working order over the long term. APHIS manuals provide detailed guidance for necessary equipment.

Ensure facilities for incoming passenger and cargo inspection are adequate for necessary inspections.

- Ensure that passengers arriving at A.B. Won Pat International Airport to transit Guam cannot move restricted or prohibited agricultural or wildlife products to other jurisdictions. GCQA personnel should be stationed with DHS, Transportation Security Administration (TSA) personnel for expertise in screening transiting passengers for restricted or prohibited materials or all transiting passengers should be routed through GCQA inspection before they move to the departure area.
- Build physically secure facilities at the Port of Guam with ample warehouse space and equipment and resources required to unload cargo and conduct agricultural inspections to centralize inspection of maritime cargo. Current import practices allow imported maritime shipments to proceed to destination for inspection. There are insufficient areas within the maritime Port of Guam to offload cargo and inspect contents of sea containers. These inspection facilities must have sufficient lighting, inspection tables, and dedicated areas as specified by APHIS–PPQ to detect and identify intercepted pests on foreign cargo, and confirm the integrity of animal product and byproduct shipments. Appropriate facilities will allow agriculture inspectors to increase their skills and abilities in pest detection.
- Maintain secure areas for storage of vehicles and cargo at the air and sea facilities to prevent the dissemination of plant pests and reduce risks of cross contamination of other cargo items. Sterile staging facilities for incoming and outgoing vehicles and other cargo must be maintained at military and commercial locations.

- Build out the foreign inspection area for passenger clearance in the main terminal at Andersen AFB to a sufficient size for physical inspections of passenger baggage. The facility lacks space, lighting, and equipment (e.g., x-ray equipment, tables, and materials for collecting samples) sufficient to enable GCQA to complete all aspects of inspection.
- Ensure there are sufficient inspection facilities for express courier operations at the airport.
- Replace the garbage grinder drainage pipes with pipes sufficient in diameter (minimum of 4 inches) for effective drainage and disposal of ground-regulated materials in the new GCQA cargo inspection facility at the A.B. Won Pat International Airport.

Develop/enhance the tracking system for all cargo with unique identifiers for cargo shipments. Include an electronic system for tracking, identifying, and collecting data from manifests for containerized commercial cargo arrivals to Guam and Saipan to streamline the import process while maintaining biosecurity. This recommendation is especially necessary for cargo that originates in areas affected with significant plant and animal pests and diseases. Implement a data collection system and incorporate it into a centralized, secure system that could be modeled on the one used by CBP. Though all arriving cargo is subject to inspection, selection of containerized cargo is based on the shipping company's paper manifest that itemizes container contents (Merfalen, personal communication). The paper-based system of recording, identifying, and tracking these manifests is vulnerable to missing or lost documentation, unregulated and recurring biosecurity breaches, and omission from integration with electronic tracking. Develop MOUs with other entities to share shipping information across the region.

Ensure an adequate number of canine inspection teams to detect animals, plant materials, plant pests, and animal products and by-products. Teams should be scheduled routinely at airports, maritime ports, and the USPS mail facility for screening baggage, express mail carrier packages, and other cargo or incoming mail.

Establish decontamination sites for cleaning military and civilian equipment. Such sites must be available at all locations where military training exercises will take place and at both military and commercial maritime ports and airports. The importer bears the costs of remedial cleaning. Procedures should meet USDA-APHIS standards for soil-contaminated vehicles and equipment. Wash racks planned for the naval facility are not available at the commercial port. They should have sufficient water supply with high-pressure cleaning capability and lifts or ramps for access to undercarriage areas. Remedial cleaning must include the interior and exterior, engine compartments, and trunk areas with special attention to undercarriage, wheel wells, etc., as sites for soil, plant materials, and invasive species. Decontamination sites should have a quarantine area for storing contaminated equipment prior to cleaning. Precautions must prevent contaminated water from running off into the soil. All wash sites and decontamination systems must be effective. At a minimum follow Technical Guide No. 31, *Armed Forces Pest Management Board, Retrograde Washdowns: Cleaning and Inspection Procedures (AFPMB)*.

4.1.2 Offshore Mitigations

Establish an agricultural pre-clearance program in Okinawa, Japan, for all military equipment and other assets transferred to Guam and throughout Micronesia. The Pacific Command does not participate in any voluntary military agriculture pre-clearance program for containers, retrograde cargo, vehicles, or other assets. USDA-APHIS trains military personnel to conduct pre-clearance inspections. Shipments then would be selected randomly for inspections to monitor program efficacy. Large amounts of military assets will be moved from the closed facilities in Okinawa. Military shipments noncompliant with agriculture regulations or in need of cleaning will be refused entry or required to undergo remedial cleaning for entry requirements, leading to massive bottlenecks at the seaport. The military should support and fund this regional program similar to other Commands.

Include requirements and provisions in military and civilian contracts for the relocation to reduce the risk of introduction of animal and plant pests and diseases. Along with increased containerized cargo and vehicles, there will be substantially increased bulk shipments entering through the Port of Guam for construction and infrastructure upgrades. In addition to U.S.-origin workers and materials, other sources will include China, Japan, Korea, the Philippines, Malaysia, and Indonesia (Guam Contractors Association, personal communication). Provisions should include: 1) contractor-provided education for employees on import requirements (educational materials should include penalties [firing, pay-docking, etc.] for workers violating import regulations and should be developed collaboratively by officials who will have the greatest direct impact from the relocation [DoD, USDA-APHIS, Guam, and CNMI]; 2) contractor compliance with all import requirements [import permits, procedures at port of entry and beyond, etc.]; and 3) company-driven pre-inspection of their own materials for plant pests.

Require weed risk assessment for the importation of exotic plant species. Prohibit the importation of all plant species exotic to and not yet naturalized on Guam unless deemed unlikely to become invasive by a weed risk assessment with exceptions for plants historically imported without becoming invasive.

Require treatment of all WPM according to ISPM No. 15. All domestic and foreign, military and non-military WPM entering the Micronesia Region should be required to comply with ISPM No. 15. Even though these treatments do not fully mitigate pest risk, they help reduce the presence of wood-boring pests.

Require phytosanitary treatment of all imported timber, including timber from domestic locations to mitigate the risk of pest entry on this pathway. Required treatments should be effective in removing pests.

4.1.3 Point-of-entry Activities

Conduct agricultural inspection of arriving conveyances, military and non-military, for plant pests and animal contamination. Inspection must include a thorough search of the exterior and the interior of the conveyance for plant and animal pests and wildlife of concern. GCQA officers must be allowed to inspect military vessels as USDA-APHIS cooperators. Other jurisdictions must also have the ability to inspect U.S. DoD craft that enter their ports.

Minimize pest contamination of containers and WPM by:

- Minimizing outdoor storage
- Sealing storage site surfaces
- Keeping storage sites clean
- Controlling pests around storage sites
- Limiting use of nighttime lighting around storage sites

Treat storage areas with molluscicides or install barriers to prevent mollusks from infesting WPM and shipping containers. Remove weeds and other contaminants from container and WPM storage areas. Storage areas should be hard surface or gravel.

Conduct phytosanitary inspection of WPM. Thoroughly inspect an adequate percentage of all domestic and foreign, military and non-military WPM accompanying agricultural and nonagricultural cargo for pests. WPM must not harbor organisms. SOPs should require consistent inspection methods. All inspections and interceptions should be documented. Pest interceptions should be recorded in an appropriate database to be available for analysis that may contribute to safeguarding improvements and quality control.

Clean containers and conveyances that arrive in the Micronesia Region contaminated with soil or exotic plant pests. Follow all APHIS policies and guidelines as applicable. Evaluate the effectiveness of current cleaning methods, and improve as appropriate.

Conduct phytosanitary inspection for contaminating pests of all incoming construction materials including materials previously treated or cleaned (for recontamination after treatment) and construction material from the United States.

Properly clean all equipment (construction and military) according to APHIS guidelines prior to entry into any part of the Micronesia Region to remove hitchhiker pests and soil contaminations. Equipment must be cleaned before moving within the Micronesia Region (between countries or islands of the same country, and, where appropriate, between areas of the same island).

Adopt a local DoD-GCQA MOU to codify agreements, clarify collaborator roles, and establish protocols and procedures for military vessel and cargo inspections. GCQA must be allowed to monitor military ships to fulfill responsibilities under USDA regulations and authorities agreed upon with USDA-APHIS.

Improve detection methods for rodents and other wildlife on vessels and in cargo. Rodents and other wildlife have been implicated in the transmission of zoonotic diseases. Methods may include trapping, monitoring for signs, etc. Rodent detection methods are not well developed and other wildlife detection methods have not been well documented. NAVMED P-5010-8, the Naval Manual of Preventative Medicine, Chapter 8, Navy Entomology and Pest Control Technology (U.S. Navy BMS 2004) outlines preventive measures for rodent control on ships, including proper sanitation, pier side inspections, rat guards, illumination and movement restrictions, glue boards, snap traps, and limitations on vessel access points.

Inspections are constrained by resources to only a portion of air freight conveyance crates and containers. Air cargo conveyance crates and containers tend to be inspected if shipments are labeled as containing agricultural products, have insufficient or improper documentation, or are from a country of concern. Standardized methods similar to the APHIS-PPQ Agriculture Quarantine Inspection Monitoring Program are needed for random container searches regardless of documentation, type of shipment, or country of origin. Allocate funding to increase the number of containerized and crated air cargo shipments to be inspected. Paperwork for air cargo shipments arriving in crates and containers should be automated for more rapid selection of containers to be screened and for new avenues for implementing pre-clearance procedures.

Mandate and enforce regulations for handling palletized cargo. Contamination can occur during the packing, handling, and staging processes prior to arrival as imported cargo or after arrival when staged for loading for inland transport. Optimally, packers should handle and pack cargo items individually, especially those of high risk. Mandate and enforce regulations for palletized cargo, including procedures for labeling, packing, and transport prior to arrival and for eventual staging and loading for inland transport after arrival. Personnel must be trained in identifying high-risk cargo and handling it to reduce contamination. The likelihood of visually detecting species in complexly combined cargo is lower than in cargo with few hiding places, especially for BTS detection by canine inspection teams.

Enhance collaboration between USFWS and GCQA. GCQA and other agencies with port-of-entry inspection responsibilities should work with USFWS to increase the effectiveness of interdiction capabilities and inspections for wildlife and their products at the ports of entry to prevent the introduction of animal and zoonotic diseases.

4.2 CARGO

Agencies responsible for enforcing USDA-APHIS regulations should have access to the APHIS ePermits system for assistance in clearance of restricted agricultural materials. APHIS import permits may be required, in conjunction with local import permits, for various agricultural commodities imported into Guam and CNMI. All officers acting under an MOU with APHIS inspecting for agricultural commodities need access to the ePermits system to validate APHIS import permits presented with incoming shipments.

Inspections are constrained by resources to only a portion of air freight conveyance crates and containers. Air cargo conveyance crates and containers tend to be inspected if shipments are labeled as containing agricultural products, have insufficient or improper documentation, or are from a country of concern. Standardized methods similar to those of the APHIS-PPQ Agriculture Quarantine Inspection Monitoring program are needed for random container searches regardless of documentation, type of shipment, or country of origin. Allocate funding to increase the number of containerized and crated air cargo shipments to be inspected. Paperwork for air cargo shipments arriving in crates and containers should be automated for more rapid selection of containers to be screened.

Construction and other commercial equipment must be inspected, cleaned, and washed down at the port of entry, and military aircraft and other military vehicles arriving as maritime cargo must be inspected, cleaned, and washed down at a retrograde wash facility before entry. Washdown procedures for military vehicles should target soil, plants, insects, and other wildlife. Tracked vehicles can be cleaned on shore only if they can be reloaded without recontamination of the treads; otherwise they must be cleaned on the ship's well-deck. They should be cleaned to USDA-APHIS standards (USDA-APHIS-PPQ Treatment Manual 2008) prior to shipment from the port of departure. Vehicles may be cleaned at the port of entry provided wastewater soil is collected and drained fully into an approved collection system.

4.2.1 Live Animals

All health certificates and necessary permits should accompany imported livestock, poultry, and other animals. Make sure the animals are subject to health inspection by the territorial veterinarian and quarantined as required.

4.2.2 Animal Products and By-products

Require the use of USDA or GDOA VS import permits or for restricted animal products.

4.2.3 Plant Products

Standardize methods and implement the random inspection of air cargo containers regardless of documentation, type of shipment, and country of origin. Paperwork for air cargo shipments arriving in crates and containers should be automated for more rapid selection of containers to be screened, and for new avenues for implementing pre-clearance procedures.

4.2.4 Propagative Plants

There should be sufficient equipment and supplies at the Plant Inspection Station for the full range of necessary inspections. Processes and equipment should provide for intensive inspections for insect, plant pathogen, foreign weed seed, and invasive plant detection in propagative plant shipments.

4.2.5 Wood Packing Material

Re-export or treat infested or noncompliant WPM. Non-compliant and infested WPM should be treated as regulated garbage; if not re-exported it should be incinerated or sterilized. Chipped WPM may present a pest risk when the chips are re-used or improperly disposed.

4.3 MAIL

Follow a model similar to that established in Hawai'i by utilizing detector dogs for establishing probable cause for inspection of first-class (domestic) USPS packages.

Use appropriate x-ray technology for all foreign-origin mail. Ensure that all x-ray equipment is in working order and operable.

PPQ should work with CBP and the Hawai'i Department of Agriculture for an adequate level of inspection in Hawai'i.

Establish effective working relationships between customs officials, agricultural officials, and USPS personnel in Guam so safeguarding personnel can carry out their responsibilities. Guam safeguarding personnel must have sufficient access to the postal facility to conduct appropriate biosecurity screening at all times. This could be modeled after the USPS policies in Hawai'i. The USPS in Hawai'i granted U.S. Customs officers and canine full access to the facilities to perform all inspection activities while international mail is being processed or is in the facility. While domestic mail is being processed or is in the facility in Hawai'i, USDA PPQ officers and canine have full access to the mail to perform all inspection activities.

Develop secure procedures for opening international mail without customer witnesses.

Record and analyze data on pest interceptions in mail. Analysis should improve targeting of phytosanitary and general sanitary hazards.

4.4 REGULATED GARBAGE

Consider construction of a waste-to-energy facility on Guam. The current landfill is not EPA-compliant. The future landfill will have only an estimated 30-year capacity with the increased military presence (Cruz 2010). A waste-to-energy facility will incinerate garbage, reduce the need for landfills, reduce the exposure of the environment to agriculture diseases and pests, and provide electricity to a significant number of households. Such a facility would serve as back-up processor of regulated garbage if other equipment is inoperable.

Appropriate disposal mechanisms should be in place before training on Tinian and other locations begins. Each location should have mechanisms to dispose of garbage generated on-island as well as regulated garbage from other locations. The Tinian incinerator should be repaired ASAP since periodic DoD training has already started there. The incinerator owned by the Tinian government is currently inoperable, the overfilled local dump was ordered closed previously, and the military is not authorized to use facilities approved by EPA. Transporting garbage generated during DoD training events violate APHIS regulations over movement of regulated garbage between U.S. possessions (9 CFR § 94.5, 7 CFR § 330.400-403).

DoD should consult with PPQ or local governments so they institute appropriate mitigations for handling regulated garbage in compliance with APHIS and local regulations. Collaboration with appropriate officials of Tinian or of any U.S.-affiliated country should ensure that proper (land-filled, sterilized, or incinerated) on-island disposal can be achieved. Military activities are currently not compliant with appropriate measures for handling regulated garbage. Some of the known issues which need to be addressed include:

- The use of sterilizing equipment without automatic temperature/time recording devices.
- Failing to use appropriate containers to move regulated garbage.
- Authorizing dumping of pulped-food waste within 12 nm of the coast of Guam and other U.S. territories and affiliates.
- Planning to move garbage generated during training on Tinian to Guam or Saipan.

begins.

Unannounced monitoring of APHIS-regulated garbage compliance agreement holders should be conducted at least quarterly. Appropriate agency representatives must be trained to conduct enforcement visits to compliance agreement holders to monitor whether they follow required procedures.

Include specific information in the Port Authority of Guam Master Port Plan to address equipment and other resources needed to handle regulated international garbage properly. There is nothing in the Guam Master Port Plan addressing resources and equipment required to handle regulated international garbage.

Enforce current swine health protection regulations requiring cooking of certain types of food waste (heating to an internal temperature of 212°F for 30 minutes) before feeding to pigs. The proper cooking of food waste will prevent the dissemination of foreign animal diseases of concern (9 CFR § 166).

Consider all garbage within the passenger sterile area for incoming and transiting passengers at the A.B. Won Pat International Airport to be regulated garbage. Food, food materials, and other prohibited and restricted agricultural and wildlife materials discarded in sterile area receptacles and bathrooms are handled as routine trash. These materials go to the local dump without mitigation and can present a significant risk with increased numbers of temporary workers on Guam. This garbage should be removed and processed under USDA compliance agreements.

4.5 EXPORT

Preferentially load conveyances in a way that minimizes pest entry whenever possible. For example, avoid night-time loading because the lights attract insects. Workers should be trained in and cognizant of pest conditions at all times.

Provide a pre-clearance staging area for all military vessels requiring immediate departure from Guam.

Coordinate USDA-APHIS agreements with commercial air cargo shipping agencies to prevent invasive species transportation. Despite high levels of cooperation by most cargo export entities, APHIS-WS still makes regular discoveries of previously unknown cargo handling processes or companies, and there are several private companies on Guam that refuse to provide information on or access to outbound cargo for inspection purposes. Coordinate agreements and procedures with air cargo shipping agencies for handling cargo, including packing, over-land transport, cargo-staging, palletizing, canine inspection, and final loading.

4.6 REGULATIONS, GUIDELINES, AND COMPLIANCE

Systematically review all guidelines and SOPs of agricultural relevance so they are clear, complete, detailed, and in compliance with appropriate laws and regulations. Develop guidelines or SOPs where lacking.

Put appropriate local and federal regulations in place to carry out biosecurity measures to prevent the introduction of plant and animal pests and diseases. Regulations should support the issuance of penalties and fines to enforce compliance.

Utilize the APHIS-PPQ port manuals as guidance in locations with APHIS cooperators as appropriate. The manuals contain information on port operations and commodity regulatory decision making designed to enhance biosecurity at the ports of entry.

Revise and update all military guidelines and SOPs for compliance with APHIS regulations where appropriate. In some cases, the military uses outdated guidance with inaccurate information. For example, the OPNAVINST 6210.2 lists only the States, District of Columbia, Guam, Puerto Rico, and the U.S. Virgin Islands as the U.S., notably excluding the CNMI and American Samoa (7 CFR § 330.400[a] and 9 CFR § 94.5[a]). The NAVFAC Guam Program Management Office/PSC 15 Jan 2010 *Summary of Navy Pollution Control Discharges Restrictions* authorizes the discharge of garbage containing pulped or comminuted food within 3 to 12 nm of the coasts of Guam and the CNMI. This instruction is accurate in only very specific situations; much of this garbage is regulated by USDA for agricultural issues.

The military should execute an MOU with all Micronesian countries and develop appropriate agricultural disease exclusion and invasive species SOPs for compliance when conducting activities in their respective countries. The U.S. Navy has a Seabee unit stationed in the Republic of Palau. How much this unit will participate, if at all, in the military relocation is unknown. Military officials do not inform Palau quarantine officials when aircraft arrive, leave trash for government officials to destroy, and drop cargo and supplies for Palau construction projects. Equipment is washed on the tarmac without proper drainage facilities.

Develop BMPs for contractors and construction sites. Work with industry to gain support preventing the introduction and spread of exotic plant pests. Implement “clean” practices at construction sites to minimize land disturbance that spreads plant pests.

Adopt a voluntary code of conduct for nurseries, landscaping companies, hotels, and other businesses as appropriate to promote the sale and use of native and noninvasive plants. This code of conduct should encourage businesses:

- To make their staff knowledgeable about invasive plants.
- To inform their customers about invasive plants.

- To report immediately any likely exotic pest organisms found on their premises.
- To use native or noninvasive plants locally sourced.

Revise the DoD landscape plan by removing plant species with the potential to be invasive in the Micronesia Region or Hawai'i. Request technical support from the University of Guam as appropriate.

4.7 TRAINING

Provide adequate information about the potential adverse consequences of the introduction and establishment of plant and animal pests and diseases and ways to prevent their spread. Provide a list of enterable and prohibited materials. Create awareness of the potential legal consequences of violations. Inform people how they can contribute to exotic species-prevention efforts. Alert the following groups: 1) military personnel and dependents; 2) nonmilitary workforces; 3) tourists; 4) the general public; and 5) private industry.

Provide training to increase inspection and identification expertise. Safeguarding inspectors (both civilian and military) should receive regular adequate training in proper techniques for detecting, collecting, recognizing, and identifying pests. A communication network for continuous sharing of new information is recommended.

Provide specific and detailed guidance to military personnel on how to inspect clothing and personal effects for plant pests.

Enhance training for military personnel and their dependents about phytosanitary and general sanitary regulations and the risks of sending or receiving agricultural and wildlife materials in the mail.

Train inspectors specifically on livestock, wildlife, and poultry diseases and pests.

Train appropriate agency representatives to conduct enforcement visits to APHIS Compliance Agreement holders handling regulated garbage. The number of personnel trained to monitor compliance agreement holders for functional equipment and appropriate procedures in handling regulated garbage is insufficient.

Develop a wildlife reference collection (i.e., taxidermy mounts or computer photo files with APHIS-WS) to aid identification of incoming species. Adequate resources (taxonomic keys, microscopes, etc.) should be available for assistance in taxonomic identifications.

4.8 EDUCATION AND OUTREACH

Develop education and outreach programs to inform the public and the military about the potential harmful effects of animal and plant pests and diseases with emphasis on consequences of smuggling animals and agricultural products. Provide adequate information on ways to prevent the spread of plant and animal pests and diseases. Provide reports and newsletters to educators, journalists, lawmakers, and business and community leaders; develop curricula for local schools; provide lists of enterable and prohibited materials; place posters in private and public mail facilities; and conduct a pre-education survey of residents and other stakeholders to gauge their understanding of animal and plant pests/diseases introductions/invasions and subsequent impacts. Create awareness of the potential legal consequences of violations. The following groups should be included: 1) military personnel and dependents; 2) nonmilitary workforces; 3) tourists; 4) the general public; and 5) private industry.

Inform temporary workers about the consequences of carrying, mailing, or receiving restricted and prohibited agricultural and wildlife commodities or live organisms by working with contractors and other organizations hiring temporary foreign workers. Coordinate with contractors employing migrant workers and with overseas employment agencies for migrant workers. Communicate the reasons for prohibiting these materials in the Micronesia Region, including the potential loss of business if invasive species are introduced to Guam and other Micronesian Region locations.

Develop voluntary agreements between Guam government officials and pet stores and other businesses in the pet trade industry to curtail smuggling and create safe avenues for import (i.e. no imports or sales of prohibited animals or plant pests).

4.9 MONITORING, SURVEILLANCE, AND ADDITIONAL SAFEGUARDING PRACTICES

Conduct background surveys as soon as possible to establish baselines for plant pests and livestock and wildlife populations and diseases. Initial measures to prevent introduction of livestock, poultry, and wildlife diseases should be implemented with a surveillance and monitoring strategy to determine whether measures perform adequately. These measures then should adjust to improve biosecurity.

Develop a biosecurity surveillance system for improved data collecting, reporting, and information sharing. A paucity of information is available to fully assess risks from intentional and unintentional movements of animal and plant pests and diseases posing significant risks to biosecurity efforts in the Micronesia Region and Hawai'i. A biosecurity surveillance system could serve as an early detection program for plant, animal, and zoonotic pests and pathogens emerging in Pacific Rim countries. Sustained surveillance and record keeping of interceptions will facilitate tweeking biosecurity mechanisms to reduce future incursions ultimately decreasing risks from varying threats and changes in the ways cargo and people are moved in the future.

- A well-documented process of pest and disease prioritization, surveillance, data collection, and record keeping must be followed. The system should include routine surveillance for wildlife, livestock, and poultry diseases and vectors as well as plant pests.
- Specific surveillance methodology should be appropriate for target species, (i.e. modifying sampling programs to account for behavioral differences in diurnal and nocturnal lifestyles). Utilize systematic surveillance for plant pests following the model of the Cooperative Agriculture Pest Survey (CAPS), and include both military and civilian properties as appropriate.
- Such a system should improve communications of survey results among all island mitigation programs. The communications plan will allow GCQA and other responsible biosecurity

authorities to react to changing risks posed by travelers and cargo based on countries of embarkation or origin.

Encourage and participate in actions to preserve biodiversity.

Include actions taken by joint agency collaborations like the Micronesia Challenge and the Micronesia Regional Invasive Species Council.

Conduct periodic surveys of ethnic markets, pet stores, and grocery stores to identify and intercept prohibited animals and animal and plant products following the model of the USDA-APHIS-PPQ Smuggling, Interdiction and Trade Compliance program.

4.10 OVERSIGHT

Centralize biosecurity efforts for maximum effectiveness. A central group acting as a liaison can bridge gaps between formal and informal and military and civilian communications. A central group would outline the current network of biosecurity communications in the Micronesia Region; find communication gaps; publish information in appropriate formats for public, private, and military sectors; and issue media and news releases on biosecurity.

Establish a Pest Risk Committee with participants from various agencies and organizations responsible for managing exclusion and control efforts at the ports of entry. This group could function as the operational arm of the larger regional biosecurity group.

4.11 EMERGENCY RESPONSE

Develop a hazard response plan for animal and plant pests with all entities responsible for these activities. Include military and civilian public health authorities for diseases with serious animal health and zoonotic potential.

Improve rapid response capabilities at military and commercial airports on Guam and the CNMI Islands of Saipan, Tinian, and Rota. Rapid response measures prevent establishment of introduced pest species. Rapid response takes place at and within the border at levels ranging from federal to local community involvement. Review the current process for rapid response to border and post-border detections and unconfirmed reports or sightings.

Improve rapid response capabilities at military and commercial airports on Guam and the CNMI Islands of Saipan, Tinian, and Rota.

Conduct practice drills to hone response skills and test communications.

4.12 CONCLUSIONS

The scope of the MBP is to describe mitigation recommendations sufficient to prevent and mitigate risks posed to human health, animal and plant health, economies, and ecologies of the Micronesia Region from the intentional or accidental spread, introduction, or establishment of terrestrial animal and plant invasive species and diseases as a result of proposed military activities. Guam must be emphasized because the proposed military activities are focused there. Prevention of both the introduction of invasive species to Guam and the transport and spread of BTS from that island are the broad objectives and priority concerns. Guam is a transportation gateway for the rest of the Micronesia Region, facilitating the wide-spread movement of species.

Risks of the introduction of invasive species and diseases to Guam and the Micronesia Region are diverse. Plant propagative material may present phytosanitary risks as either a pathway for introduction of exotic plant pests or as an invasive species. Increased importation of plant propagative material during the military relocation may increase the risk of pests entering the Micronesia Region. The current DoD landscape plan may facilitate the spread of potentially invasive plants. Increases in plant propagative imports as a result of the military relocation will place increased demands on customs staff and infrastructure resources and may allow more pests to enter the Micronesia Region.

The introduction of many of the livestock and poultry diseases considered in this risk assessment could have major consequences to animal and human health throughout the Micronesia Region and far-reaching impacts on trade in the rest of the U.S. With the arrival of increased numbers of pet dogs and cats, current resources for inspection and follow-up could be overwhelmed. There is no ongoing surveillance for livestock and poultry disease on Guam; therefore, it is difficult to know what disease agents are already in the region and to detect the introduction of an exotic disease agent. Lack of a diagnostic laboratory in the region also diminishes the ability to detect disease agents. Rapid detection is critical to timely responses to new disease introductions, especially with the highly transmissible exotic diseases considered in this assessment. The potential for importation of zoonoses that pose major public health threats warrants increased surveillance for imported wildlife in the United States and Micronesia.

Safeguarding Guam and the Micronesia Region during the military relocation is challenging with the number of pests continuously approaching their shores. While federal, territorial, and military regulations aim to mitigate effects of the introduction of hazards, the estimated increase in population and goods from the military relocation will strain current capacity for inspection and interdiction of illegal goods, and increase the likelihood of invasive species throughout the region. There is reason to believe that Guam’s biosecurity protection systems and resources may be overburdened and underfunded and therefore not sufficient to inspect cargo, passenger baggage, and conveyances appropriately during the military relocation.

The challenges, risks, and costs of long-term control and eradication of an established invasive species could be significant. The most cost-effective approach to protecting natural and agricultural resources on Guam and throughout the Micronesia Region is prevention and early detection.

5 OUTREACH

To reduce the demand on protection program resources, an outreach program should increase awareness of risks from the introduction of invasive species, pests, and plant and animal diseases throughout the Micronesia Region. In support of outreach, a comprehensive training program should be developed to increase awareness of risks and consequences to agriculture, human health and safety, the environment, and the economy from the transport of potentially invasive plant and animal pests, diseases, and species to Guam and the other Micronesian Region islands.

5.1.1 General Outreach Program

The outreach program should include awareness and prevention training in sources, activities and conveyances (pathways). Knowledge of certain high-consequence or high-probability animal and plant types or species is essential to reduce the frequency of personnel, equipment, and cargo transport of infective or invasive species on conveyances within the Micronesia Region.

5.1.2 Strategic Plan

A strategic plan should be developed to set objectives, design components, assign roles, determine costs, and integrate outreach planning with the biosecurity plan leadership.

5.1.3 Target Groups

The outreach program should target the following audiences:

- Military personnel and dependents relocating to the Micronesia Region
- Local government entities
- NGOs
- Guam and other Micronesian Region residents
- Foreign contractors and temporary workers
- Agents of commercial airlines
- Owners of shipping, fishing, and recreational craft
- Local businesses (e.g. pet stores and purveyors of specialty foods)
- Community associations
- Schools and universities
- Visitors to the region

5.1.4 Program Components

All components of the outreach plan should be well-defined, including:

- Publishing a regular schedule of outreach events.
- Scheduling locations or venues for outreach events that are convenient for the target audiences.
- Formalizing a message development process for high-risk species and their pathways.
- Developing information delivery systems for print media (newspapers, periodicals, posters, handouts, etc.), television, radio, and the Internet.
- Developing a mechanism for outreach communications to military personnel.

5.1.5 Measures of Program Efficacy

A method of measurement should gauge the effectiveness of the outreach program. This metric could be determined in many ways specific to outreach program objectives. Each outreach event should keep a record, tracking participating organizations, venues, topics covered, and any lessons learned. This information should be analyzed to re-evaluate and re-target the outreach program content, format, venues, and audience as needed.

Suggestions for general metrics to measure program effectiveness:

- Number of outreach events
- Number of individuals or organizations reached
- Number of individuals or organizations participating in program events
- Number of reports from outreach targets of suspicious animals or plants
- Number of ancillary education or outreach programs developed by governments, businesses, schools, community organizations, and citizens

5.2 ORGANIZATIONS AND ROLES

A planning and coordinating body for each jurisdiction of Micronesia and Hawai'i should be designated to direct and manage outreach activities. Every organization with a stake in the biosecurity of the Micronesia Region and Hawai'i should engage in the outreach planning process. Existing programs should be leveraged wherever feasible. For example, the Office of Economic Adjustment and the Military Integration Management Committee conduct community outreach dialogue sessions on Guam, the CNMI, and other locations to hear citizen concerns. Such organizations could expand their charters to formal outreach and awareness programs using established educational materials. Another good example is that of the regional response team which has been conducting outreach on IAS in all jurisdictions (except Hawai'i) for 10 years. RISC as a regional IAS council for Micronesia should also be involved in this development process.

5.3 FUNDING RESOURCES

In accordance with planning, managing, and reporting outreach activities, a contracting officer and an oversight committee are necessary to develop a source of funding. The primary stakeholders, such as the U.S. military, Guam, and other Micronesian Region islands, should determine appropriate funding sources for a comprehensive outreach program. Potential increases in current user fees or new fees could be imposed on permitted imports. Legislatively appropriated funds could be utilized for these activities. The justification for this legislation is that outreach efforts would be effective long-term prevention campaigns.

5.4 MICRONESIAN REGION AWARENESS TRAINING AND OUTREACH:

The outreach program should involve biosecurity partners throughout Micronesia. A representative body should coordinate outreach programs among sovereign nations for each of these programs.

A comprehensive and continued information program on identification and potential impacts of invasive plant and animal species in Guam should be developed. The information in this program should target: residents, visitors, military personnel, businesses, governments, and associations throughout the Micronesia Region.

The program should provide information through the distribution of printed materials that show examples of how various released species can become economic, ecologic, or human-health threats. Schools should be target audiences to educate children on the importance of preserving natural ecosystems.

A person or organization should be designated as responsible to the Government of Guam (GovGuam) for developing high-priority outreach messages about invasive species and their pathways. GCQA, GDOA, and the Guam Invasive Species Advisory Committee are candidate organizations.

Topics should be highest-rated risks as determined by probability of introduction and level of impact. Suggested biosecurity topics include:

- Import and export requirements
- Precautions in traveling to Guam and other Micronesian Region islands
- Recognition and reporting of BTS and other invasive species
- Risks from domestic and international mail
- Proper handling and disposal of regulated garbage
- Pre-inspection of cargo for shipment
- Procedures for reporting sudden deaths in wildlife
- Personal sanitary precautions—washing shoes, cleaning vehicle tires, and checking for invasive species and wildlife of concern
- Reports of illegal movement of restricted agricultural commodities or invasive species
- Reports of observed incidents of invasive species on Guam and other Micronesian Region islands

5.5 OUTREACH METHODS

5.5.1 Training

Official sponsors who assist with relocation of military personnel should be designated and trained per regulations on the movement of animal and plant products. Designated sponsors should work with contractors and temporary workers to identify potential introduction pathways and reduce risks of transporting invasive species wherever possible.

5.5.2 Educational Materials

Educational materials for the outreach program could include reports and newsletters to educators, journalists, lawmakers, and business and community leaders; curricula for schools; and a pre-campaign poll of island residents to gauge levels of awareness of species introductions/invasions and subsequent impacts. Educational materials should portray the hazards of the import of illegal animals and plants and their products and by-products. Information should be posted in public locations in USPS mail and express courier facilities to inform customers of the potential economic and environmental impacts of exotic plants and pests.

The education program should focus on the dangers of maintaining populations of invasive species for food or sport with examples of potentially invasive species (e.g., rabbits, banteng, water buffalo, Polynesian rat, spotted turtledove, water frogs, African snails).

5.5.3 Outlets and Media

The following outlets and media should disseminate essential outreach information and answer questions and concerns about the risks of invasive species:

- Meetings in local communities
- Radio and television public service announcements
- Newspaper articles
- Websites (e.g., military, local governments, and federal government) that address restrictions and regulations on movements of animals and plant materials

5.5.4 Monitoring

A response network should be developed for community members to report incidents of illegal sales (independent or retail), illegal releases of plants or animals, and invasive species sightings. Community monitoring efforts should be aligned with those of local governments in a formal monitoring and surveillance plan (see Chapter 9, *Monitoring and Surveillance Plan*) to enhance biosecurity efforts.

5.5.5 Incentives

Incentives to participate in an outreach program should be explored. For example, state or local governments could offer tax incentives or preference points for municipal projects, trade agreements, or monetary awards. These measures would be codified in public proposals that solicit Micronesian projects, reducing the burden on other funding sources.

Nonprofit organizations and higher-learning institutions promoting outreach programs could receive direct grants. Private industries that initiate an awareness and education program could receive tax advantages or preferential consideration for government contracts. Outreach to trading countries could be on the terms of trading or shipping agreements. Local governments could receive direct grants or reductions in financial obligations to the state government.

6 MONITORING AND SURVEILLANCE

6.1 INTRODUCTION TO MONITORING AND SURVEILLANCE

A Micronesian Region monitoring and surveillance program is important to improve efficacy in detecting the occurrence of foreign animal and zoonotic disease and plant pest introduction on Guam and other Micronesian Region locations. The RA recommends establishment of specific baseline monitoring for each program.

The monitoring plan should select specific locations and conveyances of potentialintroduction of high-risk or high-probability invasive species. A surveillance plan should present methodologies to collect and analyze data leading to action taken to prevent and control the introduction and establishment of invasive species. The plan should describe the strategies, resources, and methodologies that should be developed and applied to manage a monitoring and surveillance program for high-consequence or high-probability risk pathways and species.

USDA-APHIS-PPQ promulgates standards for plant pest and disease monitoring. For current information on survey protocol for specific pests, please consult the USDA-APHIS-PPQ Domestic program manuals at: http://www.aphis.usda.gov/import_export/plants/manuals/domestic/index.shtml.

6.2 OBJECTIVES

Objectives for a Guam and Micronesian Region monitoring and surveillance program include the following:

- Develop a comprehensive biosecurity surveillance system for an improved data collection, reporting, and sharing network.
- Conduct periodical surveys of markets and pet shops to intercept prohibited animals and plants and their products.
- Implement pest survey programs for the early detection of pests from imported fruits and vegetables, WPM, garbage, and construction materials.
- Augment surveillance measures and equipment at military and commercial airport and harbor ports-of-entry.
- Inspect imports randomly (e.g., cargo containers) for plants, plant pests, insects, disease agents, and wildlife.
- Develop a system of routine systematic surveillance for livestock and bird and poultry diseases and vectors.
- Work with the military for access to military sites and activities to monitor for pest conditions.
- Establish standards for surveillance reports and systems to manage surveillance data.

6.3 COMMUNICATIONS SYSTEM

All organizations and offices associated with Guam and Micronesian Region monitoring and surveillance programs should establish a communication system for pest surveys, outreach programs, port inspections, and pest identifications. A SOP should be developed for communication with rapid response teams (Chapter 10, *Rapid Response Plan*). The communications plan should allow PPQ, GCQA, GDOA, and other authorities responsible for inspection and identification to react to changing risks based on countries of origin of arriving travelers.

6.4 MONITORING AND SURVEILLANCE PLAN

6.4.1 Regulations

APHIS and Guam regulations justifying a monitoring and surveillance program include:

- AHPA
- PPA
- NEPA, 42 U.S.C. § 4321 et seq.
- AWA
- WBCA
- GARR Titles 8, 9, and 10
- GDOA, 5 GCA § 60108
- APHIS plant health regulations (7 CFR)
- APHIS animal health regulations (9 CFR)

6.4.2 Scope

The plan objectives should determine the scope of monitoring and surveillance activities. Ideally, a regional monitoring and surveillance program should be integrated closely with each location's biosecurity program. The regional monitoring and surveillance organization should serve as a communication network, rapid response resource, and information source for identifying and reporting potential invasive species incidents.

6.4.3 Organization/Roles and Responsibilities

A coordinating body should be designated to plan and direct all monitoring and surveillance activities on Micronesian Region locations and this body should coordinate closely with similar authorities in Hawai'i (as well as other locations which are linked to Micronesia by trade and/or human transport). Roles and responsibilities for the Micronesian Region monitoring and surveillance program should be identified and described and responsible parties designated according to program expertise. Individuals from across the biosecurity spectrum should participate in the monitoring program. At a minimum, each organization should reach out to the public. RISC, jurisdictional ISC, and a regional ISC would be the most likely components of this regional coordination body. Most jurisdictions already have IS councils which could feed information via their ISC to the RISC which in turn would support and guide the regional ISC who could then serve as the main point of contact with Hawai'i and other locations regarding IAS issues for Micronesia.

6.4.4 Identification of Target Species and Pathways

High-risk species and pathways should be priority targets for monitoring and surveillance. The APHIS Terrestrial Risk Assessments in Appendix A identify these pathways and targets.

6.4.5 Monitoring Methods

Local governments should determine monitoring methods including SOPs, according to the threat and in conjunction with each technical program area such as plant (APHIS-PPQ), agricultural animal (APHIS-VS), and wild animal (APHIS-WS). These methods should be integrated into a comprehensive monitoring program that leverages resources and aligns strategies across risk groups.

6.4.6 Locations/Schedules

Appropriate governmental entities should select high-priority surveillance locations. Monitoring activities should be based on current APHIS risk assessment data and recommendations associated with special-risk military operations and training events.

6.4.7 Resources

Sources for critical funding, personnel, equipment, and materials should be ascertained. Offices to determine resource needs, coordinate resource requests, and manage resource allocation should be established. A monitoring and surveillance coordinating body should take the lead in requesting needed resources.

6.4.8 Reporting

Reporting procedures for detections of invasive species through monitoring or surveillance programs are unique to each program area. See Chapter 10, *Rapid Response Plan*, for details.

6.5 CURRENT APHIS AND GUAM MONITORING AND SURVEILLANCE PROGRAMS

A monitoring and surveillance program should leverage existing programs of this type wherever possible. On Guam and in the CNMI, current ongoing monitoring activities are limited to BTS and plant pests. These programs can serve as foundations for a more extensive and far-reaching monitoring program for Guam and other Micronesian Region locations.

All current monitoring and surveillance programs should be enhanced. At this time, there is no ongoing systematic surveillance of livestock and poultry on Guam, an inadequacy that may hinder early detection of any introduced agricultural hazard.

APHIS-WS conducts the following disease monitoring programs in the United States:

Feral Swine Diseases. The National Wildlife Disease Program (NWDP) operates in management, research, surveillance, emergency response, education, and outreach for feral swine diseases. NWDP considers these animals, weighing up to 181 kg (400 pounds), non-native to the United States and invasive. They can be reservoirs of disease and can be hosts to a number of parasites threatening the U.S. domestic swine economy.

HPAI. Avian influenza is a Type A influenza virus found in some species of waterfowl and shorebirds. A particularly dangerous set of subtypes of this virus, called HPAI, is of particular concern for its potential impact on wild birds, domestic poultry, and human health if introduced into the United States.

Plague. Plague is a disease of concern to human, wildlife, and domestic animal populations within the United States.

Tularemia. Tularemia is a disease of concern to human, wildlife, and domestic animal populations within the United States.

6.6 NATIONAL MONITORING PROGRAMS

No national animal monitoring programs are current on Guam or other Micronesian Region islands. There are several programs that could serve as models for surveillance. The National Animal Health Monitoring System Program Unit conducts studies on health management of U.S. domestic livestock and poultry. Reports are available for aquaculture, beef cow-calf, beef feedlot, dairy, equine, food safety, goat, poultry, sheep, and swine. The National Animal Health Surveillance System is a program for animal health surveillance through ongoing systematic collection, collation, analysis, and interpretation of data and dissemination of information about animal health risks.

If opportunities such as on-island slaughterhouse operations arise, passive surveillance (e.g., sampling animals at slaughter for foreign and domestic animal diseases) should be conducted.

CAPS is a USDA-funded program that operates through cooperative agreements with state agriculture departments and universities. The CAPS program manages a plant pest list derived from a national survey committee through input from regional and state committees with support from leading scientific and regulatory specialists. CAPS uses a scientific system for prioritizing pests of significance to U.S. agriculture and the environment. The Global Pest and Disease Database system contains information for pest risk assessments. CAPS produces federally funded domestic surveys conducted by cooperators from National CAPS for plant pests, biological control agents, and weeds and provides a means of detection, documentation, and rapid dissemination of this information. Survey information is available from the National Agricultural Pest Information System database.

Domestic pest detection and survey activities traditionally have trapped exotic fruit flies and tracked occurrences of imported fire ants, gypsy moths, Japanese beetles, and witchweed. Other activities have been national surveys on various exotic plant pests, diseases, and weeds and some pest detection activities to help meet various export requirements of foreign countries.

The systems, methods, and resources of these programs could be applied to monitoring and surveillance on Micronesian Region islands. The monitoring and surveillance coordinating body should consult with APHIS experts to determine the feasibility and value of including Micronesian Region islands in these programs.

7 RAPID RESPONSE

A rapid response plan describes a formal process recommended for responses to reports of invasive species or animal disease outbreaks on Micronesian Region islands and the state of Hawai'i. This plan should identify authorities, policies, roles, resources, and procedures required for effective management of all plan components. A rapid response plan gives detailed guidance for awareness of potential invasive species and pathways; detection and identification of species or disease; deployment and management of resources; and reports to appropriate APHIS, Guam, and Micronesian Region authorities. The response plan should direct personnel in how to eradicate invasive populations when discovered through port inspection, reported through monitoring or surveillance programs, or established in a new Micronesian Region location.

Each plant or animal program should develop its own rapid response plan based on existing program policies, response structures, and procedures. Chapter 10, sections 10.9, 10.10, and 10.11, present information on emergency management and response processes developed for PPQ, VS, and WS, respectively. The plans, programs, systems, and resources described in these sections are included in this section as models and resources for invasive species emergencies on Micronesian Region islands and the state of Hawai'i.

APHIS has described emergency management structure and process in its Agricultural Health and Homeland Security Emergency Response Integration Plan (Volume 1, January 2007) developed by the APHIS Emergency Management Leadership Council, which provides guidance for rapid response plan development (http://www.aphis.usda.gov/emergency_response/downloads/APHIS%20Emergency%20Integration%20plan%20final%202-1-07.pdf).

All Guam and Micronesian Region rapid response organizations and offices should establish a communication system and an SOP for incident reporting and rapid response.

7.1 RAPID RESPONSE OBJECTIVES

The primary objectives of the Micronesian Region Rapid Response Plan include the following.

- Community outreach and education is the most important part of any ED/RR effort. Without community engagement and education there will be nothing to respond to. The local communities are the eyes and need to be the reporters for potential invasive species incursions.
- Develop an emergency response plan or ERP in collaboration with appropriate stakeholders to mitigate, contain, and/or eradicate significant animal or plant pest and disease outbreaks with appropriate coordination. ERPs already exist in all jurisdictions for alien snakes and some jurisdiction have additional ERPs for other species, for example Yap has an ERP for Rhinoceros Beetles. These existing ERPs can be utilized to develop more generic ERPs for each jurisdiction.
- Support local rapid response teams for pest issues (most jurisdictions already have at least some staff which are trained and/or on standby for response actions).

- Improve rapid response capabilities at military and commercial ports on Guam, the CNMI, Hawai'i, Palau, Yap, Chuuk, Kosrae, Pohnpei, and the Marshall Islands.
- Expand the communication network system among responding agencies and groups for detection and reporting of suspected invasive plant, animal, and insect species and diseases of concern.
- Coordinate monitoring and surveillance programs with rapid response capability through community-watch groups and a pest species hotline to report sightings immediately. Most jurisdictions already have hotline such as the Pest hotlines for Guam and Hawai'i, and the BTS hotline for the CNMI. Jurisdictions which do not yet have dedicated hotlines often you a combination of key individual office and cell numbers and general emergency hotlines such as 911 for back-up. Ideally each jurisdiction will eventually have a dedicated pest hotline with trained staff answering, recording information from incoming calls and alerting proper authorities as needed.
- Leverage the BTS Rapid Response Team capability and utilize this existing framework as a partial model for development of truly regional early detection and rapid response capacities. The RRT team, although only a loose affiliation is in some respects regional and in the past has developed outreach programs across the MBP region, supported ERP development for each of the jurisdictions and has been involved in determining the credibility of potential IAS reports and response field actions for more than just BTS.

7.2 REGULATIONS

The development of a rapid response plan is justified in the following regulations:

- AHPA
- PPA
- Public Health Security and Bioterrorism Preparedness and Response Act
- DHS Presidential Directive 5

7.3 INCIDENT COMMAND

The National Incident Management System (NIMS)-Incident Command System (ICS) should be a framework to manage the response needs for single- or multiple-incident emergency situations. Upon evaluation of an incident, the lead program unit will determine if an Incident Commander (IC) is needed to manage it. If established, the IC or the unified command (for multiple-agency response) is responsible for all aspects of the response, including incident objectives and all incident response operations.

The IC includes the command staff and general staff. Command staff positions may include a public information officer, safety officer, and liaison officer as required and assigned by the IC. General staff includes operations, planning, logistics, and finance/administrative responsibility. If requirements for these responsibilities warrant, they may be established as separate functions under the IC and managed by section chiefs. They may be supported by other functional units.

Personnel should be designated to fill key ICS roles in the rapid response plan:

- IC
- Planning Chief
- Operations Chief
- Logistics Chief
- Administrative/Finance Chief

Responsibilities of the incident command and its general staff:

- Providing response direction
- Coordinating effective communication
- Coordinating resources
- Establishing incident priorities
- Developing incident objectives and approving response strategies
- Assigning objectives to response managers
- Reviewing and approving incident action plans
- Integrating response organizations into the ICS
- Establishing protocols
- Safeguarding worker/public health and safety
- Informing the media

7.4 RESOURCES

Micronesian regional governments and the state of Hawai'i should find funding sources for rapid response. The APHIS Emergency Mobilization Guide, available at: www.aphis.usda.gov/emergency_response/downloads/APHIS%20Emergency%20Mobilization%20Guide.pdf, facilitates cost-effective, timely coordination of resources needed for successful responses to agricultural health and homeland security emergencies by standard procedures guiding operations.

7.5 EXISTING MICRONESIAN REGION RESPONSE PROGRAMS

Several rapid response programs are in operation on the Micronesian Islands. These programs can be foundations for a comprehensive regional emergency rapid response program network. Examples are listed below.

- A regional response team has been developed for alien snake incursions. This team has trained members in each jurisdiction covered by the MBP. Until recently this team was coordinated by a US federal office on Guam. Currently that office is vacant.
- USDA-APHIS-WS, USGS and DAWR on Guam, CNMI DFW on Saipan, Tinian and Rota, the Hawai'i DOA and DLNR (as well as the various ISCs), Palau Agriculture, FSM Quarantine, Yap Agriculture, Pohnpei Agriculture and EPA, Kosrae Agriculture, and the RMI R&D all have resources for alien snake detection work, albeit no agency nor group has extensive resources and most groups (other than WS and USGS) have general capacity for IAS response work instead of focusing specifically on snakes.

7.6 RAPID RESPONSE TEAM

Rapid response teams should respond to suspected or confirmed introductions of invasive species and to disease outbreaks. Rapid response team members and contact information for specific emergencies depend on whether the emergency is a threat to plant, agricultural, animal, or wild animal populations. Rapid response teams direct the overall response to the emergency.

7.7 DETECTION-ERADICATION TEAM

Detection-eradication teams respond to specific introductions of invasive species and to disease outbreaks. Detection-eradication team members are subject matter experts skilled in identification and eradication procedures for specific plant and animal risks.

7.8 LEAD APHIS PROGRAM UNIT

For each emergency, hypothetically an APHIS program unit could lead the response under established APHIS authorities where they apply. For incidents related to U.S. agriculture, PPQ serves as the lead program unit for plant health incidents (Section 10.9) and VS for animal health incidents (Section 10.10).

The introduction of invasive species and emergent agricultural incidents in U.S. territories and possessions should be reported to the APHIS Emergency Management Response System (EMRS) and APHIS program emergency response managers. Each program has specific reporting requirements in their individual emergency management guidelines (see Sections 10.9, 10.10, and 10.11 and the APHIS website).

In some instances, WS, Animal Care, or Biotechnical Regulatory Services may serve as the lead program unit for incidents in their mission areas (Section 10.11). For example, Biotechnical Regulatory Services responds to incidents involving genetically modified organisms.

For Micronesia which includes both US and non-US jurisdictions, a non-US Federal agency approach to regional response support may be the most appropriate approach.

Additionally agencies such as the USGS have supported development of regional response capacity to IAS and there are numerous groups and agencies already established within the region that have some capacity in this regard. These varied efforts and groups should all be considered when ultimately determining how best to further regional capacity in regards to early detection and response to IAS.

7.9 PLANT EMERGENCY RESPONSE–PLANT, PROTECTION AND QUARANTINE

The APHIS-PPQ program safeguards U.S. agriculture and natural resources from the introduction, establishment, and spread of plant pests and noxious weeds. PPQ's Emergency and Domestic Programs unit provides national leadership and coordination in plant pest programs and emergency management. As the lead federal agency for plant health emergencies, PPQ cooperates with national and international plant protection organizations; federal, state, and local agencies; Native American tribes; universities; industries, and private entities in developing and implementing scientific frameworks for optimum protection against invasive pests and diseases.

APHIS uses offshore information and pre-clearance programs, port inspections, and extensive domestic surveillance to prevent, detect, and respond to plant health emergencies. The PPQ emergency management framework consists of four key elements: 1) prevention, 2) preparedness, 3) response, and 4) recovery.

Prevention. PPQ works with trading partners and international plant protection organizations to develop and implement offshore pre-clearance, inspection, early detection, and control strategies to prevent the entry of invasive pests and diseases into the United States. PPQ works with the U.S. DHS-CBP and other cooperators to continue the success of agricultural inspection operations at all U.S. ports of entry. PPQ regulates plant imports, effects international safeguards, and operates domestic pest detection programs.

The first line of defense against the entry of harmful plant pests and weeds into the United States and U.S. territories is through the inspection of commodities, conveyances, and passenger baggage by APHIS cooperators at seaports and airports outside of CTUS. PPQ trains these cooperators to detect and identify these pests.

Preparedness. PPQ works with federal, state, tribal, and local governments and with industries to prepare, build, and sustain operational capacity and capability for early detection, timely diagnostics, and effective control strategies against plant health threats.

Response. PPQ works with federal, state, tribal, and local governments and with industries to coordinate actions to contain, control, or eradicate plant pests and diseases. PPQ uses ICS, which helps agencies and entities with a unified strategy for working together in response to plant health emergencies.

Recovery. After an emergency response is complete, PPQ works with federal, state, tribal, and local governments and the private sector to develop and implement systems for long-term stability and protection from the pest or disease that caused the emergency. Recovery includes plant health regulations, eradication, BMPs, and restoration plans.

Table 10-1 identifies key PPQ Offices.

Table 10-1: Key PPQ Offices and U.S. Plant Health Non-Government Organizations

Office	Location
PPQ Emergency and Domestic Programs	Riverdale, Maryland
PPQ Western Region	Fort Collins, Colorado
PPQ Hawai'i State Plant Health Director	Honolulu, Hawai'i
PPQ Port Director	Guam

7.9.1 National Identification Services

APHIS' National Identification Services (NIS) coordinates the identification of plant pests to support USDA's regulatory programs and quarantine actions. NIS collaborates with scientists specializing in plant pest groups, weeds, insects, mites, snails, and plant diseases. These scientists are stationed around the country in federal research laboratories, plant inspection stations, land-grant universities, and natural history museums.

NIS supports the use of alternative diagnostic methods to enhance the speed and precision of the identification process. The Remote Pest Identification Program utilizes digital imaging of suspected pests and transmits them electronically to qualified specialists for identification. The Molecular Diagnostics Laboratory is responsible for biochemical testing services supporting the agency's pest monitoring programs.

7.9.2 National Plant Diagnostic Network

With support from USDA's National Institute of Food and Agriculture, from land-grant universities, federal agencies, state departments of agriculture, and other stakeholders, the National Plant Diagnostic Network (NPDN) is a consortium of plant diagnostic laboratories developing a nationwide network of public agricultural institutions with a cohesive distributive system that quickly detects high-consequence pests and pathogens introduced into agricultural ecosystems, identifies them, and immediately reports them to appropriate responders and decision makers. The NPDN has invested in plant diagnostic laboratory infrastructure and training, developed an extensive network of first detectors through education and outreach, and improved communication among agencies and stakeholders that respond to outbreaks and mitigate them.

Guam is served by the Western Plant Diagnostic Network, a regional member of the NPDN. The network is a consortium of land-grant institutions and state departments of agriculture throughout the western United States and Pacific U.S. territories with services for plant disease diagnosis, plant identification, and insect or pest identification. The Western Plant Diagnostic Network uses a common software interface to process diagnostic requests and to share information among diagnostic laboratories.

7.9.3 APHIS-PPQ Incident Command System

APHIS-PPQ emergency planners have developed the 2004 *USDA-APHIS-PPQ Incident Command System Guide* for development of an ICS during a plant health emergency. The guide offers the following information:

- Report requirements
- Notification procedures
- Exotic pest identification
- Pest status assessment
- Financial support
- Incident management teams
- Legislative and public affairs

7.9.4 Standards for Plant Health Emergency Management Systems

APHIS-PPQ emergency planners have developed *Standards for Plant Health Emergency Management Systems* to help state and federal plant health officials and state emergency managers determine their needs in mounting successful responses to plant health emergencies. Information includes:

- Emergency plans
- Written agreements
- Authorities and policies
- Plant pest survey, containment, control, and eradication
- Communications
- Training and education
- Funding and resources
- Standards for state plant health emergency management systems

7.9.5 Specific Plant Emergency Programs

APHIS-PPQ emergency planners have specific response programs for multiple plant disease and plant pest emergencies. APHIS-PPQ prepares new pest response guidelines for anticipated arrivals of new pests into the United States and for detected new pests already arrived. These guidelines are for many insect, mollusk, and virus pests that attack crops, wood, grain, nursery stock, and other resources.

Additional information is available at http://www.aphis.usda.gov/plant_health/index.shtml.

7.10 ANIMAL EMERGENCY RESPONSE–VETERINARY SERVICES

APHIS-VS safeguards U.S. poultry and livestock from the introduction, establishment, and spread of foreign animal diseases by regular surveillance of domestic animal herds and flocks and monitoring animal disease outbreaks around the world. APHIS-VS personnel also work with other federal agencies at airports and maritime ports to inspect and approve incoming shipments of animals and animal products.

APHIS-VS is responsible for detecting and responding to animal disease incidents that occur within the United States. The APHIS-VS National Center for Animal Health Emergency Management (NCAHEM) manages the agency's animal health emergency activities. The center develops strategies and policies for effective incident management and helps coordinate incident responses. As liaison to outside emergency management groups, NCAHEM keeps the agency's animal health emergency management policies, strategies, and responses current with national and international standards.

NCAHEM and VS programs are valuable resources in animal disease emergencies from invasive species on Micronesian Region islands.

7.10.1 National Veterinary Stockpile

The National Veterinary Stockpile (NVS) provides the veterinary countermeasures—supplies, equipment, field tests, vaccines, response support services—that states need to respond to large-scale, catastrophic animal disease outbreaks that terrorists or nature may create.

NVS provides USDA-APHIS expertise for responding to animal diseases by:

- Deploying countermeasures against the worst animal diseases: HPAI, FMD, Rift Valley Fever, END, and CSF.
- Helping states plan for, train, and exercise the rapid acquisition, receipt, processing, and distribution of countermeasures during an event.
- Focusing exclusively on NVS and state logistics of disease response.
- Coordinating logistics planning especially for large-scale, catastrophic outbreaks.
- Preparing states to acquire, receive, process, and deliver NVS countermeasures as well as those from other sources rapidly.
- Managing delivery time of countermeasures.

Countermeasures and response capabilities:

- Vaccines as alternatives to destroying animals
- High-speed vaccination equipment
- Personal protective equipment

- Animal handling and depopulation equipment
- Field diagnostic tests for rapid, presumptive identification of disease
- Decontamination supplies to eliminate disease agents
- Emergency transport of supplies, equipment, vaccines, reagents, samples, and trained personnel equipped to support state response

NVS outreach and exercise programs help states, tribes, and territories plan, train, and respond logistically to large-scale disease outbreaks. NVS personnel assist states in developing test exercises conforming to DHS Exercise Evaluation Program guidelines.

Additional Information about the NVS program and resources is available at: http://www.aphis.usda.gov/animal_health/emergency_management/nvs.shtml

Emergency Management Response System

EMRS supports management of animal disease outbreak data with state and tribal partners with a secure, accessible nationwide system for data collection, management, and analysis in a web-based, comprehensive investigation, task, and resource management suite on a universal information platform. Primary EMRS users are federal, state, and tribal veterinary medical officers, animal health officials and technicians, animal disease specialists, and epidemiologists. EMRS provides APHIS-VS and cooperators with a management system for:

- Responses to animal disease outbreaks
- Routine surveillance of foreign animal disease
- Emerging disease incidents
- All hazard animal incidents

Access to EMRS requires registration at EMRS_Registration_Approvers@aphis.usda.gov. EMRS technical assistance is available from the APHIS Technical Assistance Center via phone (877) 944–8457, or E-mail, atac@aphis.usda.gov.

Additional assistance is available from EMRSSupport@aphis.usda.gov.

7.11 ANIMAL EMERGENCY RESPONSE–WS

NWDP does wildlife disease monitoring and surveillance in all regions of the United States. NWDP wildlife disease biologists act as first responders through NWDP's Surveillance and Emergency Response System (SERS). NWDP collaborates with NGOs and officials from other countries to promote development of wildlife disease monitoring programs worldwide.

7.11.1 Surveillance and Emergency Response System

SERS, an essential NWDP component, is the primary emergency response contact point within APHIS-WS. SERS has a cadre of wildlife disease biologists ready to mobilize within 24 to 48 hours of a request. NWDP-SERS biologists have extensive ICS training, medical clearances for personal protective equipment, and experience in emergency response scenario drills. Selections for requested incident response teams depend on the specifics of the request (e.g., immobilization and euthanasia-certified, shooter) and the number of people needed.

SERS will respond to requests for assistance from the following agencies and organizations:

- APHIS-VS
- APHIS Animal Care
- APHIS-PPQ
- Non-APHIS Emergency Support Function (all-hazards event)
- Federal Emergency Management Agency (all-hazards event)

Whether the request for emergency resources comes from within APHIS or from emergency support functions of the national response framework, the SERS national coordinator immediately develops an incident response team of SERS biologists whose skills and training meet the needs of the request. Once the team is formed and dispatched, SERS tracks it for the duration of the emergency response.

8 TERRESTRIAL VERTEBRATE SPECIES[3]

8.1 EXECUTIVE SUMMARY

This RA is based on the USDA-APHIS-WS Micronesian Region Risk Assessment, provides recommendations for preventing and mitigating regional threats to human health and safety, the economy, and ecology of the Micronesia Region posed by intentional and accidental transport of terrestrial vertebrate invasive species resulting from three actions proposed by the DoD, namely the relocation of Marines from Okinawa, providing visiting aircraft carrier berthing, and establishing an Army AMDTF for Guam and the CNMI. The scope of this plan also covers the Republic of Palau, FSM, and the RMI, including Hawai'i and the continental United States, but focuses on Guam because a majority of proposed actions will occur there, it serves as a regional transportation hub thereby facilitating wide-spread species movement, and because preventing off-island transport of the BTS is a high priority.

Proposed military actions are expected to significantly increase the flow of transportation throughout the region, thereby increasing the likelihood of introducing species intentionally, both legally and illegally, and unintentionally as hitchhikers, in air and water conveyances, cargo and cargo conveyances, and on people and in their baggage. Biosecurity strategy emphasizes a holistic approach of sterilizing pathways by implementing measures pre-border, at-the-border, and post-border. Prevention is more effective and cheaper than eradication or long-term control of established species, and eradication is more effective and cheaper over time than permanent population control.

Five key issues pertain to all recommendations: funding, coordination and communication, education and training, control methods development, and enforcement (of regulatory drivers). General recommendations serve as a starting point for more formalized, pathway-specific recommendations. Several recommendations focus on preventing the BTS from leaving Guam because resulting impacts extend well beyond Guam's jurisdictional and physical boundaries. Funding issues are weak links for regional biosecurity, crippling law enforcement and inspection processes, decreasing the efficacy of control measures, and preventing new methods from being developed. Education, training, and awareness are key preventative measures in unintentional and intentional pathways. Biosecurity is compromised in military sectors because exemptions are often granted to personnel; deployment can be immediate at any time to any place; military transportation traffic in the region will increase over time; there is overlap between military and civilian/commercial pathways; and the multipurpose and technologically advanced aircraft, vessels, and equipment used by the military pose unique risks. Current agricultural inspections need to target terrestrial vertebrate species, and inspectors require added knowledge, equipment, and facilities for proper screening and reporting; improved detection; and safe handling of such species. Cargo pathways warrant particular attention, as they are most vulnerable to transporting species because of the diversity of goods moved, the wide array of exposure to various handling and packing procedures, and the multiple modes of transport used.

[3] This chapter was prepared by USDA-APHIS-WS, compiled by: W.C. Pitt, C.V. Deringer, and J.M. Gaudioso. 6 November 2010.

The number of stowaways detected per inspection, in combination with the huge volume of transported products and expected increases in regional transportation traffic, implies a substantial number of species will go undetected. Regulations and enforcement need to be enacted and implemented to address illegal transport of species, which occurs insidiously, even via legal routes like the pet trade and food imports. Effective regional biosecurity requires a long-term commitment, adequate and sustainable funding, cooperation, and enforcement of regulatory drivers. This plan can be used in its entirety, or as individual pathway- or taxa-based sections for specific action plans.

8.2 INTRODUCTION

The Micronesian Region Biosecurity Plan for terrestrial vertebrate species focuses on threats posed by the intentional and unintentional transport and introduction of terrestrial vertebrate invasive pest species as a result of increased military activities in the region. The scope of this plan covers Guam, the CNMI, the Republic of Palau, the FSM, and the RMI, including Hawai'i and the continental United States.

Military relocation refers to three actions proposed by the DoD, 1) the relocation of Marines from Okinawa, 2) providing visiting aircraft carrier berthing, and 3) establishing an Army AMDTF for Guam and CNMI. The military relocation and post-relocation training and operations are expected to significantly increase the flow of cargo, people, and transportation conveyances into and out of Guam and the CNMI (Helber et al. 2006). The estimated increase of goods and people during and following military relocation increases the likelihood of transporting terrestrial vertebrate invasive pest species throughout the region.

This action plan provides background on biosecurity efforts in the Micronesia Region, reviews potential risks identified in a pathway-based risk assessment, and provides recommendations for developing a comprehensive operational biosecurity strategy to prevent or mitigate risks posed by terrestrial vertebrate invasive pest species. Risk assessment covers unintentional and intentional pathways, with unintentional pathways identified by mechanism of transport and intentional pathways identified by motive for transport. Risks and mitigating recommendations are general and specific, with general information being applicable to all pathways, both military and civilian sectors, and regardless of pest species and transport mode or motive.

We also incorporate applicable information from successful biosecurity strategies currently implemented by governments to safeguard their people, commerce, and environments against marine and terrestrial pest species and diseases. These jurisdictions include New Zealand (NZ MAF 2003), Australia (Australian Government 2009), Galapagos Islands (CDF and WWF 2002), Europe (EEA 2010), the Caribbean (Meissner et al. 2009), British Virgin Islands (Perry et al. 2006), the Pacific (Sherley and Lowe 2000; SPREP 2000), Hawai'i (Kraus and Duffy 2009), Fiji (FQD 2010), and Guam (BTSCC 1996). We also use information from reviews on policy and management at a global scale (SCBD 2001, Meyerson and Reaser 2002; Grotto and Tucker 2006; Reaser et al. 2007; Reaser and Waugh 2007; Hulme et al. 2008, Sheppard 2010) and at local/regional scales for Japan (Takahashi 2009), New Zealand (Pearson 2004; Takahashi 2005; 2006, NZ MAF 2008, 2009), Australia (VPC 2004, 2007a, b), Hawai'i (Beard and Pitt 2005; Kraus and Duffy 2009), and Europe (Pyšek et al. 2010).

8.3 BIOSECURITY STRATEGY FOR THE MICRONESIA REGION

8.3.1 Purpose

The goal is to provide a biosecurity action plan with a strategic approach to minimizing negative impacts to the region's human health and safety, economy, and ecology due to risks associated with the transport and introduction of terrestrial vertebrate species. Objectives are to summarize information on pathway transport and introduction of terrestrial vertebrate species based on the USDA-APHIS-WS Micronesian Region Risk Assessment of proposed DoD activities in the region, and recommend prevention and mitigation measures that safeguard against biosecurity threats.

8.3.2 Scope

The scope of this plan covers the relocation and post-relocation operational phases of military activity in the defined Micronesia Region. Biosecurity measures on Guam are unique in that efforts include screening and inspection of both arriving and departing people, cargo, and conveyances to prevent the transport and spread of the BTS from Guam to other locations. This plan summarizes pathways capable of transporting and introducing terrestrial vertebrate species, with an emphasis on BTS.

Issues and concerns regarding BTS extend well beyond Guam's jurisdictional and physical boundaries. Encounters with BTS outside of Guam (extralimital encounters) have occurred in a variety of place around the globe (Stanford and Rodda 2007). As a hub for commercial and military shipments in the Micronesia Region, transportation activity from Guam greatly increases the probability of BTS transport to new locations such as Saipan, Tinian, and Rota in the CNMI, and Oahu, Hawai'i.

Ecosystems on oceanic islands are particularly vulnerable to pest invasions (Loope et al. 1988), as evidenced by the history of BTS on Guam (Fritts and Leasman-Tanner 2001b).Numerous snake encounters have been reported for the island of Saipan with most of these encounters (but not all) being suggestive of BTS (Stanford, personal communication). The exact number of these encounters that is considered credible varies depending on the criterial one uses to define the term credible but what can be stated is that there have been numerous confirmed BTS captures on Saipan and that the number of credible encounters for Saipan is much higher than for any other island outside of the BTS's native range (other than Guam) (Stanford, personal communication). A variety of search efforts conducted on Saipan during the past 10 years has not confirmed the presence of an incipient BTS population there (Stanford, manuscript in preparation). Further, given that Saipan receives much of its cargo from Guam, and the other Mariana Islands receive most of their cargo from Saipan, BTS infestation of Saipan is possible and would be problematic if it did occur (Stanford and Rodda 2007). Similarly, a BTS infestation on Oahu increases the risk of introduction and spread throughout the main Hawai'ian Islands because of the amount of inter-island cargo traffic that occurs from Oahu (Stanford and Rodda 2007).

This plan allows for some flexibility in accommodating changes to the proposed military relocation, trainings, and operations, depending upon the types of changes proposed, the magnitude of change, and the timeframe for the change to be implemented.

8.3.3 Proposed Military Activity

This section provides a general description of the military relocation and post-relocation activities proposed in the Final EIS (FEIS), July 2010 (U.S. Navy 2010a). Military relocation includes three actions proposed by the DoD, 1) the relocation of Marines from Okinawa, 2) providing visiting aircraft carrier berthing, and 3) establishing an Army AMDTF for Guam and the CNMI.

The proposed relocation of Marines to Guam also includes development and construction of facilities for training and operations that would occur on Tinian. The MIRC FEIS includes training area/facilities on Guam, Rota, Tinian, Saipan, and Farrallon de Medinilla (FDM), and covers training on existing DoD land and on training areas in and around Guam and the CNMI; therefore, overlap exists between the two FEISs in the area of usage of existing DoD by Marine Corps units. The proposed Army AMDTF would be placed on Guam to defend U.S. interests on Guam; its defensive umbrella would ensure that local military assets are protected and remain available to meet their military missions.

All descriptions are based upon the “preferred alternatives” listed in the following documents, and are subject to change pending upon the final ROD:

- FEIS = FEIS/OEIS; Guam and CNMI military relocation; relocating Marines from Okinawa, visiting aircraft carrier berthing, and Army air and missile defense task force, July 2010 (U.S. Navy 2010a)
- IMP = Integrated Military Plan, July 2006 (Helber et al. 2006)
- MIRC = MIRC FEIS/OEIS, July 2010 (U.S. Navy 2010b)
- ROD = August 2010

8.4 MILITARY OPERATIONS, TRAININGS, MISSIONS

8.4.1 Military Relocation

As noted above, the three proposed actions of Guam military relocation include 1) the relocation of Marines from Okinawa, 2) providing visiting aircraft carrier berthing, and 3) establishing an Army AMDTF for Guam and CNMI. Proposed relocation of Marines includes the development, construction, and use of facilities for training and operations on Tinian because not all training can be accommodated on Guam. The concept for Tinian is to provide the next stage in the training progression, which includes development of ranges for tactical use of the basic weapons skills developed on Guam, skills that complement the elements of ground training (U.S. Navy 2010a, Vol. 3, pg. 2-1).

The Guam relocation of Marines includes four military elements:

1. Command Element, III (3rd) Marine Expeditionary Force (MEF). III MEF is the Marine Corps’ forward-deployed Marine Air-Ground Task Force (MAGTF); it has the ability to deploy rapidly and conduct operations ranging from humanitarian assistance and disaster relief to amphibious assault and high intensity combat. The MAGTF command element consists

primarily of headquarters (HQ) and supporting organizations. Collocation and communications connectivity is a primary facility citing requirement. Estimated personnel: 3,046.

2. Ground Combat Element (GCE), 3rd Marine Division Units. The GCE has the mission of locating, closing with, and destroying the enemy with fire, maneuver, and close combat. It supports MAGTF expeditionary operations with infantry, armor, artillery, reconnaissance, anti-tank, and other combat arms. It consists of Division HQ and subordinate organizations. Ground combat and combat support organizations require proximity to ranges and training areas as well as traditional base support facilities. Estimated personnel: 1,100.

3. Air Combat Element (ACE), 1st Aircraft Wing and subsidiary units. The ACE operates from a variety of sea- and shore-based facilities to support MAGTF expeditionary operations. The focus is to support the MAGTF during assault landings and subsequent operations ashore. The ACE includes the Marine Aircraft Wing HQ, expeditionary, and garrison supporting organizations. Unlike aircraft squadrons, aviation command and general supporting elements can be located close to the airfield and higher commands, and do not necessarily need to be located at the airfield. Estimated personnel: 1,856.

4. Logistics Combat Element (LCE), 3rd Marine Logistics Group (MLG). The LCE provides all support functions beyond the capabilities of the GCE and ACE units. Functions include: communications, engineering support, motor transport, medical, supply, maintenance, air delivery, and landing support. The LCE consists of MLG HQ and supporting organizations that provide a variety of direct logistics support to the rest of the MEF. The MLG HQ element would be sited in proximity to Command HQ and other HQs. Indirect and industrial support facilities of the LCE would be located in proximity to support activities and maximize efficiency, with efficient access to roads, ports and airfields. Estimated personnel: 2,550.

With the Marine relocation, training activities would be increased on Guam and in the CNMI to include training in major exercises that involve multiple strike groups and task forces. Major exercises provide multi-service and joint participation in realistic maritime and expeditionary training that replicates the types of events and challenges potentially faced during real-world contingency operations. Major exercises also include providing training to submarine, ship, aircraft, and special warfare forces in mission tactics, techniques, and procedures (U.S. Navy 2010b, Vol. 1, pg. ES-11).

Existing training capabilities on Tinian would be expanded to support company and battalion level live fire ranges; a battalion is a group of 5 companies, approximately 960 individuals. The main components of the proposed action are: 1) development and construction of live-fire training ranges: a platoon (42 Marines) battle course, 2) automated combat pistol range, 3) rifle known distance range, and 4) field firing range. These proposed training components complement the existing ground training practices undertaken at Tinian and in the CNMI as described in the MIRC (U.S. Navy 2010a, Vol. 3, pg. 2-1).

Operational training on Rota includes hostage crisis rescue operations, undercover operations or surveillance, fighting in urban areas, evacuating civilians during a war or natural disaster, preventing terrorist activities, and protecting troops while they are in combat situation. The training on Rota will be held at least twice a month, but frequency may increase depending on the kind of training that may be urgently needed (Todeno 2009).

Relocation activities would include aviation units and aviation support units that require runway and hangar space and maintenance, and supply and administrative facilities. There is also a need for air embarkation operations that are comparable to, compatible with, and co-located with, existing Andersen AFB operations on Guam. Air embarkation operations refer to loading and unloading cargo and passengers to and from aircraft, comparable to a civilian airport terminal (U.S. Navy 2010a, Vol. 2, Ch. 2).

Firing ranges are required for live and inert munitions practice by the Marine Corps, which generates the need for safety buffers called Surface Danger Zones, and special use airspace (SUA) on Guam for certain weapons [note: SUA not applicable to Tinian] (U.S. Navy 2010a, Vol. 3; U.S. Navy 2010a, Vol. 2, Ch. 2). Range Alternative A (preferred FEIS Alternative) would require the realignment of approximately 2.8 km (1.7 miles) of Route 15 to the interior of the existing Andersen South parcel. The total land area, not including submerged lands, is estimated at 441 hectares (1,090 acres) (ROD 2010).

Military Operations in Urban Terrain trains Marine Corps, Army, Air Force, Special Warfare, and Navy Expeditionary Combat Command personnel combat tactics appropriate for a small city environment inhabited by noncombatants but occupied by a hostile force to search out and capture or destroy the hostile force. Primary training area (PRI) is Guam: Andersen AFB South, Finegayan Communication Annex, Barrigada Housing, and Northwest Field. Secondary training area (SEC) is Tinian, Rota, Saipan (U.S. Navy 2010b, Vol. 1, Table 2-8, pg. 2-53). Non-fire maneuver ranges are required for vehicle and foot maneuver training by Marine Corps, including urban warfare training. Urban warfare training is conducted in buildings that simulate a city or town. These buildings would be arranged close together so that Marines can practice entering and maneuvering in tight spaces (U.S. Navy 2010a, Vol. 2, Ch. 2).

Maneuver training areas are used for training Marines in the variety of skills specified in the Infantry Training and Requirements Manual (NAVMC DIR 3500.87), as defined in the Required Capabilities Document. Generally, for company-level (200 Marines) training, a 3,108 hectare (12 square mile) maneuver space is optimal, but this amount of space is not available on Guam. Maneuver training can be conducted in smaller areas depending upon the size of the Marine units and the size and complexity of a training event. Proximity is an important characteristic for efficient-to-use training areas, as cost and difficulty of transportation directly diminish the amount of training that can be accomplished within a given budget (U.S. Navy 2010a, Vol. 9, Appendix M).

Proposed activities call for creating a U.S.-based forward operating port for modern littoral warfare ships, combat logistics force ships, submarines, surface combatants, and high-speed transport vessels by improving U.S. Navy's Naval Base Guam to serve as a forward operational and logistic support hub for a mix of platforms and joint operations (Helber et al. 2006). The development of a Navy Transient Aircraft

Capability on Guam: Polaris Point Preferred Alternative—this alternative would construct a new deep-draft wharf at Polaris Point with shore side infrastructure improvements:

- The existing Outer Apra Harbor Channel would be widened to 183 meters (600 feet) with minor adjustments to channel centerline and navigational aids. There is a sharp southward bend in the existing channel toward Inner Apra Harbor that would require widening to 183 meters (600 feet) and dredging to meet aircraft carrier requirements.
- A new ship turning basin would be established that would require dredging to -15.1 meters (-49.5 feet) Mean Lower Low Water plus 0.6 meters (2 feet) overdraft. The turning basin would be located near the wharf and north of the Inner Apra Harbor entrance channel. The eastern edge of the new wharf would not have the required full 183 meters (600 feet) of distance from the wharf face and care would be necessary to nudge the carrier into position. However, Commander, U.S. Pacific Fleet requirements show that ships can safely navigate the reduced clearance at this site. The aircraft carrier would be assisted by tug boats, pivoted within the minimum radius turning basin to be aligned starboard (i.e., right side when facing the front or "bow" of the ship) to the wharf and the bow would be facing east. On departure, the aircraft carrier would follow the same route.
- It is anticipated that a transient aircraft carrier and its escort ships would rely on shore side utility infrastructure for water, wastewater, and solid waste after 2015. Electric power would be provided in accordance with customer service agreements (CSA) between Guam Power Authority and the U.S. Navy. Any Guam Power Authority commitments for additional power to support the aircraft carrier and its escort ships will be determined by future CSA modifications. Any required changes in the shore side power infrastructure or their operations to meet the requirements for the aircraft carrier and its escort ships may require additional NEPA review.
- Pertaining to aircraft carriers arriving to Guam, a new Port Operations support building and various utility buildings would be constructed on a terrestrial vertebrate-proof staging area at the wharf. There would be an area established for morale, welfare, and recreation activities and vehicle parking (ROD 2010).

The Army AMDTF is a ground force and would not be accompanied by aircraft or ships. Components would include command and control, missile field teams, maintenance, and logistics/supplies support. Establishing an AMDTF includes developing facilities and infrastructure on Guam to support relocating approximately 600 military personnel and their dependents (U.S. Navy 2010a, Vol. 1, Ch. 2). The proposed Army AMDTF on Guam contains the following three missile components:

5. The Terminal High-Altitude Area Defense (THAAD) system is a long-range, land-based theater defense weapon that acts as the upper tier of defense against ballistic missiles. This system is designed to intercept missiles during late mid-course or final stage flight. The THAAD flies at high altitudes and provides broad area coverage against threats to critical assets such as population centers, industrial resources, and military forces.

6. Patriot Missiles target short-range ballistic missiles that threaten the THAAD or other civilian or military assets on Guam. This weapon system is a point defense option with limited range designed to strike ballistic missiles, aircraft, unmanned aerial vehicles, and cruise missiles just before impact. This system utilizes hit-to-kill technology.

7. A Surface-Launched Advanced Medium-Range Air-to-Air Missile (SLAMRAAM) engages targets to beyond line-of-sight and defends against the air threat from unmanned aerial vehicles and cruise missiles.

Two major categories of training would be required: individual/crew and collective. Individual/crew training would include basic rifle marksmanship and crew-served weapons training. Training ranges on Guam and in the CNMI are considered joint use (i.e., available to all U.S. forces). Consequently, the Army would utilize ranges within the MIRC for this type of training. Collective training would be required for the AMDTF. Regular crew training on all aspects leading up to and through a launch would be required for THADD, Patriot, and SLAMRAAM weapons systems. These training exercises would be conducted at the Army facilities and no training-specific facilities would be required. No live-fire missile launch training exercises would occur on Guam or in the CNMI (U.S. Navy 2010a, Vol. 5, Ch. 2).

Continue efforts to develop U.S. Air Force Global Intelligence, Surveillance, and Reconnaissance (ISR) and Strike hub. Aviation training areas used are either improved (paved runway) or unimproved (unpaved landing sites) used to practice landing/takeoff and air field support (including loading/unloading of fuel, munitions, cargo, and personnel). Aviation training includes use of both international airspace and U.S. controlled airspace within the MIRC area (U.S. Navy 2010a, Vol. 2, Ch. 2).

Waterfront functions serve transient (visiting) ships and assault crafts associated with the proposed Marine Corps relocation. The transient vessels support Marine Corps operations and transient forces that presently train on Guam and in the CNMI. These ships would continue to support Marine Corps requirements in the western Pacific after the proposed relocation, and would continue to require transient vessel support facilities on Guam. The planning criteria for harbors, regardless of usage, differ from those for land-based facilities (U.S. Navy 2010a, Vol. 2, Ch. 2).

Associated infrastructure, housing, quality of life improvements (IMP) (Preferred Alternative): This alternative would co-locate AMDTF support facilities with the proposed Marine Corps units at Finegayan. The Administration/HQ and Maintenance operations would be co-located in the eastern portion of NCTS Finegayan and would be compatible with adjacent proposed Marine Corps land uses. Housing facilities for unaccompanied personnel would be located within NCTS Finegayan. Accompanied personnel housing facilities would be co-located with the Main Cantonment housing areas in South Finegayan, while recreational and QOL facilities would be co-located within and adjacent to the housing areas (ROD 2010).

Munitions Storage Alternative 1 (Preferred Alternative): Munitions storage would be in three non-contiguous areas near the Habitat Management Unit (HMU) of the Andersen AFB Munitions Storage Area, the latter being Alternative 1 of candidate sites for ammunition storage. The proposed magazines would be constructed at these two sites (requiring demolition) and at a third site located east of the HMU across an unnamed roadway. The area of ground disturbance including a buffer is estimated 2.5 hectares (6.2 acres). The existing Explosive Safety Quantity-Distance arc(s) at the Munitions Storage Area 1 would be expanded approximately 122 meters (400 feet) to the north to provide the required safety distances for the new munitions storage facilities (ROD 2010).

Combat Search and Rescue (CSAR) operations include fixed-winged aircraft, helicopters and submarines, and use tactical procedures to rescue military personnel within a hostile area of operation. The PRI is both Tinian (North Field), and Guam (Northwest Field), SEC is Orote Point Airfield, and Rota Airport (U.S. Navy 2010b, Vol. 1, Table 2-8).

ISR is conducted to evaluate the battlefield and enemy forces, and gather intelligence. For training of assault forces, “red cell” or “OPFOR” units may be positioned ahead of the assault force and permitted a period of time to conduct ISR and prepare defenses to the assaulting force. ISR training has occurred at urban training facilities at Finegayan and Barrigada on Guam, and both the EMUA and the LBA on Tinian. The PRI is Guam: Northwest Field, Barrigada Housing, Finegayan Comm. Annex, and Orote Pt. Airfield. The SEC is Tinian, Rota, and Saipan (U.S. Navy 2010b, Vol. 1, Table 2-8, pg. 2-56).

8.4.2 Post Relocation

8.4.2.1 *Speculative*

Speculative (notional) base loading (U.S. Navy 2010a, Vol. 7) includes:

- A brigade-sized portion of a MEF
- An Army Brigade Headquarters and Army Battalion (to be determined), and various U.S. Air Force mission support initiatives
- New forward support Littoral Combat Ships, High-Speed Vessels/Theater Support Vessels (HSV/TSV)
- Auxiliary Dry Cargo/Ammunition Ships (T-AKE) that will replace aging Auxiliary Ammunition Ships (T-AE) and Auxiliary Combat Stores Ships (T-AFS), in addition to existing homeport Nuclear Attack Submarines
- Berthing accommodations for a transient nuclear powered aircraft carrier (aircraft carrier, fixed wing, nuclear powered [CVN]) and support for the carrier air wing (CVW), infrastructure for transient ships that support Marine Corps embarkation activities, and various training and support elements
- Facilitate use of transient U.S. Navy Nuclear Aircraft Carrier CVN at Naval Base Guam
- Infrastructure improvements to fuel pumps and pipelines that extend from the Sasa Valley Fuel Farm to Andersen AFB. Project includes a new 25.3-km (15.7-mile) pipeline that is parallel and adjacent to existing pipeline and located within an existing 3.05-meter (10-foot) wide easement (PACAF A7P, Air Force and U.S. Navy). This action is scheduled for 2013 in Central Guam

- Amphibious assault vehicle training by the Marine Corps. Beach improvements: one concrete revetment at each beach, remove non-native vegetation, no inland water improvements. This action is scheduled for 2014 and beyond[4]
- One concrete boat ramp in southern end of Inner Apra Harbor, for one amphibious assault vehicle at a time, overland paved route to Tipalao includes steep descent to Tipalao Beach. Site improvements associated with amphibious training include a new ramp at the southernmost point of Inner Apra Harbor. Overland route would be along the wetland area between the inner harbor and Dadi Beach. This action, by the Marine Corps is scheduled for 2014 and beyond[5]
- Redevelopment of munition igloos at Andersen AFB

8.4.2.2 *Pertaining Specifically to Tinian*

All scheduled for 2014 and beyond[6] for Marine Corps (FEIS Vol. 7 Ch. 4 Table 4.3-2):

- Additional construction to accommodate up to 3,000 personnel (housing, recreation, medical, etc.)
- Ammunition storage facility. Includes six igloo magazines, a segregation facility, operations building, security systems, and a road network
- Automated multipurpose range. Includes range support building, ammunitions storage, range observations tower, general instruction building, covered mess, covered bleachers, field range latrines, and 788 target emplacements
- 1.5 x 3 mile area for live-fire and maneuver training, including stationary and automated targets. Supports up to .50 caliber ammunition
- 2,000 x 4,000-foot area for live-fire and movement training. Supports up to 7.62-millimeter infantry weapons
- Areas for mortar and artillery firing points
- Paved area at North Field for helicopter landings, weekly aviation training. Includes fire protection and bermed area for fuel bladder
- Six pistol and rifle firing ranges, including stationary/automated targets, standard set of range support facilities
- 100 x 300-foot area for tank/fighting vehicle training. one firing point, central dubbed impact area
- Breakwater repair, pier face structures repair, loading ramp, holding yard for customs, storage/transfer area, harbor dredging. Includes demolishing the finger pier

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[4] Ibid, p. 2-1.
[5] Ibid.
[6] Ibid.

- Roadway improvements, electrical distribution changes, fire protection facilities, and access to Unai Dankulo on Tinian

8.5 PATHWAYS

8.5.1 Description

Overall biosecurity strategy emphasizes a holistic approach that focuses on sterilizing pathways capable of transporting terrestrial vertebrate pest species. Species are transported intentionally, both legally and illegally, and unintentionally as hitchhikers, moving to a different location in cargo, packing material, a shipping container used for transport, or on/in the conveyance of transport (Meissner et al. 2009). Redundancy occurs among pathway recommendations where risks are similar and the same regulatory drivers apply. For implementation purposes recommendations are organized per pathway into stand-alone sections. For example, the Port of Guam would use those recommendations pertaining to water conveyances and vessel cargo pathways, as opposed to those in air transportation.

In general, terrestrial vertebrate species transport is via air transportation conveyances (hereafter aircraft) (e.g., airplanes, helicopters), water transportation conveyances (hereafter vessels) (e.g., ships, barges, fishing boats, amphibious landing crafts), cargo (i.e., types and associated packing materials) including cargo conveyances (e.g., containers, crates), and people and baggage.

8.5.2 Air Transportation

Recommendations in the air transportation pathways focus on the aircraft itself as the mode of species transport. The term ‘aircraft’ includes both fixed and rotary-wing aircraft in military, commercial, and private sectors. Different types of military, commercial, and private-owned aircraft currently visit, are home-based, or routinely operate on Guam, with air transportation traffic in all three sectors expected to increase from military activities during and after relocation. Plans for the relocation include training and field exercises conducted on the islands of Tinian, Rota, and Saipan, which involve aircraft operations from Guam and from aircraft carriers.

Aircraft pose several risks in transporting terrestrial vertebrate species. Aircraft are capable of rapid transit, equating to higher species survival during the short travel time. Global air transportation facilitates the widespread movement and dispersal of species. Aircraft are capable of harboring a variety of species, including birds such as Java finch (*Padda oryzivora*) and the Red-vented Bulbul (*Pycnonotus cafer*), snakes like BTS and rodents such as mice (*Mus musculus*). Aircraft are also capable of repeated introductions of species because of routine routes travelled and regularity of flight schedules. Further, aircraft cabins and cargo holds that are maintained at mild temperatures during transit, such as on passenger planes, offer hitchhikers in those craft recesses a thermal environment that is conducive to species survival during transport. All of these aspects increase the probability of successful species transport, including their myriad possible combinations.

Inspections of aircraft are mainly to detect agricultural pests such as insects, plants, and plant pathogens, and only target one terrestrial vertebrate species, BTS, when aircraft are departing Guam. Inspections do not occur for BTS on aircraft that have been grounded less than 3 hours, operate during daylight hours, or require immediate departure, such as for military aircraft that depart Guam on urgent missions; however, aircraft leaving repair facilities for operational use are not usually inspected (Vice 2010a). Military aircraft are not exempt from agricultural inspections due to a MOU between GCQA and PPQ, where PPQ has granted GCQA the acting authority to inspect aircraft. However, military aircraft have the option of operating out of commercial and military airports, and military airfields, complicating inspection procedures. Also, military aircraft may be granted exemption in the following three cases: the aircraft is engaged in warfare, the cargo of the aircraft is classified, or pre-clearance procedures have been granted to the aircraft. Aircraft come into direct contact with the ground, giving terrestrial vertebrate species direct access to the craft. Aircraft can be difficult to inspect externally, depending upon the type of aircraft and its undercarriage configuration, but also internally, because of the numerous recesses, compartments, and storage holds aboard a craft, and the physical size of the craft. Chartered, personal, and airfreight aircraft are difficult to inspect because flight activities are hard to monitor, hence transportation of species can occur any time, to numerous places without detection. Despite the difficulties, inspection procedures and control efforts are efficient for aircraft. For example, USDA-APHIS-WS use visual and canine team detection methods to prevent BTS from departing Guam aboard an aircraft, and flight crews should adhere to sanitation regulations and be observant to signs of rodents. Aircraft are usually kept clean, reducing the attraction by species seeking a food source. External hitchhikers, such as those in wheel wells, may not survive the cold temperatures at high altitudes flown by some aircraft (Perry and Vice 2009).

8.5.3 Water Transportation

Recommendations in the water transportation pathways focus on the vessel itself as the mode of species transport, and include military, commercial, and private sector vessels. Types of vessels are numerous, including but not limited to, rigid inflatable boats, long-line fishing boats, sailboats, amphibious landing crafts, high-speed catamarans, container ships, cargo ships (bulk, break-bulk, roll-on/roll-off), aircraft carriers, landing craft utility vessels, barges, inter-island ferries, cruise ships and shuttles, platforms, and hovercrafts. Different types of military, commercial, and private-owned vessels currently visit, are home-based, or routinely operate on Guam with water transportation traffic in all three sectors expected to increase from military activities during and after relocation. Plans for the relocation include the construction and use of training ranges for field exercises and activities on the islands of Tinian, Rota, and Saipan, which involves water transport of materials, equipment, and vehicles for range construction, operation, and field exercises.

Typically, vessel access is limited; terrestrial vertebrate species either board themselves, or are intentionally and unintentionally brought on by persons or loaded as cargo. Species can board via fenders, mooring lines, and gangways that come into contact with land when vessels are at port, a pier, or a wharf, thus providing species with direct access to the hull. Departure from craft may be by the same routes plus directly through the water. Military vessels are not exempted from agricultural inspections due to a MOU between GCQA and PPQ, where PPQ has granted GCQA the acting authority to inspect craft. However, the arrangement that grants the authority for GCQA to conduct these inspections has been questioned. Military vessels such as Landing Craft Utility Vessels with direct access to the hull from beachheads via a ramp, and Amphibious Landing Crafts that can transport and spread terrestrial vertebrate hitchhikers over water and land complicate inspection procedures. Also, military vessels may be granted exemption in the following three cases: the vessel is engaged in warfare, the cargo of the vessel is classified, or pre-clearance procedures have been granted to the vessel. However, these inspections are mainly to detect agricultural pests such as insects, plants, and plant pathogens, and do not target terrestrial vertebrate species specifically. Like military aircraft, vessels that depart Guam for urgent missions without inspection can harbor and transport terrestrial vertebrate species without notice. Vessel inspections can be difficult or easy to conduct, depending upon the type of vessel, its physical size, and the vessel configuration, both above and below deck (e.g., are there cabin areas, storage holds, bunk rooms, etc.). Chartered and privately-owned vessels and private, chartered, and commercial fishing vessels are difficult to inspect because boating activities are hard to monitor, hence transportation of species can occur any time, to numerous places without detection. Control efforts exist for safeguarding vessels from harboring unwanted species. Cargo exported from Guam via water transport is typically inspected by USDA-APHIS-WS canine teams prior to loading to detect BTS presence. Vessel captains have the option of using rodent guards on mooring lines to block mice and rats, the WHO's sanitation regulations for cleaning galleys and waste disposal reduce the probability of attracting and sustaining rodents and crews should be observant to signs of rodents.

8.5.4 Cargo

Recommendations in the cargo pathways focus on the cargo itself as a mode of species transport, including how cargo is packed and handled (e.g., crate, container, pallet, box, individual items); associated packing material; mode of transport (aircraft or vessel); shipping process, such as whether transport is via commercial or military-contracted commercial companies (e.g., Matson and Horizon vessels, passenger planes); military-owned transport systems(e.g., USTRANSCOM); or privately chartered shipping companies (Freedom Air 2010; Stratos 2010). Cargo is broadly defined as goods carried on a vessel or aircraft, or in a motorized vehicle. Cargo can be military, private, or commercial goods. Types of cargo vary and include both food and non-food goods. Types of cargo include, but are not limited to, personal checked airplane luggage; imported aquaculture (e.g., live fish or fish parts) and plants and plant parts (cut flowers, leis, nursery industry plants); animals imported legally and illegally (pet trade, personal pets, smuggling); vehicles such as cars, trucks, armored tanks, bulldozers, military vessels and aircraft (i.e., shipped aboard aircraft carriers, Landing Craft Utility vessels, Landing Craft Air Cushion vessels, hovercrafts); household goods; and empty shipping containers (for lease by shipping companies). Cargo can be handled and packed in a variety of ways. For example, household goods can be handled by private homeowners, commercial packers, or military personnel, with goods boxed and palletized for airfreight shipping, or further containerized for vessel transport, hence termed containerized cargo as opposed to palletized. Cargo like fuels, grains, and coal are termed bulk because the goods are transported unpackaged in large quantities and typically dropped or poured with a spout or shovel bucket as a liquid or as a mass of relatively small solids into a bulk carrier ship's hold. Break-bulk or general cargo must be loaded individually, as opposed to within intermodal containers or in bulk, and transport is via a cargo ship, whereas roll-on/roll-off cargo, such as vehicles, tanks, semi-trailers, and trailers which are driven on and off the vessels or aircraft on their own wheels. Different types and amounts of military, commercial, and private cargo is currently moved to, from, or through Guam and the Micronesia Region, with cargo transports aboard aircraft and vessels in all three sectors expected to increase from military activities during and after relocation. Cargo pathways pose many risks in transporting terrestrial vertebrate species. Cargo originates from many sources, both within and outside the Micronesia Region, and species access can occur during the packing and handling process, or during transport, if contaminated from another source while en route, such as rodents moving from the vessel to the cargo shipment. Cargo is also transported to numerous destinations, making it difficult to track and monitor shipments while facilitating the widespread movement and dispersal of terrestrial vertebrate species. Cargo arriving to the region may be targeted for agricultural inspection of insects, plants, and plant pathogens if manifests declare it as coming from a country of concern, having agricultural goods, and using proper certification for packing materials, but such inspections do not target terrestrial vertebrate pests. Cargo departing Guam may receive USDA-APHIS-WS canine inspection for BTS, especially if deemed high-risk cargo or if originating from a location of high snake density; however, the probability of detecting snakes or any type of species is drastically reduced when cargo is sealed inside containers, or packed and staged in complex configurations that offer numerous hiding places and challenges for inspectors and canine teams. The type of cargo can influence the type of species being transported. Cargo such as nursery plants and associated growing mediums offer environments conducive for transporting amphibians; food shipments can attract and harbor rodents; equipment cargo can offer intricate hiding places for reptiles like snakes, anoles, and geckos; and outdoor household items, such as tubing from swing sets and barbecue grills, can transport BTS. Animals shipped live, including those for research, personal pets, the pet trade, work, or food, are a risk because escapees can contaminate other types of cargo, an aircraft, or a vessel. Illegal movement of species can occur through legal routes, such as frog eggs and tadpoles entering through the plant nursery trade and aquaculture industries, respectively. Further, transport durations and packing and shipping methods vary, thereby influencing species' survival probability differently.

Cargo inspections can occur on goods imported to and exported from the region. Arrival inspections are mainly to detect agricultural pests such as insects, plants, and plant pathogens, and do not target terrestrial vertebrate species. Departure inspections are also agricultural in nature, and on Guam and Saipan, all departing cargo should be inspected for BTS. The volume of cargo being moved in the region is difficult to inspect thoroughly because of a lack of resources to meet current and military relocation demands, the myriad shipping companies that process and move cargo, and the need to avoid delays in loading and unloading cargo at air- and seaport facilities. Chartered and private airfreight cargo is difficult to inspect because unlike typical commercial airfreight services, flight activities can be unscheduled, hence transportation of species can occur any time, to numerous places without detection. For example, the private company Freedom Air carries various types of cargo, including personal vehicles, which can be transported from Guam without inspection for BTS (Freedom Air 2010) (Figures 11-2a-2b.). Cargo moved through private routes present a risk; visiting sailboats, private aviators, and long-line fishing boats can transport and disperse species. Military cargo presents additional risks, including classification and therefore exemption from inspections, and immediate shipping without advanced notice for medical emergencies. Military cargo such as personnel field gear and training equipment can be transported directly from the field via amphibious landing craft, helicopters, or personnel, as well as via commercial and military airports, and military airfields, complicating inspection procedures.

Figures 11-2a and 11-2b: Vehicle Transported as Airfreight Cargo Through Chartered Service Company

2. a.  2. b. 

Source: Freedom Air

8.5.5 People and Baggage

Recommendations concerning people and baggage pertain to the travelers and their carry-on items (hereafter referred to as baggage). People tend to opt for the quickest mode of travel, making travel duration short and species survival high in this pathway. Risks associated with the recommendations for this pathway are due to intentional and unintentional transport of vertebrates. Transport of people and their baggage can occur either by air or water, and can be private, commercially or military-operated, with each mode differing in the inspection process at the border. Commercial air transport of people and baggage includes commercial airlines or private charters, while commercial water transport consists of cruise ships or private charter boat passengers. On the other hand, military air transport of personnel may be involved in purely transportation from airfield to airfield, routine aviation training, or immediate departures of urgency (warfare, medical). Similarly, military water transport of personnel includes transport from one base to another, training missions, and immediate departures or urgency (warfare, rescue).

While inspection agencies are in place at commercial ports, the inspections do not target for detection of vertebrate species, but rather target for direct human health and safety threats and agricultural pests. Also, the equipment available for the inspection procedures (x-ray machines) of passengers may be inadequate both in number and sensitivity for the detection of vertebrate species. For example, while GCQA has two x-ray machines at the airport, they were inoperable at the time this was document was written and are awaiting replacement RapidScan machines (Berringer, personal communication). Furthermore, while paper-based agricultural forms are used for arriving passengers, the forms may not be reviewed quickly enough by inspection agents in order to address breaches in regulations, or passengers may be dishonest with their entries or have difficulty completing the form due to a language barrier.

Military personnel that travel on a military-operated passenger aircraft (http://www.baseops.net/spaceatravel/) must describe their travel by category (i.e., emergency leave, ordinary leave, retiree or dependents leave). Like commercial air travel, personnel and passengers departing Andersen AFB are subject to security screenings and carry-on baggage clearance operated and regulated by the TSA. However, exceptions to the regular passenger screening process apply to personnel whether they are departing from a civilian or military airport. For example, personnel do not have to remove their boots during the screening process unless the walk-through alarm sounds. While these exemptions expedite the travel process for personnel that must travel quickly due to the nature of their service, the exemptions leave gaps in the inspection process for vertebrate species. Personnel transported by water will utilize military-operated vessels such as high-speed catamarans, amphibious vehicles, or hovercraft departing out of Navy Base Guam, Apra Harbor.

Under the authority of the MCI, passengers, crewmembers, accompanied baggage, and equipment boarding any DoD-sponsored ship or aircraft departing an overseas area for the CTUS must be inspected or examined prior to departure. All travelling personnel must complete U.S. Customs Accompanied Baggage Declaration, DD Form 1854 while civilian crewmembers must complete Customs Form 5129. The MCI should accomplish this inspection or examination immediately before departure of the ship or aircraft. Urgent departures such as medical emergencies are still subject to MCI inspection. The mandatory inspection includes opening and examining baggage carried on by personnel and a physical search of personnel for prohibited items (as outlined in DD Form 1854), and breaches are addressed by military enforcement officials. Unfortunately, MCI does not yet operate in Guam, although its role is currently being supported by PPQ. The Navy is advocating instituting MCI on Guam.

8.6 SPECIES OF CONCERN

The level of risk to biosecurity is heavily influenced by the type of species and pathway of potential transport (USDA-APHIS-WS 2010). Species of concern are those that exemplify serious biosecurity risks pre-border, at the border, and post-border due to distinct biological and behavioral attributes documented for each species.

Species-specific characteristics that pose risks to biosecurity include the conduciveness of the species to enter a pathway (e.g., physical size and conspicuousness, number of individuals), and survival probability (individual fitness and thermoregulatory abilities). In addition, shipping logistics introduce risk depending upon the duration and type of transport, food availability during transport, air temperature and ventilation during transport, type of cargo, cargo packing and shipping method used, type of commodity, and origin of the shipment (e.g., history of incidence, large pet trade industry).

At the border, the stringency (see Chapter 3, *Regulatory Drivers*) and technology available regarding the inspection process of vessels and cargo influences the potential for introduction at the destination. If introduction does occur, the establishment of a population is again subject to support of the species' distinct biological and behavioral attributes (invasiveness, habitat matching, diet type, release from predators, increase in natural resource availability, circadian rhythm type). Also, establishment can be facilitated by interactions with other species, both native (e.g., prey shift) and non-native (invasional meltdown) (Simberloff and Von Holle 1999), and humans (human-facilitated dispersion). Emerging issues of modernity include climate change and genetic introgression (genetically engineered captive-only species), which introduce further uncertainty and complexity.

In application, the following section may be used for taxa-specific action plan purposes. Species of concern are organized by taxa, and the recommendations that apply to each group are found within each section. More attention was given to taxa of highest risk, such as BTS and species involved in the pet trade.

8.6.1 Reptiles

8.6.1.1 *Brown Treesnake*

BTS is venomous, posing a risk to human health and safety. Approximately one in every thousand hospital visits on Guam is due to a BTS biting incident, with victims including infants, agricultural workers, and BTS field staff (Fritts et al. 1990; Fritts and Leasman-Tanner 2001a). Accidentally introduced to Guam via imported military cargo presumably at Apra Harbor in the 1950s (USGS 2005), BTS has been a nuisance species that continues to pose risks to Guam's ecology, economy, and human health interests. The snake's native range includes portions of Indonesia, New Guinea, the Solomon Islands, and Australia (Colvin et al. 2005), but extralimital populations currently thrive on Guam where the species occurs in very high densities of up to 40 individuals per acre (Colvin et al. 2005) due to optimal environmental conditions like abundant prey, absence of predators, decreased competition for food, and favorable breeding habitat and climate, as well as life history characteristics like high reproductive rates. On Guam, BTS has extirpated 10 of the 12 native forest bird species and 2 of the 11 native lizard species. It is associated with frequent power outages, with economic impacts including the loss of power generation, damaged equipment, and time needed to conduct emergency repairs to restore electrical services. Loss of power equates to human health and safety concerns when facilities such as hospitals and airport control towers are involved. Further economic impact is caused to the tourism industry on Guam when power outages notably disrupt vacationers' activities (Fritts and Leasman-Tanner 2001a). BTS appears to have a trophic cascade effect that indirectly affects insect populations; some bird species extirpated by BTS were primarily insectivores. With avian predators extirpated, insect populations typically increase in abundance, with negative economic consequences to the agricultural industry on Guam (Kraus 2009a, Chapter 3).

Extralimital occurrences of BTS have been documented for Pacific Regions and in air and sea transportation pathways, for both commercial and military sectors. Incidences with military crafts include BTS found in the landing gear of military cargo planes (Kwajalein), in an Air Force B-52 bomber (Darwin, Australia, n=1, 1984) (USGS 2005), and possibly but not confirmed, disembarking and disappearing from a cargo plane (Hickam AFB, Honolulu, Hawai'i, n=1, 1997) (Claiborne 1997; USGS 2005). The snakes enter residential and commercial structures in search of food and cover, and they have been detected in household items such as appliances, vehicles, lawnmowers, swing-set tubing, barbecue grills, and outdoor recreational equipment, making this species of extreme concern for military relocating from Guam. there are also numerous BTS encounter and capture reports for a variety of locations that are not specifically tied to military activities. More specific information on locations and number of encounters can be found in Stanford and Rodda (2007).

The abundance of snakes on Guam, coupled with the tendency of BTS to hide in cargo and aircraft, creates a significant threat to the biodiversity and economic security of the tropical Pacific, as well as military operations on Guam. BTS is the single greatest threat to terrestrial ecosystems in the CNMI and the rest of Micronesia and is one of the greatest ecological threats to Hawai'i, making it a prime species of concern.

While it is unlikely that established populations of BTS will be completely eliminated with current technology where high densities exist (e.g., Guam), it is possible to control this species on a smaller scale (Rodda et al. 1999). An effective program for BTS interdiction must involve wide-area population suppression, snake-proof barriers, visual searches, and canine detection and interdiction, but also requires effective ED and RR capabilities for all areas at risk such as the jurisdictions covered by the MBP.

8.6.1.2 *The Asian Beauty*

The Asian Beauty snake (*Elaphe taeniura*) is native to Southeast Asia and Taiwan, but has been found on Okinawa since 1985, including gravid females. Although non-poisonous, this species poses an ecological threat as a potential predator of native mammals and birds (Ota 1999c; Ota 1999a) via intentional and unintentional transport. Due to its presence in the Ryuku archipelago, there is a high risk for its introduction to Guam via air or water transport related to military relocation efforts from Okinawa to Guam. In fact, one of these snakes was discovered in a shipping container holding munitions on Guam that had been shipped from Okinawa and held in storage for approximately 2 months in 2004 (Vice et al. In preparation). There is little information on effective control methods specific to *E. taeniura*.

8.6.1.3 *Habu*

The habu (*Trimeresurus flavoviridis*), a venomous viper, is native to the high islands of Amami and Okinawa. In these islands, the habu is a common human health threat, with high incidence of extremely painful bites. The venom can cause hemorrhaging and necrosis, and may progress to unconsciousness and death (Mishima et al. 1999). The incidence of habu bites varies with region; about 80% occurs in agricultural and residential areas, and up to 5.8 bites per 1,000 people can occur (Ota 1999b). The habu is also an ecological threat because it preys upon native birds, especially on islands with little or no rodent populations (e.g., Minnajima). The presence of an additional venomous snake on Guam could alter the effectiveness of current BTS interdiction measures. Unlike BTS, the habu is relatively sedentary and an affective attractant for habu traps has not been found (Hattori 1999), but trapping and barrier fences are the best methods available for control of the habu in residential areas. Due to its presence in the Ryuku archipelago, there is a high risk for its introduction to Guam via air or water transport related to military relocation efforts from Okinawa to Guam.

Only three snake species are mentioned here but it is worth noting that there are numerous species which could become established either through accidental transport or via pet trade. Various species other than those mentioned in this section have already been recorded for various island in Micronesia and for the state of Hawai'i, the number of species and encounter incidents is much higher. Snakes in general are highly efficient predators which if allowed to establish will cause tremendous negative impacts to any of the islands within the region.

8.6.1.4 *Geckos and Lizards*

The mutilating gecko (*Gehyra mutilata*), and green anole (*Anolis carolinensis*) are introduced species found within the region that have the potential to be spread (Kraus 2009a, Chapter 3), and pose ecological threats to native ecosystems. Although a single individual generally will not lead to an incipient population, many lizard species are capable of parthenogenesis, a form of asexual reproduction found in females, where growth and development of embryos occurs without fertilization by a male. The lizard species of most concern for the region is *Carlia ailanpalai*, a lizard species already established in parts of the FSM (Buden 2009), and a known aggressive predator of the Pacific Blue-tailed skink (*Emoia caeruleocauda*) on Guam (Wiles et al. 1989). It is therefore considered a possible causal factor in the decline in native scincid lizards in the Marianas (Case and Bolger 1991; Rodda et al. 1991; Rodda and Fritts 1992). Furthermore, this scincid lizard is a main diet item for BTS, helping support the large population of BTS on Guam (Rodda and Fritts 1992). *Anolis* species can be transported via cargo containers, and the swimming ability of some enables them to jump ship in favorable scenarios, such as when the vessels are close to shore (Perry et al. 2006). *Anolis carolinensis* are known habitat generalists and the feeding behavior of these animals caused insect populations to collapse on the Ogasawara Islands of Japan, resulting in this species being listed as an Invasive Alien Species in Japan since June 2005. Although the green anole population on Guam has not recently under gone rapid growth, its density could nevertheless approach hundreds to thousands of individuals per hectare (Toda et al. 2010) in the absence of predators like BTS. Green anole populations on some of the islands of the CNMI are found at high density levels. Preventing invasions of small reptilian species such as geckos is often difficult to manage, and once established there are no known methods of eradication (Cole et al. 2005). Even the mangrove monitor (*Varanus indicus*) is not ubiquitous within Micronesia and it is known as a predator of sea turtles, crabs and birds. It is hoped that island which do not currently have populations of mangrove monitors can in fact be kept free of this predatory species.

Green iguana (*Iguana iguana*) are also a concern. They are known as IAS in other areas, are common in the pet trade and individuals have been recovered previously in both Guam and Hawai'i. Green iguana are known to be established in Florida, Puerto Rica, and on at least several islands in the Fiji island group (Pers Comm. J. Stanford).

Additionally it might be worth mentioning that Brown Anoles, Day Geckos and a few other lizards not yet known to be establish in Micronesia are established in Hawai'i. Again, there is also likely potential invasive lizard candidates in places like the Philippines which might make it to Guam give the anticipated increases in the flow of people and goods from southeast Asia to Guam. Another lizard which we should be concerned about is *Calotes versicolor*. One individual has been found on Saipan and this species is a known invasive in some areas of Asia and also on Diego Garcia (Pers. Comm. J. Stanford).

Most lizards which become established not only will likely compete for resources with native biota as well as consume native species but they are also a great food source for predators which might establish like snakes and feral cats.

8.6.2 Amphibians

Guam has no native anurans, yet 13 anuran species have been discovered in Guam since 1937 of which at least 6 have established populations (Christy et al. 2007a).The modes most involved in alien anuran introduction are biocontrol, cargo, on/in shipping containers, food imports, plant trade, pet trade, and aesthetic release (Perry et al. 2006; Kraus 2009a). Due to their physical size and broad physiological tolerance, anurans can hide and survive various transport conditions, resulting in unintentional introduction on arrival if they remain undetected. Furthermore, anurans are most successful in transport survival when they are stowaways associated with living industry (e.g., plant propagation materials, live plants, and aquaculture) cargo, as the environmental conditions during transport are more likely to be optimal for anuran survival.

8.6.2.1 *Cane Toad*

The cane toad (*Bufo marinus*), native to Latin America, has been intentionally introduced in the tropics for the purpose of biocontrol, and unintentionally through air- and water-transported cargo, especially cargo associated with the plant trade (Kraus 2009a). As a generalist, the cane toad has proven to be an extremely successful invader throughout the Caribbean and Pacific (Lever 2001). It is a human health threat because it secretes bufotenine toxin that can potentially lead to serious illness or even human fatalities, particularly in children (Lever 2001). In addition, cane toads carry extremely high levels of pathogenic *salmonella*, specifically *S. waycross*, a species that contributes to high human salmonellosis rates on Guam (Haddock et al. 1990). Cane toads also pose ecological threats to native species through depredation; they are known to destroy nest burrows and prey on eggs and young nestlings of rainbow bee-eaters (*Merops ornatus*) (Boland 2004) in Australia. Further, the expected influences of global climate change on the worldwide problem of species invasions (Zhang et al. 2006; Ward and Masters 2007; Sommer et al. 2010) is evident in cane toads introduced into Australia; the species is rapidly expanding its range in part because of changing environmental and habitat conditions (Urban et al. 2007; Kearney et al. 2008).

8.6.2.2 *Frogs*

Introductions to Guam of the coqui frog (*Eleutherodactylus coqui*), Guenther's frog (*Rana guenthiri*), spot-legged tree frog (*Polypedates megacephalus*), greenhouse frog (*Eleutherodactylus planirostris*), crab-eating frog (*Fejervarya cancrivor*), cricket frog (*Fejervarya limnocharis*), banded bullfrog (*Kaloula pulchra*), Northern Pacific tree frog (*Pseudachris regillis*), and the Mantella (*Mantella pulchra*) have occurred either through aquaculture or plant trade imports (Christy et al. 2007b), all of which have become established with the exception of the coqui frog and banded bullfrog (Vice 2009). Guenther's frog (widely known locally as the barking frog) was introduced to Guam in 2001 from an aquaculture shipment most likely originating in China or Taiwan, and has since flourished throughout Guam. A more recently introduced species is the spot-legged tree frog (in 2004), which was introduced via an aquaculture shipment originating in China. The greenhouse frog arrived in Guam in 2003 through horticultural shipments originating in Hawai'i. An active horticultural trade exists between Hawai'i and Guam, and the species was found on Guam either at or in the vicinity of active plant nurseries or recent plantings (Christy et al. 2007a). All three established frog species pose ecological threats on Guam because they potentially may provide an additional source of food for non-indigenous invasive populations of rats, mongooses, and BTS. In fact, the barking frog and the green house frog are now found throughout Guam and in some areas can be found in remarkably high densities. Gut content of BTS from areas with high green house frog densities over the past several years have suggested that as the frog populations increase, so does predation on the frogs by BTS (Per Comm. J. Stanford).

The coqui frog and banded bullfrog were detected on incoming cargo to Guam (Christy et al. 2007a), the former found on horticultural material, while the latter in military cargo on a U.S. Air Force cargo plane. The coqui frog was also detected on Guam near a plant nursery (Christy et al. 2007b) but is not believed to have successfully established on the island. It has also been detected and intercepted on bulk palletized cargo shipped from Hawai'i (Vice et al. In preparation).The coqui frog is a significant economic threat in Hawai'i where it has negatively impacted the real estate market, nursery trade, and tourism industry, primarily due to the frogs loud and incessant calling behavior (Beard and Pitt 2005; Kaiser and Burnett 2006). The coqui frog also poses an ecological threat; in Hawai'i it has the potential to reduce endemic invertebrates and increase nutrient cycling rates, which may confer a competitive advantage to invasive plants in an ecosystem where native species have evolved in nutrient-poor conditions (Sin et al. 2008). The Northern Pacific tree frog is annually detected in imported Christmas trees shipments (Vice, personal communication); repeated introductions are likely to lead to the establishment of this species.

Prevention of the introduction and spread of anurans are the most efficient type of biosecurity measures for the taxa as attempts to rapidly eradicate invasive anurans in general have been unsuccessful, but some exceptions do exist. For example, if eradication is undertaken at an early stage of development (tadpole stage), success increases dramatically, as seen in the case of *Limnodynastdes dumerilii* in New Zealand where all egg masses and individuals detected were destroyed quickly (Kraus 2009a). On the contrary, removal of adults may actually increase survivorship of metamorphs due to the release from canabalism inherent in some species such as *R. catesbeiana* (Govindarajulu et al. 2005). However, most cases of anuran invasion pose more complex challenges to eradication efforts. In Hawai'i, *E. coqui* requires long-term management, and eradication is unlikely due to high incidence of repeated introductions and invasions. Still, *E. coqui* management options include intensive surveys and monitoring of populations, clearing of optimal habitat, and spraying (ground and aerial) of citric acid and hydrated lime to kill individuals. Management efforts of cane toads in Australia include the forming of the Cane Toad Task Force and implementing various short- and long-term control measures such as large-area barriers and fencing to prevent further dispersal of cane toads (Taylor and Edwards 2005; Sawyer 2006).

8.6.3 Mammals

8.6.3.1 *Rodents*

Introduced rodents have historically posed significant economic, ecological, and human health threats worldwide. Rodent species of concern to Guam include house mice and black rats (*Rattus rattus*). Both are transported as hitchhikers by air and water transportation pathways. Larger rodent species, such as nutria (*Myocastor coypus*) imported for fur ranching, also pose a threat.

House mice can economically threaten the food industry, and are known to be associated with salmonella, rickettsial pox, and choriomeningitis (Long 2003b). Also, the gnawing behavior common to rodents may cause damage to electrical wiring within the aircraft electrical equipment or infrastructure, threatening human safety and causing economic impacts. They also prey and therefore are attractive to other invasive species like BTS. The potential ecological destruction of established rodents may be exemplified by the infestation of more than 700,000 house mice on Gough Island off South America; since their establishment, these mice have physically tripled in size because they prey on albatross chicks in lieu of their typical insect and seed diet (Vidal 2008). House mice have been found hitchhiking aboard commercial airplanes, both within the cabin (Bodry 2008) and in wheel well compartments (Vice 2010b).

Black rats have reached about 80% of the world's islands, and are among the most successful invasive mammals (Caut et al. 2008). Rat infestations can occur in port facilities due to improper garbage disposal and handling, in addition to inadequate eradication measures (USDA-APHIS-WS 2010). These rodents can cause economic threats to livestock and poultry operations, crops such as rice, sugarcane, coconut, and macadamia, and damage to buildings and electrical materials. Rats can be reservoirs of zoonotic diseases, including *leptospirosis, typhus, and trichinosis*; rat fleas are vectors for *pasteurella* and *murine typhus* and plague; these all pose threats to human health through bites, contamination of food and water, and air-borne transmission. Lastly, ecological threats include predation on and extinction of native mammals, reptiles, and birds (Stenseth et al. 2003), either directly or by sustaining higher risk predators (e.g., BTS) as prey themselves (Fritts and Rodda 1998).

Furthermore, rodents may be transported along with a food source, thereby increasing their chance of survival during transport, such as a shipment of rodent-infested grain (Baker 1994a). Hitchhikers aboard civilian pathways include rodent pups discovered in the rear wheel well of an aircraft that had landed on Guam in March 2010 (Vice 2010b). Management of invasive rodents most often utilizes rodenticide methods, primarily anticoagulants. These methods are implemented in and around buildings, together with practices of exclusion, sanitation, and habitat modification (Timm 1994a, b). Day and night shooting is used with some larger species (e.g., nutria) (LeBlanc 1994). Most island eradications of rodents have utilized anticoagulant rodenticides, hand broadcast, in bait stations, or aerially broadcast (Howald et al. 2007). Military implementation of rodent control can be found in NAVMED P-5010-8, the Naval Manual of Preventative Medicine, Chapter 8, Navy Entomology and Pest Control Technology (U.S. Navy BMS 2004).

Established rodent and other small mammal populations provide excellent food sources which can support other non-native species, especially predators such as the BTS. There are a variety of rodent species already established in the region with some species overlapping and others not. More details on specific species can be found at the issg.org website.

8.6.3.2 *Indian Mongoose*

The Indian mongoose (*Herpestes javanicus*) is an example of an early attempt at biological control of an invasive pest species. It was introduced to the Hawai'ian Islands in an effort to control damage in the sugar cane industry caused by invasive rat populations that invaded the islands (Matthews and Turner 2009). The mongoose is established on some islands in Hawai'i but likely not all of them. A mongoose capture occurred recently on Kauai which prompted officials to set up a response system including interview formats based on those used by the alien snake team through the region (Pers. Comm. J. Stanford). Mongooses have also been introduced to control rats in Fiji, Mauritius, and to Amami-Oshima Island in Japan (Watari et al. 2008). Since their establishment, mongooses have contributed to the decline of populations of many native and endemic species of ground-nesting birds and reptiles, posing a serious ecological threat to Pacific islands. In addition, mongooses can also threaten mammalian health by their transmission of diseases such as *leptospirosis*, canine distemper, canine hepatitis, *toxoplasma, salmonella*, feline panleukopenia, *streptococcus,* and pulmonary virus.

Trapping and toxic baits placed in bait stations are the main methods used for control and eradication of mongoose, although success has usually been marginal (Roy et al. 2002; Quinn and Whisson 2004). Currently, National Wildlife Research Center scientists are working to identify attractants to better monitor and capture mongoose on Hawai'i. Additional methods development will further investigate effective, durable toxic baits and multiple-capture traps for mongoose. Where rabies exists, the development of an oral rabies vaccine for mongoose is also considered an important research goal due to the role of the mongoose as a vector for this virus (Quinn and Whisson 2004).

8.6.3.3 *House Shrew*

In high densities, the Asian house shrew (*Suncus murinus*), also known as the Musk shrew, poses ecological threats and impact on a wide range of other species, including plants, invertebrates, and vertebrates, either through predation or competition (ISSG 2005). This species can also act as a reservoir for the plague (Duplantiera et al. 2005), posing a serious human health threat. The house shrew is currently established on Guam, and due to their commensal nature, they are believed to be transported accidentally in cargo and personal effects (e.g., vehicles, cargo containers) (USDA-APHIS-WS 2010). The house shrew is thought to be anti-coagulant bait resistant and control measures rely on using baited snap traps (ISSG 2005). These shrews are also established on several other islands within Micronesia, including Saipan where they are found at much higher densities than on Guam (the reduced population on Guam is likely due to heavy predation by BTS).

6.3.4 Crab eating Macaque

Crab eating Macaques (*Macaca fascicularis*) are established on one island of Palau where they are produced tremendous negative impacts including reducing numbers of native bird species and impacting the human inhabitants by direct completion for food and destroying crops. While it is unlikely that macaques could "accidently" stowaway and hitchhike to other islands, the fact that some humans consider the young to be valuable pets does make this a species of concern for the islands of Palau as well as the remainder of the region.

8.6.4 Birds

8.6.4.1 *Wild Passerines*

While there are several passerine species that have the potential to be introduced to Guam by air and water transportation pathways, wild passerine species of concern are those that are known agricultural pests of crops grown on Guam, possess highly invasive biological and behavioral characteristics, and exist along routes of frequent transport to and from Guam (Pacific Rim). The red-vented bulbul (*Pycnonotus cafer*) has been introduced to Australia, Fiji, French Polynesia, RMI, New Caledonia, New Zealand, Samoa, Tonga, and the United States via sea freight and more recently, Majuro (RMI) likely via the commercial air transport pathway. It is an agricultural pest (economic threat), an aggressive competitor of endangered native birds such as the Tahiti Flycatcher, a disperser of invasive plants like Lantana, and a prey source for BTS (ecological threat) (ISSG 2005). The black drongo (*Dicrurus macrocercus*), already introduced to Rota and Guam, continues to be an extremely aggressive species that harasses and displaces native bird species, a predator of bees, disperser of invasive plants, and prey source for BTS (ecological threat). The drongo also tends to nest on utility structures, in avoidance of BTS, meanwhile causing electrical damage (economic threat) (Fritts and Rodda 1998). Java sparrows (*Padda oryzivora*) are small passerine birds that are popular in the pet trade and have been introduced to many countries worldwide, including China, Myanmar, Thailand, Sri Lanka, Borneo, Sumatra, Ambon and Lesser Sundas, Fiji, Philippines, Taiwan, Japan, South Vietnam, Christmas Island, and Hawai'i. They feed on a variety of seeds in grasslands and are considered an agricultural pest of grain crops, especially rice (economic threat) (Koopman and Pitt 2007), and have a high reproductive rate with a modal clutch size of eight eggs (Islam 1997). While USDA Code of Federal Regulations prohibits the importation of this species into the United States and its territories, many states allow the possession and interstate traffic of captive-bred birds. Eurasian sparrows (*Passer montanus*) are well established on Guam and several other islands within Micronesia. These sparrows on Guam (as well as other bird species) are an additional food source for non-native predators such as the BTS. There also also a variety of other species including doves and pigeons spread throughout the region. Hawai'i has by far more non-native feral bird species established than any of the islands within Micronesia. Some of these feral population are from original pet stock.

8.6.4.2 *Exotic Pet Birds*

The pet industry is a well-organized and profitable industry in the United States (Ginsburg 2004). At least 94 species of introduced and invasive birds have become established in the United States, and most introductions originated from pets. Most of these are passerines (39 species), but many are psitticines (22 species), popular animals in the pet industry (Kraus 2003). The pet industry is a major pathway for the introduction of vertebrates into the United States (Kraus 2003) because very few are prohibited from entry and can be imported legally with the proper permitting. Requirements of importation of exotic birds to the United States include a USDA import permit, 30-day quarantine at a USDA Quarantine Port Center, and veterinary certification of health from the country of origin (http://www.aphis.usda.gov/import_export/animals/nonus_pet_bird.shtml, accessed 9/14/10).

Once imported, release of caged birds may result in feral populations that can pose economic, ecological, and health threats, respectively to local industry (agriculture, electrical damage), native ecosystems (natural resource competition), and native bird species (host shift of ectoparasites). For example, the monk parakeet (*Myiopsitta monachus*), now established in the Midwest and Eastern United States, is a significant agricultural pest destroying up to 45% of some crops. In some regions, the monk parakeet utilizes native bird species' nest sites (introduced competition), or can cause electrical damage by nesting on utility structures. Currently, there are feral populations of pet bird species in Hawai'i and also likely within Micronesia. The continued importation of bird species for the pet trade sustains the potential risk of release of additional species and in new locations. Pet retailers on Guam are known to import exotic species such as Meyer's parrot, red-bellied parrot, green-cheeked conure, society finches, red-factor canaries, lovebirds, cockatiels, budgerigars, and ringneck doves (Guam pet retailer, personal communication). The non-native Java Sparrow (*Padda oryzivora*) has established at least one (if not more) small populations on Guam (Pers. Comm. J. Stanford).

Control methods for invasive bird species may include disrupting or destroying nests, targeted poisoning, trapping, and hunting. Farmers in Australia have shot more than 27 species of pest birds, but active control of invasive birds remains rather uncommon (Usher 1989). Characteristics inherent to birds such as ability to fly large-distances and high fitness, a commonality of invasive birds species, makes re-colonization a continuous issue, such that pest birds are very difficult to control.

8.7 BIOSECURITY RECOMMENDATIONS

8.7.1 Three-tiered Perspective

Biosecurity measures implemented to mitigate risks posed by terrestrial vertebrate species are necessary at three levels: pre-border, at-the-border, and post-border. Recommendations may be associated with one or more level and may overlap across levels, depending upon the mitigation measures. There are five key issues pertaining to all recommendations: funding, coordination and communication, education and training, early detection, rapid response, and enforcement (of regulatory drivers). For example, cooperative trade agreements, which would fall under coordination and communication, affect pre-border activities, while rapid response programs include at-the-border and post-border activities, and enforcement issues generally range across all levels. Prevention is more effective and cheaper than eradication or long-term control of established terrestrial vertebrate species, so exclusion of these species pre- and at-the-border should be the first line of defense. Eradication is more effective and cheaper in the long run than permanent control of a pest population, so eradication should be considered where feasible.

8.7.2 Key Issues Regarding General Recommendations

This section will discuss some overall, general recommendations for mitigating the risk of transporting vertebrate invasive species unintentionally. More specific recommendations are covered in other sections. These general recommendations should not be considered as the only, or the most important, recommendations. Rather, they should be viewed as a starting point for more formalized recommendations. Five key issues are central to successful implementation of the recommendations given here. These key issues are: funding, coordination and communication, education and training, control methods development, and regulatory drivers and enforcement.

8.7.2.1 *Funding*

Regardless of the biosecurity strategy developed, lack of sufficient and properly managed funds will be the weak link in any effort implemented. Military presence in the region calls for long-term allocation and ongoing management of biosecurity funds. Current funding for regional biosecurity is distinctly inadequate relative to the magnitude of the existing problems posed by invasive species, the emerging problems and associated risks to other islands, and the scope and magnitude of military activity in the region.

Short-term funding cycles hamper necessary methods development and interdiction activities and restrict the forward momentum needed for effective control programs. For example, because BTS efforts are currently underfunded, much higher costs are expected in the future to resolve expanding threats not addressed now. Cost-sharing among agencies and the transportation industry has advanced greatly, with more room for improvement. Although DoD supplies funding for interdiction on military facilities, the DOI Office of Insular Affairs (OIA) is carrying much of the funding responsibility at present for BTS. The Office of Insular Affairs is the primary entity supporting BTS rapid response. Both Interior and DoD support BTS research efforts. Greater and sustainable investment by DoD and other federal agencies is warranted as part of their efforts to reduce the comprehensive impact of military activities and their overall stewardship of natural resources on their lands.

8.7.2.2 *Coordination and Communication*

The multiple economic, ecological, and human health impacts of invasive species create complex challenges in policy formation and governmental coordination (Williams 2007). NISC was established by EO 13112 to provide coordination and planning, and to facilitate cooperation among the diverse federal agencies and to take a more comprehensive approach to invasive species. NISC is co-chaired by the Secretaries of Agriculture, Commerce, and the Interior; and includes a total of 13 federal agencies and departments that have a role in invasive species (Williams 2007).

Federal agencies that must work in coordination to maintain a biosecurity plan include USDA-APHIS, USFWS, CBP, Interior, DoD, Department of Commerce, Department of Energy, DHS, and the Department of Transportation, among others. Interagency coordination is pertinent, as is frequent and comprehensive communications. The communication network that occurs between government agencies results in information that can be compiled, consolidated, and reproduced in a manner suitable and clear to the general public and private industry (e.g., transportation, construction). Local capacity-building is needed to support research, operations, and program management, and to improve local recruitment pools. Efforts could include cooperative university and government programs, so that funding is utilized in a most resourceful manner (Colvin et al. 2005). For example, the public outreach program on Saipan is a model, particularly the partnership with private industry. This public outreach effort, fielded by the Office of Economic Adjustment and the Military Integration Management Committee, conducts community outreach dialogue sessions on Saipan to hear concerns of citizens. This and other demonstration projects illustrate attempts at achieving biological, social, and economic objectives through managing invasive species on islands (Saunders et al. 2007).

In addition there are various local and regional entities which can and should be involved in biosecurity and IAS work. An important or potential important regional body which already is involved with IAS for Micronesia is RISC. This group, if better supported could become a key mechanism for regional communication and coordination activities and in some regards it already is. Many of the jurisdictions also already have established invasive species tasks forces or councils/committees. Groups such as the Pacific Island Learning Network (PILN), the Pacific Invasives Partnership (PIP), and Pacific Invasives Initiative (PII) are also already involved in supporting regional IAS efforts. A few of the jurisdictions also have invasive species coordinators and it is hoped that in the near future each of the jurisdictions could have such a position to support communication and coordination throughout the region on IAS issues. SPC and SPREP, 2 Pacific region groups, are also already very involved in IAS issues within Micronesia and it is hoped that the roles of both of these groups can be expanded to further the support they can provide in this regard.

8.7.2.3 *Education and Training*

Gaps in invasive species management can be bridged by increased education and training, with an emphasis placed on public outreach. Public perception and lack of support have affected efforts to manage or eradicate vertebrate species in the United States, as elsewhere in the world (NISC 2001). Knowledge levels regarding invasive species and the harm they can cause are relatively low among the general public (NISC 2001, Conover 2002). For example, reports on invasive species management in Hawai'i (TNC and NRDC 1992) concluded an overall gap in public awareness of invasive species. This resulted in the formation of the Coordinating Group on Alien Pest Species (CGAPS), a voluntary government/non-government partnership, formed in 1995 to increase public awareness of invasive species. Following the formation of the partnership, CGAPS launched a campaign in 2006, with television and print media and a new toll-free hotline number regarding the dangers of BTS. Encouragingly, follow-up surveys confirmed a rising awareness about BTS (Martin 2007). Educating the public on preventative measures must be continual, especially given that, over time, the longer an invasive species is not discovered, the further it tends to slide from public concern.

Furthermore, staff involved in the enforcement aspect of invasive species (e.g., inspection agents) need to be educated on biological risks on which they act daily. Knowledge of the impacts of introduction is bound to increase staff motivation and efficiency in the workplace. Training should include the taxonomic identification of species, continued education on species status updates, changes to regulations, and new pest species listings (e.g., White List). In conjunction, multimedia educational material will further facilitate proper identification of species, with written descriptions, physical attributes, and animal behavior, as well as immediate human health and safety concerns (see Distance Diagnostic and Identification System, [University of Florida 2010]).

Rapid response programs are designed to implement immediate action on the detection of invasive species. They are comprehensive programs that require the melding of coordination, communication, education, and training. Rapid response actions and sightings are documented in incident reports, and response times are substantially reduced by emphasizing training and public awareness, as shown in the CNMI in 2003 (Colvin et al. 2005). The BTS review by Colvin et al. (2005) found rapid response to be most successful when the following aspects are incorporated into the program: extensive training, public awareness and outreach, use of technological advances, centralized documentation (e.g., SOPs), and networking that allows the program to operate on a regional level. These aspects are central to the recommendations for rapid response programs outlined in the review. Currently, the most developed rapid response programs exist in Guam, Saipan, and Hawai'i, but training and organizational efforts in other archipelagoes in the Pacific Basin are underway. For example, the USGS Rapid Response program has conducted BTS trainings for quarantine officers throughout Micronesia, including the CNMI, Palau, Chuuk, Pohnpei, Kosrae, Kwajalein, Ebeye, and Majuro (Stanford and Rodda 2007). It should be clear that while the BTS response team has existed for more than 10 years, it is not well funded in regards to being able to address issues such as regional outreach and staff turnover at participating agencies has been higher than expected. It has been moderately successful with regional networking, supporting response actions and working within the FSM, RMI, Palau and the CNMI on outreach initiatives due in large part to support from OIA and local authorities. Not all local agencies (none) are well funded and most are extremely understaffed and have little equipment and few training opportunities. Building a high capacity response team on a shoe string budget across multiple countries in an area bigger than the continental US is not an easy task. The fact that RRT has a regional team with trained responders on all of the major islands of the region and the Hawai'ian islands, is to be applauded. So while funds have been appropriated, but given the extent of the situation, those funds and the ability to use them to address ED and RR activities across the region are insufficient.

8.7.2.4 *Control Methods Development*

Methods development is also needed to facilitate prevention measures occurring at the pre-border stage, but its largest application is in mitigation at the post-border stage of introduction of an invasive species. Methods development is most productive when closely coordinated and integrated with SOPs to maximize efficient use of funds and execution in the field (Colvin et al. 2005).

While extensive progress has been made on many aspects of BTS biology and control measures, additional research is needed to facilitate control and interdiction, including topics such as bait and attractants, application of control agents, logistics of control measures (Colvin et al. 2005). Unlike BTS, there remains a lack of methods development for particular invasive species, such as the Asian beauty snake, garter snakes, gecko species, mongoose, and house shrews. Certain species require integrative solutions for effective control methods; characteristics inherent in their biology and behavior may make some species more difficult to control. For example, effective baited trapping of BTS is feasible due to their large movements, while bait and attractants are not as effective on the more sedentary Habu snake (Hattori 1999). Successful methods development relies heavily on sufficient funding to fuel the education, training, human resources, and facilities required to pursue a comprehensive, integrative approach to control and management of invasive species.

8.7.3 General Recommendations

Address funding issues necessary for regional biosecurity. Regardless of the biosecurity strategy developed, lack of sufficient, consistent, and properly managed funds will be the weak link in any effort implemented, allowing for biological invasions of terrestrial vertebrates to occur in the region.

Military funding for biosecurity efforts in the region must be sufficient, consistent, and properly managed. Military presence in the region calls for long-term allocation and ongoing management of biosecurity funds, as many risks to biosecurity are associated not only with the relocation, but with continual and growing military regional activities resulting from the relocation. Management of funds outside the military sector is necessary to curtail gaps in the biosecurity system that hamper success. For example, although sustained military funding to implement biosecurity measures are in place for some species, like BTS, allocation of those funds can be drastically delayed when new transfers of military personnel solely in charge of those funds reassess the BTS threat, as well as the amount and timing of funds that are allocated. Military funding should address current needs, which are grossly inadequate for even basic biosecurity in the region. Military funding solely for the relocation is disproportionate to the need being created over the long term, and therefore funding should extend to cover ongoing and cumulative impacts of the relocation. For example, funding for BTS management should extend beyond the 1-year limit being imposed currently in the final ROD (pg. 104) following military construction and the permanent relocation of non-transient Marine Corps military units to Guam.

Re-authorize the BTS Control and Eradication Act (2004-2009). The 5-year BTS Control and Eradication Act expired in 2009 and needs to be reauthorized. This is an important regulatory driver pertaining to prevention, mitigation, and management of BTS and pertinent for protecting areas exposed to BTS from trade, travel, and tourism. Once reauthorized, USDA and Interior should engage in rulemaking to develop regulations that further protect Micronesia from the spread of BTS.

A centralized group should be responsible for creating avenues for funding within the Micronesia Region. Regional funding is necessary because many of the risks are interrelated and require efforts that cross political boundaries, and sustained efforts are required to effectively minimize risks. Representatives from all pertinent parties could act as a panel to organize priorities, ensure timely and adequate allocation of funds, and implement adaptive management practices of consistently reviewing and refining the funding processes to adapt to changes needed to maintain efficacy. In addition, a centralized group could apply checks and balances to quickly detect problems or shortcomings in the system.

Mandate and enforce regulations for handling cargo, including packing, transport, cargo-staging, palletizing, and loading. Because cargo originates and is destined for myriad locations increasing the potential for transporting unwanted terrestrial vertebrate species, the most cost-effective solution is to regulate the processes involved in cargo movement. Funding is required to adequately develop and enforce regulations for movement of cargo by military and civilian sources with an emphasis on terrestrial vertebrate species. Warehouse facilities that consent to and help facilitate inspections of cargo and cargo handling procedures, such as providing training to staff, and allowing inspections and control efforts to be implemented should be given incentives to maintain this proactive approach. Cargo staging area issues need to be addressed, for example, to reduce the cross-contamination between high- and low-risk cargo. Regulations need to be enforced to show that penalties not only apply, but are actively being implemented.

Centralize biosecurity efforts. The NISC was established by EO 13112 to provide coordination and planning, facilitate cooperation among the diverse federal agencies, and to take a more comprehensive approach to invasive species. However, the multiple economic, ecological, and human health impacts of invasive species create complex challenges in policy formation and governmental coordination (Williams 2007), so that efforts must be centralized in order to operate cohesively and effectively. A central group acting as a liaison can bridge gaps between formal and informal, and military and civilian communications. A central group would outline the current network of the biosecurity communications in the Micronesia Region; identify communication gaps; provide information in the appropriate format for public, private, and military sectors; and be a representative for media and news releases concerning biosecurity.

Develop a biosecurity surveillance system for improved data collection, reporting, and information sharing network. There is a paucity of available information from the military to fully assess risks associated with the unintentional and accidental movement of terrestrial vertebrate species, posing significant risks and undermining biosecurity efforts in the Micronesia Region (USDA-APHIS-WS 2010). Sustained surveillance of biosecurity risks to lead an adaptive response would decrease the risk due to changing threats and changes in the way cargo and people are moved in the future. Further, information sharing would allow programs to be fully integrated into new projects, new cargo routes, or new air and sea shipping companies.

Encourage and participate in action to preserve biodiversity. Include actions taken by joint agency collaborations, such as the Micronesia Challenge (Micronesia Challenge 2009).

Create community funding sources for local programs. Promote local programs, such as "Environmental citizenship" (Barry and Knab 2005), for local training, education, eradication efforts.

Expand and manage University programs. The universities of the region can serve as local facilities for education and training to enhance biosecurity measures.

Comprehensive and continued education is needed. Educate everyone who can help or positively influence the campaign against invasive species. Elements can include disseminating reports and newsletters to educators, journalists, lawmakers, and business and community leaders; establishing local reporting systems for rapid response teams; developing curricula for the schools; and conducting a pre-campaign poll of island residents to gauge levels of awareness regarding species introductions/invasions and subsequent impacts (Holt 1997). Include military and military-civilian personnel.

Implement biosecurity measures for detecting myriad terrestrial vertebrate species. Biosecurity activities need to account for several species of terrestrial vertebrates in the Micronesia Region, but hazards and regulations currently driving biosecurity efforts on Guam are aimed primarily at preventing the transport and spread of BTS. Detection methods for various terrestrial vertebrate species would involve an increase in awareness, adequate training, and proper equipment for dealing with inceptions and the capabilities to report all incidences, including incidental sightings. Such an integrative approach also permits assessment of the cumulative effects of terrestrial vertebrate species movement in the region.

Ensure the number of USDA-APHIS-WS canine inspection teams at military ports. To adequately prevent the movement of BTS on military and commercial boats, the number and capacity of USDA-APHIS-WS Canine Teams should be increased in response, if necessary, to adequately cover boats departing Guam.

Enhance canine inspection teams in the CNMI. Enhance the capabilities of canine teams in the CNMI by increasing the number of personnel and canine teams available, training opportunities, the ability to conduct random inspections, and the number of inspections and amount of materials that can be inspected.

Create a centralized canine inspection station for USDA-APHIS-WS canine teams on Guam for the commercial airport, port facilities, and commercial warehouses. Make the existing canine housing facility on Guam a central inspection headquarters that houses the majority of canine teams. This centralized station may also serve as a community collection point for vertebrate terrestrial species information, and awareness/training programs, and also be a place where the public can report observations and bring specimens.

Develop a labeling and tracking system for all cargo. Implement a barcode-based data collection system, and incorporate it into a centralized biosecurity system. A barcode-based system will typically comprise any or all of the following components: barcode scanners, barcode-based mobile computers (including wireless scanners, pen/key-based terminals, and vehicle-mount computers), barcode printers, barcode labels and ribbons, and barcode data collection software. Provide funding to adequately manage and refine electronic tracking of cargo in the region. Implement adaptive management practices to continually refine the tracking abilities and the overall surveillance system.

Manage the grounds around ports to reduce populations of target invasive species. Unintentional transport of hitchhiking terrestrial vertebrate species may occur in a number of ways. Hitchhiking species may be initially attracted to certain physical or chemical conditions, such as rats nesting in aircraft wheel wells (Vice 2010c), BTS sheltering inside shipping containers or packing material (Fritts et al. 1999), and mice feeding on grain and garbage shipments transported overseas (Baker 1994b). Use USDA-APHIS-WS-approved vertebrate-proof staging areas, spot-lighting checks at night, continual trapping, large area population suppression efforts, and sighting response capabilities.

Expand capacity and funding for control methods for BTS. While progress has been made on many aspects of BTS biology and control measures, additional or improvement of methods would facilitate control and interdiction procedures, including bait and attractants, repellents, large area suppression, additional interdiction techniques, and logistics of control measures (Colvin et al. 2005). Sustained funding to refine existing strategies and develop new methods would decrease the long-term costs of interdiction, improve efficacy, and reduce risk.

Expand capacity of barrier methods for BTS and other invasive species. Develop and use more cost-effective BTS barriers systems that may permanent or temporarily deployed. Develop cost-effective barrier technologies (both physical and chemical) that keep snakes from entering cargo and for use in large- and small-area control efforts.

Develop methods for reducing the risk of transporting amphibians andr lizards. New technologies should be developed for detecting and preventing lizard and frog movement in cargo.

Improve detection methods for rodents on vessels and in cargo. Rodents are difficult to detect, whether aboard vessels, in aircraft, or within cargo. Preventing rodents from entering ports or cargo is the most cost-effective measure for reducing transport of rodent species. NAVMED P-5010-8 is the Naval Manual of Preventative Medicine, Chapter 8, Navy Entomology and Pest Control Technology (U.S. Navy BMS 2004) and outlines preventative measures for rodent control on ships. This includes proper sanitation, pier-side inspections, rat guards, increased illumination, craft/vessel movement restrictions, glue boards, snap traps, and efforts to limit access points to the vessel, aircraft, or cargo. The information available on rodent prevention measures is more extensive for vessels than that of aircraft or cargo. Current control methods for rodents in cargo consist of anti-coagulant bait, snap traps, and sticky traps. Most efforts regarding rodent presence on vessels and in cargo remain in the control realm, while methods on rodent detection are underdeveloped.

Assign trained, uniformed USFWS personnel to law enforcement at commercial and military ports. USFWS personnel can assist in preventing incidences of smuggling, help handle and process confiscated animals, provide permits, provide education, provide assistance in handling and processing terrestrial vertebrates detected by USDA-APHIS-WS inspectors, enforce laws, and be part of rapid response plans at the border.

8.7.4 Unintentional Pathway Recommendations

8.7.4.1 *Air Transportation*

Comply with 100% BTS inspection policy specified in the BTS Control Plan applicable to aircraft conveyances departing Guam in both military and civilian sectors. Comply with 100% BTS inspection of military and commercial aircraft departing Guam as per the NDAA, Public Law 110-181, Section 314 that requires prohibiting the transport and spread of BTS via aircraft, and the Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990 that authorizes a cooperative program to control BTS outside its historic range. Representatives of USDA, the Department Commerce, DoD, and Interior; the CNMI; the Territory of Guam; and the State of Hawai'i, who comprise the BTS Control Committee (formed in May 1993), all advocate for 100% BTS inspection of aircraft leaving Guam.

Comply with 100% BTS inspection policy specified in the BTS Control Plan applicable to aircraft conveyances departing Saipan in both military and civilian sectors. For military and commercial aircraft, the BTS Technical Working Group Plan (2009) specifies 100% BTS outbound interdiction on Saipan and other areas where incipient populations may be evident in the future, such as Tinian and Rota where Guam-based military actions are proposed.

Comply with 100% BTS inspection policy specified in the BTS Control Plan applicable to aircraft conveyances arriving to U.S. sites other than Guam, in both military and civilian sectors. For military and commercial aircraft, the BTS Technical Working Group Plan (2009) specifies 100% BTS inbound interdiction on U.S. sites other than Guam. This includes aircraft arrivals to the Hawai'ian Islands of Oahu, Maui, and Hawai'i from Guam and Saipan. Interdiction measures include inter-agency coordination, such as expanded communication networks to notify Hawai'ian airports and airfields of craft arrivals from Guam and Saipan that missed BTS inspection, and funding to increase inspection capacity for U.S.-bound aircraft departing from Saipan and Guam.

Expand the capacity of USDA-APHIS-WS canine teams for aircraft inspections on Guam. Current demand for canine inspections of aircraft arriving and departing Guam needs to be expanded to meet 100% BTS inspection policy for departing aircraft, as well as account for expected increase in air transportation activity due to the military relocation.

Enhance the capacity of canine teams in the CNMI for BTS inspections of aircraft on Saipan, Tinian, and Rota. Implementation of inspection capabilities for Saipan are necessary because Saipan receives much of its cargo from Guam and the other Mariana Islands receive most of their cargo from Saipan, and because of expected increased activity from military training and deployment missions and commercial travel. USDA-APHIS-WS canine inspections of aircraft departing Saipan need to be implemented to meet 100% BTS inspection policy for departing aircraft, and to meet expected increase in the island's air transportation activity due to the military relocation. USDA-APHIS-WS canine inspections for BTS on aircraft arriving on Tinian and Rota from Guam and Saipan are necessary to keep the islands BTS-free, protect the native ecology and the agricultural interests of each island, and to account for expected increased activity from military and commercial travel. Military training on Rota is expected to increase aircraft traffic, hence increasing the probability of species transport. Current canine inspections of aircraft operating on Tinian and Rota need to be created to meet 100% BTS inspection policy for departing aircraft, to inspect aircraft arriving from Guam or Saipan that missed BTS inspection at departure point, and to account for expected increase in the island's air transportation activity (arrivals/departures) due to the military relocation.

Increase aircraft inspections for BTS and other terrestrial vertebrate species during seasonal peaks in military and commercial air transportation to and from Guam. More commercial flights depart Guam during the summer months, which may reflect peak tourist season, school summer recess, and summer holiday travel (Vice and Pitzler 2008). During these seasonal peaks, aircraft departing Guam, when inspected for BTS, should also be screened to detect terrestrial vertebrate pests, such as amphibians and other reptile species.

Assign at least one USFWS personnel at military and commercial airports. USFWS personnel can assist in preventing incidences of smuggling, help handle and process confiscated animals, assist in the handling and processing of terrestrial vertebrates detected by USDA-APHIS-WS inspectors, enforce laws, and be part of rapid response plans at the border should an aircraft-related incidence occur.

Conduct an internal and external inspection on military aircraft arriving to Guam. Military aircraft carrying classified cargo are exempt from inspection procedures by non-military entities and "enjoy sovereign immunity from interference by all other governmental authorities" including police, health, customs, and immigrations (U.S. Navy 2009b; Hart 2010), compromising biosecurity efforts undertaken to prevent further introductions of unwanted terrestrial vertebrate species to Guam. Certain military aircraft arrivals to Guam warrant internal and external inspections. Military aircraft arriving from locations with known IAS for which Guam is at high risk of receiving need to be inspected either before departing those locations (ideal situation) or immediately on arrive to Guam. Military aircraft that arrive to Guam from Asian ports such as those in Japan, China, and Korea should be inspected for species of mice, birds, and amphibian and reptile species trapped within cabin and cargo compartments or hitchhiking externally in wheel well compartments.

Improve rapid response capabilities at military and commercial airports on Guam, Hawai'i, Chuuk, Palau, Pohnpei, Yap, Kosrae, Marshall Islands and CNMI Islands of Saipan, Tinian, and Rota. Rapid response measures prevent the opportunity for introduced pest species to become established. Rapid response takes place at the border and post-border, at levels ranging from federal to local community involvement. Monies have already been appropriated for rapid response capabilities in the region, but the efforts implemented remain ineffective for dealing with terrestrial vertebrate species. Conduct a review of the current process for rapidly responding to border and post-border detections and casual sightings. Apply BMPs to refine and improve protocols and coordination of efforts. Conduct practice drills to hone response skills and test communications network. Expand the communication network system. Improve processes for notifying jurisdictions receiving high-risk aircraft from Guam (e.g., contains high risk cargo, missed BTS inspection before departure). Provide information on specific species like BTS to military and civilian residential communities adjacent to airports and military airfields, and allow the public to be part of rapid response programs, with involvement levels ranging from organized community watch-groups to individuals calling into a pest species hotline for immediate reporting of a sighting.

Perform internal inspections on all military aircraft during washdown procedures, both general and retrograde washdown, to detect and capture terrestrial vertebrate species located within the aircraft.

Military procedures for washing aircraft focus solely on external cleaning, with an emphasis on soils and agricultural pests like insects. Because internal cleaning and inspections are not performed, terrestrial vertebrates hitchhiking within an aircraft being washed go undetected. This includes aircraft involved in routine flight operations, aircraft transported as cargo items (via air or water transport), or those staged upon a departing aircraft carrier.

Minimize distance between washdown facilities (general and retrograde wash facilities) and airports of embarkation. Military aircraft departing from a washdown facility (general or retrograde) should cover a minimal distance to port of embarkation to prevent post-contamination prior to loading. For example, the final ROD (2010) states that after a training event on Guam is complete, "vehicles and equipment will return to the wharf or airfield" to be washed and inspected prior to being loaded on to the ships or flying off-island." However, neither washdown facility locations, nor type (general or retrograde) at military airports and airfields like Andersen AFB, the NWF, and Orote Airfield are specified.

Implement measures to control terrestrial vertebrate species at and around washdown facilities. Terrestrial vertebrate species control efforts at washdown facilities are needed to prevent post-contamination of washed aircraft staged for loading, and to reduce populations of pest species in surrounding areas. Control efforts include constructing USDA-APHIS-WS-approved species-proof barriers around secured washing and staging areas, collection/screening of wastewater run-off, and implementation of trapping and perimeter searches for pest species like BTS and other terrestrial vertebrate species. Implementation of snake trapping and snake barriers will not assist in address issues with other vertebrate taxa such as flighted birds, amphibians, and some mammals and of course suggested measures to protect against vertebrates will also not reduce risk from other taxa groups such as invertebrates.

Military retrograde and general washdown procedures for aircraft departing Guam for the Hawai'ian Islands are not specifically for detecting hitchhiking terrestrial vertebrate pest species. Because BTS presence is likely missed by external washing and inspection procedures for aircraft departing Guam, transporting these aircraft does not comply with 100% BTS inspection of military and commercial aircraft departing Guam as per the NDAA, Public Law 110-181, Section 314 that requires prohibiting the transport and spread of BTS via aircraft to other U.S. locations. Further, other terrestrial vertebrate pest species are not targeted, and they are likely missed during inspections.

Conduct inspections on commercial/private aircraft arriving to Guam, and those departing Guam that do not meet the BTS criteria for screening exemption. Currently, aircraft departing Guam are typically inspected externally for BTS, using visual and/or USDA-APHIS-WS canine Inspection techniques. Internal aircraft inspections (both arrivals and departures) do not typically occur, even when departing aircraft fail to meet criteria for exemption, for example, if the aircraft has been on the ground more than 3 hours, was left on the tarmac overnight, or is dispatched immediately for emergency and medical needs. Further, there are currently no aircraft departure screenings to detect terrestrial vertebrate species other than BTS. Inbound commercial and private aircraft are rarely inspected, internally or externally.

Examples include planes pulled into service after being in storage or in a repair facility, privately owned or leased aircraft, charter planes, and airfreight aircraft.

Provide a pre-clearance staging area for all military aircraft requiring immediate departure from Guam. Urgent military missions such as search and rescue (CSAR) and medical evacuation (MEDEVAC), immediate humanitarian efforts, or special mission deployments by the military will not be delayed to accomplish a BTS (or other terrestrial vertebrate species) inspection. A USDA-APHIS-WS terrestrial vertebrate species-proof staging area can be built and staffed to accommodate aircraft solely for immediate departure at Andersen AFB and applicable airfields on Guam, including sustained funding and implementation of control measures in and around staging areas such as trapping, spotlight searches, bait stations, and USDA-APHIS-WS canine team inspections for BTS, trapping and baiting for rodent species, and toad-proof barriers for anurans.

Provide USDA-APHIS-WS-approved temporary barriers for military and commercial aircraft left on the tarmac overnight. The greatest concern regarding aircraft parked on the tarmac overnight is the potential for terrestrial vertebrate species to access wheel wells and baggage holds (Vice and Pitzler 2008). Temporary barriers minimize the probability of terrestrial vertebrate species access to stationary aircraft left unattended overnight. This recommendation would be fulfilled through the re-authorization of the BTS Control and Eradication Act of 2004 (H.R. 3479).

For military and commercial sectors, formalize a notification process for destinations receiving aircraft from Guam that missed BTS inspection, including creating increased capabilities for responding to notifications. The system that currently exists for notifying destinations that an aircraft departed from Guam without a BTS inspection is an informal process and is not necessarily followed. When notification is made, there is typically a limited response; locations do not have the ability to respond to those arriving aircraft. While the DoD has a more formal notification process, destination locations still lack response capabilities (Vice, personal communication).

Coordinate biosecurity among contractors (military and civilian) involved in regional military air transportation. Entities involved in air transportation activities need to be included in biosecurity measures to ensure regulatory compliance, close gaps in inspection processes, and improve effectiveness of inspection efforts. For example, the military recently solicited for Transient Alert Aircraft services on Andersen AFB, Guam (30 June 2010), to perform numerous and diverse services, including aircraft movement and operations, safety management, special events support, emergency and training support, requested vehicle escorts, and management of publications and forms (U.S. Air Force 2010). Mitigation includes establishing agreements to facilitate inspections, determining communication networks, and implementing efficient biosecurity measures.

Expand control efforts to reduce BTS populations around commercial and military airport and airfield facilities. Reducing pest populations at military and commercial aircraft arrival and departure points reduces the probability of contamination from surrounding sources, and limits the attraction by predatory species to sources of prey. Control efforts, which are already being performed for BTS, warrant expansion of efforts, including ground searches, area-wide trapping and suppression efforts, upkeep of perimeter fencing, and fence line searches.

Expand control efforts to reduce rodent populations around commercial and military airport and airfield facilities. Control of rodents is usually done on a response-basis such that detected rodent evidence will typically illicit the response to trap. Response to rodents or rodent evidence detected (feces, evidence of gnawing) in airport buildings or the surrounding grounds should be immediate. Even a single mouse or rat species can endanger aircraft passengers and compromise aircraft operations by gnawing at cables and wiring (WHO/HQ 1995). The Governments of Guam and the CNMI might consider establishing and enforcing sanitation codes and standard operational control methods as practical ways of minimizing and eliminating pest species habitat and food sources at cargo warehouses, airports, ports, and storage areas; however, stable, long-term funding for enforcement would be necessary.

Address military-related aircraft training and operations. Aircraft training exercises that use either improved (paved runway) or unimproved (unpaved landing sites) to practice landing/takeoff and air field support (including loading/unloading of fuel, munitions, cargo, and personnel), need to implement and manage biosecurity measures, such as those used for BTS (e.g., USDA-APHIS-WS approved snake-barriers, spotlight/hand-capture, and trapping) and rodents (e.g., trapping), as well as for species not usually targeted, such as geckos and frogs.

Facilitate training/education programs regarding terrestrial vertebrate pest species for inspectors. Train personnel to detect myriad species and provide continued education on species updates, such as changes to regulations and new pest species listings. Hold regular meetings to discuss pertinent issues and needs pertaining to inspection/detection at pre-border and border screenings.

There are limited methods for dealing with terrestrial vertebrate pest species detected aboard aircraft. Biosecurity measures for responding to incidents of terrestrial vertebrate pest species aboard aircraft are limited; for rodents, snake species, and insects, aircraft fumigation is an option, but it does not guarantee finding or exterminating such species detected within the aircraft, and it does not specifically target amphibian species.

Expand capacity at Guam's airports and airfields (military and commercial) to conduct comprehensive terrestrial vertebrate pest species inspections of arriving and departing aircraft. Inspections at operational airports and airfields on Guam may not adequately detect a terrestrial vertebrate invasive species moving in aircraft for various reasons like outdated equipment, understaffing, or inadequate regulation and enforcement.

Agricultural inspections at operational airports and airfields on Guam may not adequately detect a terrestrial vertebrate invasive species moving in aircraft. Agricultural inspections focus on plant pests and diseases such as plant pathogens and insect species, hence they do not directly inspect for, or report on, terrestrial vertebrate pests.

Rapid response measures for aircraft detections need to address terrestrial vertebrate pest species in addition to BTS. Rapid response is necessary for preventing species spread at the border and post-border via responses to species sightings. Rapid response measures for BTS are insufficient for responding to and preventing introductions of other terrestrial vertebrate species like frogs and rodents. In a more ideal world there would be response teams for each taxa group, but its unlikely that this can be achieved. Micronesia and Hawai'i currently do have a regional response team of highly training IAS responders who's training has been based on one taxa group, alien snakes but it should be clear that that training while focused on alien snake ED and RR also took into consideration the reality of the situation and therefore was for many years provided in a broadened manner so that trained responders could in fact support response actions to various taxa. This was done in part since the reality is that for most of the islands of Micronesia, the same responders will be call on for most taxa so as much as possible the alien snake training was conducted with the understand of a board array of concepts and tools needs to be addressed as team members will likely participate in responses to multiple taxa groups. And this in fact has happened and will continue to happen. The regional response team has supported response and detection work on a variety of snake species as well as lizards. Ultimately much of the underlying components of a response situation will in fact be standardize (or should be) and with appropriate field leadership and some individuals to lead the specific field activities modified for the correct taxa group then successful responses can be mounted across taxa groups by the same core set of well trained responders. Incident command structure is what the alien snake team used in the past to set up and conduct its field work and all responses regardless of taxa group should be following the same or similar format adjusted as needed for the specifics of that group. This flexibility is in fact part of the core concept of ICS training. What the lacking is training for more individuals, especially for the non-U.S. jurisdictions and dedicated leadership or coordinators. The ability to training additional staff for ED and RR work is readily available if courses can be provided on site (within the various jurisdictions). Coordination and leadership for response activities could come from a variety of sources and it may be worthwhile to utilized the emergency response planning documents prepared by the RRT Coordination office in conjunction with each jurisdiction as these existing materials will provide a guideline for how best to develop a more generic response capacity for the region. Additionally, IS coordinators for each jurisdiction as well as a region IS position would greatly enhance the ability to respond effectively to expected incursions of IAS throughout the region.

Expand financial resources in the CNMI (Saipan, Tinian, Rota primarily) to maintain expensive control programs. Efficient detection and prevention of introductions of terrestrial vertebrate species depends on biosecurity measures implemented and the resources allocated to accomplish them, such as border inspections, control and eradication efforts, and rapid response programs. For example, lack of funds to purchase mice for BTS trapping efforts on Tinian create a risk in delaying or ceasing control/eradication efforts (T. Castro, K-9 Dog Handler, BTS Program, CNMI, USDA 2010).

Communication is inadequate between the military and BTS inspection officials on Tinian to allow for proper inspections of aircraft associated with military training to occur. Develop effective SOPs for communication between groups that promote formalized processes for inspecting all aircraft arriving on Tinian from Guam.

Change procedures for canine cargo inspections at indoor warehouse facilities. Canine inspections at indoor warehouse facilities are compromised when exhaust fumes from operating equipment such as trucks and forklifts cannot properly vent from the building, thereby influencing detection capabilities of dogs. Implement a hiatus of equipment activity and the running of ventilation fans half an hour prior to inspections, or move cargo to be inspected to outdoor USDA-APHIS-WS-approved staging areas.

8.7.4.2 *Water Transportation*

Comply with 100% BTS inspection policy specified in the BTS Control Plan applicable to vessels departing Guam in both military and civilian sectors. Comply with 100% BTS outbound interdiction for vessels departing Guam as per the NDAA, Public Law 110-181, Section 314 that requires prohibiting the transport and spread of BTS from Guam, and the Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990 that authorizes a cooperative program to control the BTS outside its historic range. Representatives of USDA, the Department of Commerce, DoD, and Interior; the CNMI; the Territory of Guam; and the State of Hawai'i, comprise the BTS Control Committee (formed in May 1993), advocate for 100% BTS inspection of vessels leaving Guam.

Comply with 100% BTS inspection policy specified in the BTS Control Plan applicable to vessels departing Saipan in both military and civilian sectors. For military and commercial vessels, the BTS Technical Working Group Plan (2009) specifies 100% BTS outbound interdiction on Saipan and other areas where incipient populations may be evident in the future, such as Tinian and Rota, where Guam-based military actions are proposed.

Comply with 100% BTS inspection policy specified in the BTS Control Plan applicable to vessels arriving to U.S. sites other than Guam, in both military and civilian sectors. For military and commercial vessels, the BTS Technical Working Group Plan (2009) specifies 100% BTS inbound interdiction on U.S. sites other than Guam. This includes vessels arriving to Hawai'ian Islands like Oahu, Maui, and Hawai'i from Guam and Saipan used as commercial, military, and military-contracted cargo and barge shipping vessels, and vessels used for military training and mission deployment. Interdiction measures include inter-agency coordination, such as expanded communication networks to notify Hawai'ian seaports of vessel arrivals from Guam and Saipan that missed BTS inspection; funding to increase inspection capacity for U.S.-bound vessels departing from Saipan and Guam; and pre-clearance arrangements with Hawai'ian port officials, both military and commercial.

Expand the capacity of USDA-APHIS-WS canine teams for vessel conveyance inspections on Guam. Current demand for canine inspections of ocean vessels arriving and departing Guam needs to be expanded to meet 100% BTS inspection policy for departing vessels, as well as account for expected increase in water transportation activity due to the military relocation.

Enhance canine teams in the CNMI for BTS inspections of vessels on Saipan, Tinian, and Rota. Implementation of inspection capabilities for Saipan are necessary because of BTS presence on the island, because Saipan receives much of its cargo from Guam and the other Mariana Islands receive most of their cargo from Saipan, and because of expected increased activity from military training and deployment missions and commercial travel. USDA-APHIS-WS canine inspections of aircraft departing Saipan need to be implemented to meet 100% BTS inspection policy for departing aircraft, and to meet expected increase in the island's air transportation activity due to the military relocation. USDA-APHIS-WS canine inspections for BTS on vessels arriving Tinian and Rota from Guam and Saipan are necessary to keep the islands BTS-free, protect the native ecology and the agricultural interests of each island, and to account for expected increased activity from military and commercial travel. Military training on Rota is expected to increase aircraft traffic, hence increasing the probability of species transport. Current canine inspections of vessels operating on Tinian and Rota need to be created to meet 100% BTS inspection policy for departing vessels, to inspect vessels arriving from Guam or Saipan that missed BTS inspection at departure point, and to account for expected increase in the island's vessel transportation activity (arrivals/departures) due to the military relocation.

Assign at least one USFWS personnel at military and commercial seaports. USFWS personnel can assist in preventing incidences of smuggling, help handle and process confiscated animals, assist in the handling and processing of terrestrial vertebrates detected by USDA-APHIS-WS inspectors, enforce laws, and be part of rapid response plans at the border should a vessel-related incidence occur.

Conduct an internal and external inspection on military vessels arriving to Guam. Military vessels "enjoy sovereign immunity from interference by all other governmental authorities" including police, health, customs, and immigrations (U.S. Navy 2009b; Hart 2010), compromising biosecurity efforts undertaken to prevent further introductions of unwanted terrestrial vertebrate species to Guam. Certain military vessel arrivals to Guam warrant internal and external inspections. Military vessels arriving from Saipan where an incipient BTS population exists need to be screened by USDA-APHIS-WS canine teams on Guam if the vessel was not inspected at its departure point, especially if the vessel is transient and departs Guam without a BTS inspection (i.e., for emergency/medical use). Military vessels that arrive to Guam from Asian ports such as those in Japan, China, and Korea should be inspected for species of mice, birds, and amphibian and reptile species hitchhiking within cabin and cargo compartments.

Continue to expand rapid response capabilities at military and commercial seaports on Guam, Pohnpei, Palau, Yap, Chuuk, Kosrae, Marshall Islands and the CNMI Islands of Saipan, Tinian, and Rota. Rapid response measures prevent the opportunity for introduced pest species to become established. Rapid response takes place at the border and post-border, at levels ranging from federal to community involvement. The expansion of capabilities of rapid response programs would result in an increase in training and rapid response skills, while expanding communication networks. In addition, these programs provide information on species of concern, like BTS, to civilian and military, including residential communities, ajacent to seaports, and allows the public to be part of rapid response programs, with involvement levels ranging from organized community watch-groups to individuals calling into a pest species hotline for immediate reporting of a sighting.

Perform internal inspections of vessels during washdown procedures, both general and retrograde washdown, to detect and capture terrestrial vertebrate hitchhiking species. Military procedures for washing vessels focus solely on external cleaning, with an emphasis on soils and agricultural pests like insects. Because internal cleaning and inspections are not performed, terrestrial vertebrates hitchhiking within a vessel go undetected. This includes vessels involved in routine military training and operations, military deployment missions, and vessels staged as cargo for transport. Coordinate with the on-site commanders to supervise washdown facilities and inspection areas. For general washing, the 36th ABW may provide portable high-pressure washers and a cleaning area, and future plans include repair of a 36 Transportation Squadron vehicle washing area (U.S. Navy 2005b).

Minimize distance between washdown facilities (general and retrograde wash facilities) and seaports of embarkation. Military vessels departing from a washdown facility (general or retrograde) should cover a minimal distance to port of embarkation to prevent post-contamination prior to loading. For example, for military embarkation operations, "…a cargo staging and vehicle washdown area would be provided in proximity, but not adjacent to, the wharf" (U.S. Navy 2009a, Vol. 1, pg. 2-11, section 2.2.3.1), and the final ROD (2010) states that after a training event on Guam is complete, "vehicles and equipment will return to the wharf or airfield" to be washed and inspected prior to being loaded on to the ships or flying off-island." However, washdown facility locations, or type (general or retrograde), are not specified by the military.

Implement measures to control terrestrial vertebrate species at and around washdown facilities. Terrestrial vertebrate species control efforts at washdown facilities are needed to prevent post-contamination of washed vessels staged for loading, and to reduce populations of pest species in surrounding areas. Control efforts include constructing USDA-APHIS-WS-approved species-proof barriers around secured washing and staging areas, collection/screening of wastewater run-off, and implementation of trapping and perimeter searches for pest species like BTS and other terrestrial vertebrate species.

Conduct inspections on commercial and private vessels arriving to and departing Guam. Comply with 100% BTS outbound interdiction for vessels departing Guam as per the NDAA, Public Law 110-181, Section 314 that requires prohibiting the transport and spread of BTS, by conducting inspections on vessels departing Guam. Commercial and private vessels are rarely inspected, internally or externally. Such vessels include but are not limited to boats used for fishing, recreational sailing, and those in the charter industry. Expand the use of visual and USDA-APHIS-WS canine team inspections. Expand vessel inspections to include terrestrial vertebrate species other than BTS and rodents, and conduct internal vessel inspections for rodent, snake, and amphibian populations.

Provide a pre-clearance staging area for all military vessels requiring immediate departure from Guam. Compliance with 100% BTS inspection of vessels leaving Guam is not achieved if urgent military missions, immediate humanitarian efforts, or special mission deployments by the military depart without delay for a BTS (or other terrestrial vertebrate species) inspection. Such vessels include but are not limited to amphibious vessels like Landing Craft Air Cushions (LCAC), patrol boats such as PACV/ACV, PBL, PBR, and PCF, and rigid inflatable boats. A USDA-APHIS-WS terrestrial vertebrate species-proof staging area can be built and staffed to accommodate applicable vessels for immediate dispatch from

Guam at seaports and applicable beach launch sites (for amphibious craft), including sustained funding and implementation of control measures in and around staging areas such as trapping, spotlight searches, bait stations, and USDA-APHIS-WS canine team inspections for BTS, trapping and baiting for rodent species, and toad-proof barriers for anurans.

Provide USDA-APHIS-WS-approved temporary barriers for military and commercial vessels staged on land overnight. Vessels staged overnight on land for storage, cleaning, repair, or special deployment offer hitchhiking terrestrial vertebrate species access to external and internal compartments and storage holds. Temporary barriers minimize the probability of terrestrial vertebrate species access to vessels left unattended overnight.

Coordinate biosecurity among contractors (military and civilian) involved in regional military water transportation. Entities involved in water transportation activities need to be included in biosecurity measures to 1) ensure regulatory compliance, 2) close gaps in inspection processes, and 3) improve effectiveness of inspection efforts. Mitigation includes establishing agreements to facilitate inspections, determining communication networks, and implementing efficient biosecurity measures.

Expand control measures to reduce pest species populations around commercial and military seaport and beach access point facilities. Reducing pest populations at military and commercial seaports and beach access points where vessels arrive and depart reduces the probability of contamination from surrounding sources. Efforts include but are not limited to ground searches, upkeep of perimeter fencing, implementing USDA-APHIS-WS-approved terrestrial vertebrate species-proof barriers, and specific trapping for species of rodents and snakes. When rodents or rodent evidence (feces, evidence of gnawing) is found in buildings or the surrounding grounds, immediate control steps must be taken. Even a single mouse or rat species can endanger the health of ship passengers and compromise vessel operations by gnawing at cables and wiring. The Governments of Guam and the CNMI might consider establishing and enforcing sanitation codes as a practical means of minimizing and eliminating pest species habitat and food sources at cargo warehouses, airports, ports, and storage areas, and even establishing a regulatory basis for pre-clearance of cargo arrivals and departures; however, stable, long-term funding for enforcement would be necessary.

Address military-related vessel training and operations. Vessels used in training exercises at seaports or at beach access points require internal and external inspections for terrestrial vertebrate species, especially BTS. Further control measures should also be implemented at least for BTS (e.g., USDA-APHIS-WS-approved snake-barriers, spotlight/hand-capture, and trapping) and rodents (e.g., trapping, baiting), as well as for species not usually targeted, such as geckos and frogs.

Facilitate training/education programs regarding terrestrial vertebrate pest species for inspectors. Train personnel to detect myriad species and provide continued education on species updates, such as changes to regulations and new pest species listings. Hold regular meetings to discuss pertinent issues and needs pertaining to inspection/detection at pre-border and border screenings.

Increase vessel inspections for BTS and other terrestrial vertebrate species during seasonal peaks in military and commercial water transportation to and from Guam. This recommendation addresses seasonal increases in military vessel traffic, private vessel traffic, and commercial ship and barge traffic. During these seasonal peaks, when vessels departing Guam are inspected for BTS, they should also be screened to detect terrestrial vertebrate pests, such as amphibians and other reptile species.

Military retrograde and general washdown procedures for vessels departing Guam are not specifically for detecting hitchhiking terrestrial vertebrate pest species. Foremost, because BTS presence is likely missed by external washing and inspection procedures for departing vessels, movement of these vessels does not comply with 100% BTS inspection policy, as per the NDAA, Public Law 110-181, Section 314 that requires prohibiting the transport and spread of BTS via vessels.

Agricultural inspections at operational seaports on Guam may not adequately detect a terrestrial vertebrate invasive species moving in vessels. Agricultural inspections focus on plant pests and diseases such as plant pathogens and insect species, and do not directly inspect for or report on terrestrial vertebrate pests.

Expand capacity at Guam's seaports (military and commercial) to conduct comprehensive terrestrial vertebrate pest species inspections of arriving and departing vessels. Inspections at operational seaports on Guam may not adequately detect a terrestrial vertebrate invasive species moving in a vessel because of outdated equipment, understaffing, or inadequate regulation and enforcement.

Develop new methods and further develop current methods for detecting and controlling terrestrial vertebrate pest species aboard vessels. There are limited methods for dealing with terrestrial vertebrate pest species aboard vessels. Biosecurity measures aboard vessels include adhering to good sanitation practices (e.g., proper food storage and garbage disposal), routine checks by crewmembers (e.g., for rodent droppings, cast skin from ecdysis), screening all cargo coming aboard (e.g., on Guam and Saipan for BTS), and active trapping and baiting programs. Methods implemented must target multiple species. For example, methods that specifically target rodents do not guarantee effectiveness on other pest species such as amphibians.

Rapid response measures for vessel detections need to address terrestrial vertebrate pest species in addition to BTS. Rapid response is necessary for preventing species spread at the border and post-border via responses to species sightings. Rapid response measures for BTS are insufficient for responding to and preventing introductions of other terrestrial vertebrate species like frogs and rodents.

Expand financial resources in the CNMI (Saipan, Tinian, Rota primarily) to maintain expensive control programs. Efficient detection and prevention of introductions of terrestrial vertebrate species depends upon biosecurity measures implemented and the resources allocated to accomplish them, such as border inspections, control and eradication efforts, and rapid response programs.

Improve protocols for inspecting the holds of commercial and military ships. Transit times for ships sailing between Guam and Saipan are less than 1 day, increasing the probability of survival for species stowed aboard. Ship inspections are inadequate and performed perfunctorily due to time and staffing constraints. Regulations only apply to cruise ship vessels but not routinely and not entirely.

Conduct USDA-APHIS-WS inspections on vessels staged at Guam Shipyard facilities. There is no mention of impact or mitigation measures for the increased activity at the Guam Shipyard as a result of military activity. The Guam Shipyard provides vital shore industrial support, repair, maintenance, overhaul, and dry-docking services to military vessels such as those of the Military Sealift Command, Coast Guard, and local federal agencies on island. They provide authorized repair to Jones Act commercial ships such as Matson Navigation and Sealand Services, and shore support services to GovGuam agencies. Guam Shipyard has facilities and capabilities not found elsewhere in the Western Pacific, including a foundry, the largest motor rewind facility in the Pacific, a special building for environmentally controlled sandblasting and painting, micro-miniature circuit board repair, corrosion control, and an industrial laboratory. It is the only facility in the Western Pacific certified by the U.S. Department of Transportation to perform re-certification requirements on breathing air and high pressure air cylinders. With these amenities and services, biosecurity measures must be implemented and maintained at Guam Shipyard. Such measures would include building and maintaining perimeter fencing and vertebrate-proof staging areas, using USDA-APHIS-WS canine team inspections (e.g., of facilities, stored vessels), adhering to proper sanitation and material storage procedures, enforcing noncompliance such as unpermitted actions like the loading of cargo (Aguon 2009), and continued trapping (e.g., rodents, snakes, geckos).

Increase inspection frequency and quality for commercial shipping vessels from the major shipping lines inbound to Guam. Commercial shipping vessels calling on the Port of Guam are typically cleared rapidly, within 30 minutes, by GCQA (Merefalen, personal communication), with emphasis on regulated waste inspections and reviewing cargo manifests. Both the number and thoroughness of inspections need to be increased, with expanding capacity to randomly inspect vessels without delaying shipping schedules. This requires increased staffing and training of inspection personnel and strong communication between port officials, inspection agents, and vessel owners/operators.

Require the use of rat guards on mooring lines. Military and commercial vessels at seaport facilities in the Micronesia Region should be required to use rat guards on mooring lines. Currently, rat guards are used at ports with known rodent infestations. Internal Health Regulations only require rat guards to be in place where plague is endemic to the port (Regulation 40-12 SECNAVINST 6210.2A AFR 161-4, DoD, 1992, Section 9, p 2). However, ships may harbor insidious rodent populations, or unknown rodent infestations may occur at seaports; therefore, rat guards should be made a standard requirement.

Rat guards on mooring lines may not prevent BTS from ship access. Use of rat guards by vessels in port may not prevent BTS or other arboreal species access to the ship via mooring lines. The maximum diameter of a rat guard is 122 centimeters (48 inches) or 96 centimeters (38 inches) (NAVMED P-5052-26 2008, BUMED Instruction 6250.14A Feb 16, 2001).

Amphibious craft laydown locations and facilities for storing, maintaining, and deploying amphibious vehicles (chapter 5, FEIS/FOEIS 2010) should incorporate control efforts to prevent transport and

spread of terrestrial vertebrate hitchhikers that could contaminate vessels. Amphibious vehicle laydown areas are required to store, wash down, maintain, and deploy amphibious vehicles, such as landing craft and amphibious assault vehicles. LCACs would also utilize this area. Specific components of the laydown area include two new concrete ramps, which are similar to recreational boat ramps seen at private marinas, paving for amphibious vehicle parking, personal vehicle parking, staging equipment, amphibious vehicle washing, four support buildings for administration, small boat storage, and maintenance http://guambuildupeis.us/documents/final/volume_1/Vol_01_Ch02_Overview_of_Proposed_Actions.pdf.

There are proposed to be as many as 4 LCACs, 14 amphibious assault vehicles, and 8 small reconnaissance boats permanently based in such an area. Recommendations for amphibious craft laydown locations include constructing and maintaining USDA-APHIS-WS-approved terrestrial vertebrate species-proof barriers, implementing measures to control and reduce pest populations within buildings, in stored/staged vehicles, and the on surrounding grounds. The governments of Guam and the CNMI might consider establishing and enforcing sanitation codes as a practical means of minimizing and eliminating pest species habitat and food sources; however, stable, long-term funding for enforcement would be necessary.

Implement protocol for preventing terrestrial vertebrate species transport via amphibious vehicle operation/use or transport. Amphibious military vehicles are both terrestrial and marine vessels, and as such, are capable of transporting and spreading terrestrial vertebrate hitchhikers over land and water (U.S. Navy 2005c). Amphibious vehicles include, but are not limited to, amphibious armored personnel carriers, amphibious assault vehicles, amphibious land rovers, amphibious bikes and ATVs, amphibious trucks and barges such as lighter, amphibious resupply, cargo vehicles, hovercrafts, and LCAC (Figures 11-3a to 3c). The amphibious task force would require an area to load and unload personnel, vehicles, and other cargo. Equipment cleaning and inspections associated with bio-hazard and customs requirements would also occur in this area. These operations are collectively referred to as waterfront embarkation. The amphibious ships would be berthed at Victor Wharf (the wharf traditionally assigned for amphibious shipping in Apra Harbor). A new port operations building would be constructed at the wharf, and a cargo staging and vehicle washdown area would be provided in proximity to but not adjacent to the wharf. Washdown facilities should follow biosecurity protocol (e.g., routine inspection of facilities and equipment staging areas, collection/screening of wastewater run-off, perimeter fencing, lighting for night activities, USDA-APHIS-WS-approved vertebrate-proof staging areas).

Figures 11-3a to 11-3c: Types of Amphibious Vessels and Vehicles

3.a.  3.b.  3.c. 

a. LARC-V), b. AAV, c. LCAC
Sources: a. Guide to South Padre Island; b. Defense Industry Daily, LLC; c. .U.S. Navy, Mark Patterson II

Implement terrestrial vertebrate species inspection procedures for vessels with ramp-loading capabilities. Vessels capable of loading at piers, wharves, or beaches via a ramp with direct access to the hull are used in support of military activity to transport equipment, troops, tracked or wheeled vehicles, and amphibious crafts to beachheads or piers via a ramp with direct access to the hull. These include Roll-on/Roll-off Ships, Landing Craft Utility vessels (Figures 11-4a to 4d), Joint High Speed Vessels (JHSV), and LCAC. Hitchhikers can gain access to these vessels when ramps are deployed, or from the cargo load.

Figures 11-4a to 11-4d: Landing Craft Utility Vessels With Direct Access To Hull From Beach

4.a. 

4.b. 

4.c. 

4.d. 

Sources: a. Lawrence Livermore National Laboratory; b.US Air Force, Staff Sgt. D. Myles Cullen; c. US Navy, 1st Class David A. Levy; d. US Navy, 2nd Class Bradley J. Sapp

Implement terrestrial vertebrate species inspection procedures for high-speed-military vessels operating in the Micronesia Region. HSV serve as Logistic Support Vessels, provide a technically advanced and highly capable platform for deployment of troops, equipment, and vehicles, and are advantageous because of their payload capacity, high-speed transport, and distance capabilities. Such vessels include the HSV Westpac Express catamaran (Marine Corps) operating in the area of Guam, Okinawa, and Japan (Tack 2010), HSV, JHSV, and LCAC (Figures 11-5a to 5d) The high speeds mean forces and cargo reach destinations in a shorter time with shorter intervals between trips. Shorter transit times equates to increased probability of species survival during transport, the long-distance capabilities increase the range of potential spread of species, and increased payload capacities along with greater diversity in types of cargo transported equates to a higher probability of species presence.

Figures 11-5a to 11-5d: High Speed Transport Vessels

5.a. 

5.b.  5.c. 

5.d. 

a. HSV/TSV cutaway, b-c. TSV-1X Spearhead, d. HSV-2, I. Westpac Express
Source: Defense Industry Daily, LLC

Implement USDA-APHIS-WS inspections for aircraft carriers arriving and departing Guam. Given their ability to embark different combinations of aircraft, carriers are vessels that are highly flexible naval platforms. If the Port of Guam becomes a home port for an aircraft carrier fleet and/or is a port of call for visiting/transiting aircraft carrier activity in the Micronesia Region, USDA-APHIS-WS terrestrial vertebrate inspections on both arriving and departing carriers should be conducted, including staged equipment. Spell out criteria for inspection process; comply with 100% BTS inspection policy specified in the BTS Control Plan applicable to ocean vessels departing Guam, and inspect arriving carriers when the last port of call was in a country of concern.

8.7.4.3 *Air Cargo*

8.7.4.3.1 *Military Air Cargo*

Recommendations in the military air cargo pathway focus on cargo itself as a mode of species transport, including how the cargo is packed and handled, the cargo conveyance (e.g., crate, container, pallet, box, individual items), and the associated packing material used. Overlap occurs between commercial and military sectors. Military air cargo includes cargo transported for the military via both commercial (military-civilian contracts) and military routes. For example, military-civilian contracted air shipments include cargo for military use that is ordered and received by commercial businesses for pickup by military personnel or military-civilian subcontractors. Military transport includes systems owned by, contracted for, or controlled by DoD; for example, U.S. Transportation Command (USTRANSCOM) (DoD 2003, 2004). Military air cargo poses a risk of terrestrial vertebrate species transport because transport typically involves short travel durations (increased species survival), species harborage is climate controlled (aircraft cabins), types of cargo are considered high-risk because of their use (e.g., personnel field gear and training equipment, vehicles), and varying inspection procedures (arrivals versus departures, immediate versus pre-scheduled flights).

Expand capacity of the USDA-APHIS-WS canine program on Guam to comply with 100% BTS inspection policy of outbound military air cargo. The canine detection programs are an efficient way to comply with 100% BTS inspection policy for military air cargo departing Guam, per the NDAA, Public Law 110-181, Section 314.

Establish capacity of the USDA-APHIS-WS canine program on Saipan to comply with 100% BTS inspection policy of outbound military air cargo. The canine detection programs are an efficient way to comply with 100% BTS inspection of military cargo departing Saipan, per the NDAA, Public Law 110-181, Section 314. The presence of BTS on Saipan warrants inspection of outbound cargo to prevent spread and transport of the species from the island.

Establish capacity of the USDA-APHIS-WS canine program on Tinian and Rota to comply with 100% BTS inspection policy of outbound military air cargo. The canine detection programs are an efficient way to comply with 100% BTS inspection policy for military air cargo departing Tinian and Rota, per the NDAA, Public Law 110-181, Section 314 requiring interdiction for areas where incipient populations may be evident in the future.

Implement rapid response procedures for terrestrial vertebrate pest species involving military air cargo shipments and transport, as for BTS. No response networks or capabilities exist for species other than BTS, either on Guam or the CNMI. Train personnel involved in the cargo transport and inspection processes about the importance of pest interdiction at the border. Include skills training for identifying, capturing, and containing detected species. Expand capacity for initiating rapid response efforts at the border, as well as post-border, and create the capacity to perform random inspections of cargo imports as a preventative measure. Develop clear response plans with specific goals and objectives, as well as roles and responsibilities.

Conduct USDA-APHIS-WS canine inspections for BTS on Tinian and Rota of inbound military air cargo from Guam and Saipan. Prevention is touted as the most cost-effective measure in biosecurity efforts against biological invasion. To prevent the insidious spread of BTS to Tinian and Rota via the transportation of military air cargo shipments during proposed relocation, adherence to the 100% BTS outbound inspections by USDA-APHIS-WS canine teams on Guam and Saipan should be coupled with inbound USDA-APHIS-WS canine inspections on Tinian and Rota for: 1) high-risk cargo items, 2) air cargo shipments that departed Guam and Saipan without a BTS inspection, 3) cargo conveyances that appear damaged, and 4) random checks for BTS and other terrestrial vertebrate pest species. Supporting military cargo that is air shipped to Tinian and Rota from Guam or Saipan in advance of the training exercise is subject to the routine cargo inspection processes conducted on Tinian and Rota for inbound cargo. Military air cargo shipment arrivals to Tinian and Rota need to be thoroughly checked by CNMI Quarantine Inspectors to ensure that a BTS inspection was conducted on Guam and/or Saipan, and shipments are not harboring other terrestrial vertebrate pest species such as mice or frogs (U.S. Navy 2005b). A USDA-APHIS-WS-approved terrestrial vertebrate species-proof barrier used at entry points on Tinian and Rota for staging inbound military air cargo for inspection would help prevent unwanted species introductions.

Military cargo for airdrop on Saipan, Tinian, and Rota warrant thorough USDA-APHIS-WS canine inspection before departing Guam. Air-dropped military cargo departing Guam must be thoroughly cleaned and packed to facilitate USDA-APHIS-WS inspections for BTS and other terrestrial vertebrate pest species immediately prior to cargo loading or for staging in a USDA-APHIS-WS-approved area until departure.

Military procedures for cleaning gear and equipment used after training and field operations do not target terrestrial vertebrate pest species. Tent cleaning and inspection processes emphasize agricultural pest risks and do not adequately address the risk of transporting an invasive terrestrial vertebrate species. The emphasis on preventing the movement of invasive species associated with tent cities is on departure from Guam and BTS. No emphasis is placed on the risk of bringing new invasive species to Guam.

Current agricultural inspections of military air cargo do not target terrestrial vertebrate species. Inbound military air cargo is subject to routine inspection processes conducted by respective jurisdictions, like Guam and CNMI Customs and Quarantine Inspectors; however, agricultural inspections of military air-shipped cargo at military and commercial airports on Guam, Saipan, Tinian, and Rota focus on detecting plant pests and pathogens, and do not target terrestrial vertebrate species like BTS, frogs, and mice.

All military air cargo departing Saipan is to be cleaned, inspected, and immediately loaded on the aircraft for transport. Some items included in military cargo are high-risk due to their exposure to the outdoors, such as camping gear. To prevent the spread of BTS from Saipan, military air cargo that has been thoroughly cleaned should receive USDA-APHIS-WS canine inspection for BTS, and be loaded quickly and efficiently. Immediate loading of cargo reduces the risk of contamination of staged cargo.

Facilitate inspection of military air cargo shipments to improve BTS detection by USDA-APHIS-WS canine teams. Detection of BTS via canine and/or visual inspection is less effective if cargo is: 1) sealed within a conveyance container or crate, 2) complex, meaning it is not symmetrically shaped and stacked, or 3) inspected indoors with fumes from operating equipment, such as forklifts and delivery trucks. Further, BTS are less likely to be detected if the air cargo shipment is delivered to the port area and loaded, with minimal disturbance, directly onto the aircraft; the nocturnal habits of the BTS make this assumption important during daylight hours (Vice and Pitzler 2008).

Develop a labeling and tracking system for high-risk military air cargo. The ability to label and track high-risk military cargo shipments and their inspection history can streamline the transportation process and open avenues for implementing pre-clearance procedures while still maintaining biosecurity from terrestrial vertebrate pest species. High-risk cargo includes cargo originating from high-BTS-density areas, break bulk items, and outdoor items. Examples of high-risk military air cargo include construction equipment/materials, military equipment returning from a near-jungle bivouac, and cargo used in military training and deployment missions. Because outbound air cargo items originate from numerous sources throughout Guam (Vice and Pitzler 2008), a labeling and tracking system can help to identify air shipments that: 1) have been exposed to high-risk areas, 2) contain high-risk cargo items, and 3) have received official inspections, with information including the date and location of inspection, and name of inspector. Implement a barcode-based data collection system, and incorporate it into a centralized biosecurity system. A barcode-based system will typically comprise any or all of the following components: barcode scanners, barcode-based mobile computers (including wireless scanners, pen/key-based terminals, and vehicle-mount computers), barcode printers, barcode labels and ribbons, and barcode data collection software.

Coordinate USDA-APHIS-WS agreements with military and non-military air cargo shipping agencies to prevent terrestrial vertebrate species transportation. Despite high levels of cooperation by most cargo export entities, USDA agents still make regular discoveries of previously unknown cargo handling processes or companies operating on or out of Guam, and there are several private companies on Guam that refuse to provide information on, and access to, outbound cargo for inspection purposes (Vice and Pitzler 2008). Expand capacity for inspections of cargo handling and packing facilities, with requirements for: 1) allowing frequent inspections (e.g., USDA-APHIS-WS canine, visual searches), 2) being subject to random inspections, 3) more stringent packing and handling procedures (e.g., inspections of complex-packed cargo prior to packing), 4) requiring use of vertebrate species-proof barriers, and 5) implementing long-term pest species control programs at facilities. Coordinate agreements and procedures with air cargo shipping agencies for handling cargo, including packing, over-land transport, cargo-staging, palletizing, USDA-APHIS-WS canine inspection, and final loading. Require packers to individually handle and pack cargo items, especially those labeled as high risk. Provide personnel training and equipment for dealing with detections. It is recommended that air cargo be packed and tightly contained rather than remain as bulk. The probability of visually detecting species like BTS in complex cargo is lower than in cargo with few potential hiding places; for example, cargo that is symmetrically shaped, stacked, palletized, and tightly wrapped will have fewer hiding places than loosely packed, unpalletized bulk materials (Vice and Pitzler 2008).

The military personnel (734th Air Mobility Squadron on Andersen AFB) responsible for the packing process must be trained in proper species' identification of White List and Black List species. When building up pallets, Air Mobility Squadron personnel will handle and stack each box individually; therefore, unless a hitchhiker is already inside the box or crate when it arrives at the warehouse, it is likely to be detected. Address the issue of hitchhikers already packed when arriving at military warehouses by expanding inspection capabilities and increasing stringency in packing/handling of cargo; without this, there is a gap in biosecurity for the military sector, and an increase in the potential for transporting BTS from Guam. Aircraft operate 24 hours a day, but with the exception of trans-shipments originating outside of Guam, any cargo that is loaded onto an aircraft needs to be inspected by the USDA-APHIS-WS canine team.

Reduce site-specific BTS populations at military airports and airfields on Guam and Saipan to support interdiction measures. Implement BTS control efforts at military airport and airfield facilities and their surrounding areas. Such measures include but are not limited to spotlight searches and perimeter trapping. The Governments of Guam and the CNMI might consider establishing and enforcing sanitation codes as a practical means of minimizing and eliminating BTS habitat and food sources at cargo warehouses, airports, and seaports, and even establishing a regulatory basis for pre-clearance of cargo arrivals and departures; however, stable, long-term funding for enforcement is necessary.

Reduce site-specific terrestrial vertebrate pest populations at military airports and airfields on Guam and Saipan. Similar to measures for BTS, specific control measures for terrestrial vertebrate pests like rodents, amphibians, and lizard species should be implemented around military air transportation activities to reduce local populations and decrease probability of species transport. The Governments of Guam and the CNMI might consider establishing and enforcing sanitation codes as a practical means of minimizing and eliminating pest species habitat and food sources at cargo warehouses, airports, seaports, and storage areas, and even establishing a regulatory basis for pre-clearance of cargo arrivals and departures; however, stable, long-term funding for enforcement would be necessary.

Expand capacity of USDA-APHIS-WS to implement BTS control measures at military airports and airfields on Guam during nighttime cargo loading and unloading. USDA-APHIS-WS should conduct BTS surveillance during nighttime military cargo loading, staging, and transferring activities. Further, USDA-APHIS-WS can coordinate BTS spotlight searches of staging areas, fence lines, and any tree lines/forest areas in proximity to runways/taxiways that are designated as drop zones. These areas should be targeted during inbound and exiting traffic times (U.S. Navy 2005a). According to Figure 2.1-1 of the FEIS, there are five aviation areas (three paved, two unpaved) where nighttime surveillance should be conducted.

All military air shipments inbound to the region containing agricultural items, both food and non-food, and construction equipment, should be inspected for terrestrial vertebrate pest species. Agricultural imports are known to transport terrestrial vertebrate pest species of amphibians and reptiles (Christy et al. 2007a; Christy et al. 2007b; Vice et al. In preparation), but inspections generally look for insects and plant pathogens, and do not target terrestrial vertebrate species. Shipments typically considered elevated risk for accidental transport include ornamental plants, agricultural produce, aquaculture shipments (including eggs and fry), live Christmas trees, and construction materials and equipment (Vice et al. In preparation).

Air cargo, including military munitions, imported to islands in the Micronesia Region and departing from Guam and Saipan should receive USDA-APHIS-WS inspections for terrestrial vertebrate pest species. Pest species of snakes and frogs (Christy et al. 2007a; Christy et al. 2007b) have been found in military air cargo and munitions arriving from outside the Micronesia Region, indicating a need for inspections of such imports, given that agricultural inspections of imports do not target terrestrial vertebrate pest species. Departure of cargo and munitions from Guam and Saipan requires 100% BTS inspection by USDA-APHIS-WS canine teams. Inspections of imports should take place during daylight hours.

Expand control measures for amphibian and reptile species detected in military air cargo. There are limited control measures in use for amphibians such as frogs and toads, and reptiles like lizards and snakes that are transported in military air cargo. Expand the capacity for responding to, and controlling, detected amphibians and reptiles in air cargo shipments.

Facilitate military-civilian relations in the CNMI for inspecting military air cargo. Improve communication between the U.S. military and government officials on Saipan, Tinian, and Rota to allow for proper inspections of cargo associated with the military, especially cargo used in military training and field exercises. Expand capacity for inspecting military equipment and vehicles transported after field training. Develop and practice cleaning procedures for military cargo used in field training as a preventative measure. Implement and practice joint-agency rapid response capabilities.

All military personnel baggage transported as cargo to and from Guam and the CNMI on military planes and helicopters should be inspected for terrestrial vertebrate species. While regulations exist for the inspection of aircraft with a focus on BTS, checked military baggage inspection does not target terrestrial vertebrates. However, such inspection is needed because military personnel checked baggage transported via military air transportation may pose a high risk for smuggling species both in and out of the region.

Monitor if seasonal peaks occur for military air cargo transportation, and expand inspection capabilities during these peaks. Monitoring is needed if military air cargo increases in volume or frequency seasonally. If seasonal peaks do occur, inspection capabilities should be expanded during these peaks for the detection of BTS and other terrestrial vertebrates.

Monitor if seasonal peaks occur for military air passenger transportation, and expand inspection capabilities during seasonal peaks. Monitoring is needed if military air passenger transportation increases in volume or frequency seasonally. If seasonal peaks do occur, inspection capabilities should be expanded during these peaks for the detection of BTS and other terrestrial vertebrates.

Expand the inspection capabilities for military airfreight containers. Military containerized cargo is considered high risk because: 1) only a portion of containers are inspected; 2) some containers are permeable to snakes; 3) containers often sit open on the tarmac outside warehouses, providing opportunities to harbor hitchhikers; 4) climate-controlled containers may be of even higher risk because they may provide optimal environmental conditions to promote the survival of a hitchhiker; and 5) there are terrestrial vertebrate species such as snakes that can survive containerized air transport. Mitigation includes use of container scanners, which are currently not available on Guam, but are available on Saipan (currently in disuse because of insufficient funds).

Create and implement protocol to reduce contamination of low-risk cargo by high-risk cargo en route as well as on the ground. Low-risk cargo may become high-risk if handling processes expose it to potential species incursion (Vice and Pitzler 2008), particularly BTS. While air cargo such as mail is considered low-risk due to its contents and processing methods, the caveats of mail being less-containerized than freight and incurring a longer staging time while enough mail accumulates for a shipment, remain. Mail destined to other Micronesia Islands (Palau, Chuuk, Yap) is considerably higher risk for snake incursion. The potential for contamination of mail can be reduced by implementing a more-contained method of shipment for mail and continuing the same inspection process for the mail as freight, but not within the same warehouse nor within proximity to freight so that the potential for incursion is reduced.

Expand the capacity for pre-move inspections of military household goods at the residence. Andersen AFB's traffic management office has agreed that, as part of its pre-move inspections, it will identify any household shipments containing BTS high-risk materials. Arrangements are currently being made to train the inspectors to identify potentially high-risk items during these initial site visits. The proximity of each housing area to potential BTS habitat will be considered when determining risk factors. Specify the "pre-move" inspection plan components, such as training protocol, labeling procedures, how to estimate proximity to BTS habitat, and documentation of inspections.

Inspect military household goods before they are sealed in a conveyance. Detection probability decreases when household goods are packed, crated (in 4 x 8 x 8 foot wooden boxes), and sealed at the residence before being transported to the packing agent's facility (Vice and Pitzler 2008). Close/seal cargo containers staged overnight, or erect temporary barriers and employ control methods for terrestrial vertebrate species until containers are sealed for transport.

Change procedures for canine cargo inspections at indoor warehouse facilities. Canine inspections at indoor warehouse facilities are compromised when exhaust fumes from operating equipment such as trucks and forklifts cannot properly vent from the building, thereby influencing detection capabilities of dogs. Implement a hiatus of equipment activity and the running of ventilation fans half an hour prior to inspections, or move cargo to be inspected to outdoor staging areas.

Facilitate USDA-APHIS-WS inspections of military air embarkation procedures comparable to, compatible with, and co-located with, existing Andersen AFB operations for loading and unloading cargo to and from an aircraft. The Quarantine Regulations of the Armed Forces states that cargo is subject to inspection by a representative of the USDA to prevent the introduction or spread of animal and plant diseases or pests (DoD 1992). For the purposes of these regulations, Guam is considered part of the United States.

Title 7 (Subtitle B, Volume 5, Chapter 3, Parts 318.13-8 and 318.13-10) of the Code of Federal Regulations states that cargo moving between Guam, CNMI, Hawai'i, and the continental United States is subject to agricultural inspection (7 CFR § 318). OPNAVINST 6210.2 states that USDA-APHIS-PPQ personnel may inspect cargo to prevent the introduction of plant and animal pests or diseases ; however, terrestrial vertebrate species are not targeted, hence incidents may go unreported, and particular species may go undetected.

8.7.4.3.2 *Commercial Air Cargo*

Recommendations for commercial air cargo focus on the cargo itself as a mode of transport, with packing and handling influencing the risk level. Overlap occurs between military and commercial air cargo sectors. One example is that checked baggage of military personnel traveling as passengers on commercial flights is considered commercial air cargo. Commercial air cargo poses a risk of terrestrial vertebrate species transport because transport typically involves short travel durations (increased species survival), species harborage is climate controlled (aircraft cabins), inconsistencies exist in inspection equipment availability (e.g., lack of x-ray machines for agricultural inspections), there are insufficient numbers of inspectors, and the volume of airfreight material being moved is substantial.

Expand capacity of the USDA-APHIS-WS canine program on Guam to comply with 100% BTS inspection policy of outbound air cargo. The canine inspection programs are an efficient way to comply with 100% BTS inspection of air cargo departing Guam, per the NDAA, Public Law 110-181, Section 314.

Establish capacity of the USDA-APHIS-WS canine program on Saipan to comply with 100% BTS inspection policy of outbound air cargo. The canine inspection programs are an efficient way to comply with 100% BTS inspection policy for air cargo departing Saipan. Comply with 100% BTS inspection of cargo departing Saipan, per the NDAA, Public Law 110-181, Section 314. The presence of BTS on Saipan warrants inspection of outbound cargo to prevent spread and transport of the species from the island.

Establish capacity of the USDA-APHIS-WS canine program on Tinian and Rota to comply with 100% BTS inspection policy of outbound air cargo. The canine inspection programs are an efficient way to comply with 100% BTS inspection policy for air cargo departing Tinian and Rota. Comply with 100% BTS inspection of cargo departing Tinian and Rota, per the NDAA, Public Law 110-181, Section 314 requiring interdiction for areas were incipient populations may be evident in the future.

Implement rapid response procedures for terrestrial vertebrate pest species involving air cargo shipments and transport, similar to those in place for BTS. No contact networks exist for species other than BTS either on Guam or the CNMI, and this is an area of much needed expansion for efficient and comprehensive response to species introduction.

Conduct USDA-APHIS-WS canine inspections for BTS on Tinian and Rota of inbound air cargo from Guam and Saipan. Because prevention is the most cost-effective measure in biosecurity efforts against biological invasion, preventing the insidious spread of BTS to Tinian and Rota via air cargo shipments requires strict adherence to the 100% BTS outbound inspections by USDA-APHIS-WS canine teams on Guam and Saipan; couple this with inbound USDA-APHIS-WS canine inspections on Tinian and Rota for: 1) high-risk cargo items, 2) air cargo shipments that departed Guam and Saipan without a BTS inspection, 3) cargo conveyances that appear damaged, and 4) random checks for BTS and other terrestrial vertebrate pest species. Air cargo arriving to Tinian and Rota from Guam or Saipan is subject to routine cargo inspection processes conducted by CNMI Quarantine Inspectors to ensure that a BTS inspection was conducted on Guam and/or Saipan, and shipments are not harboring other terrestrial vertebrate pest species such as mice or frogs (U.S. Navy 2005a). A USDA-APHIS-WS-approved terrestrial vertebrate species-proof barrier used at entry points on Tinian and Rota for staging inbound air cargo for inspection would help prevent unwanted species introductions.

Current agricultural inspections of military air cargo do not target terrestrial vertebrate species. Agricultural inspections of military air cargo (inbound and outbound) at military and commercial airports on Guam, Saipan, Tinian, and Rota focus on detecting plant pests and pathogens, and do not target terrestrial vertebrate species like BTS, frogs, and mice.

Facilitate inspection of air cargo shipments to improve BTS detection by USDA-APHIS-WS canine teams. Detection of BTS via canine and/or visual inspection is less effective if cargo is: 1) sealed within a conveyance container or crate, 2) complex, meaning it is not symmetrically shaped and stacked, or 3) inspected indoors with fumes from operating equipment, such as forklifts and delivery trucks. Further, BTS are less likely to be detected if the air cargo shipment is delivered to the port area and loaded, with minimal disturbance, directly onto the aircraft; the nocturnal habits of BTS make this assumption important during daylight hours (Vice and Pitzler 2008).

Develop a labeling and tracking system for high-risk air cargo. The ability to label and track high-risk air cargo shipments and their inspection history can streamline the transportation process and open avenues for implementing pre-clearance procedures while still maintaining biosecurity from terrestrial vertebrate pest species. High-risk cargo includes cargo originating from high-BTS-density areas, break bulk items, and outdoor items. Examples of high-risk air cargo include outdoor household goods like children's toys, garden hoses, camping equipment, and air freight shipments of larger items like barbecue grills, swing set components, or appliances, and construction equipment/materials/supplies. Because outbound air cargo items originate from numerous sources throughout Guam (Vice and Pitzler 2008), a labeling and tracking system can help to identify air shipments that: 1) have been exposed to high-risk areas, 2) contain high-risk cargo items, and 3) have received official inspections, with information including the date and location of inspection, and name of inspector. Implement a barcode-based data collection system, and incorporate it into a centralized biosecurity system. A barcode-based system will typically comprise any or all of the following components: barcode scanners, barcode-based mobile computers (including wireless scanners, pen/key-based terminals, and vehicle-mount computers), barcode printers, barcode labels and ribbons, and barcode data collection software.

Coordinate USDA-APHIS-WS agreements with commercial air cargo shipping agencies to prevent terrestrial vertebrate species transportation. Despite high levels of cooperation by most cargo export entities, USDA agents still makes regular discoveries of previously unknown cargo handling processes or companies operating on or out of Guam, and there are several private companies on Guam that refuse to provide information on and/or access to outbound cargo for inspection purposes (Vice and Pitzler 2008). Expand capacity for inspections of cargo handling and packing facilities, with requirements for: 1) allowing frequent inspections (e.g., USDA-APHIS-WS canine, visual searches), 2) being subject to random inspections, 3) more stringent packing and handling procedures (e.g., inspections of complex-packed cargo prior to packing), 4) requiring use of vertebrate species-proof barriers, and 5) implementing long-term pest species control programs at facilities. Coordinate agreements and procedures with air cargo shipping agencies for handling cargo, including packing, over-land transport, cargo-staging, palletizing, USDA-APHIS-WS canine inspection, and final loading. Require packers to individually handle and pack cargo items, especially those labeled as high risk. Provide personnel training and equipment for dealing with detections. It is recommended that air cargo be packed and tightly contained rather than remain as bulk. The probability of visually detecting species like BTS in complex cargo is lower than in cargo with few potential hiding places; for example, cargo that is symmetrically shaped, stacked, palletized, and tightly wrapped will have fewer hiding places than loosely packed, unpalletized bulk materials (Vice and Pitzler 2008). Implement procedures to reduce site-specific populations of terrestrial vertebrate species at air cargo facilities and grounds to support interdiction measures USDA-APHIS-WS. The Governments of Guam and the CNMI might consider establishing and enforcing sanitation codes as a practical means of minimizing and eliminating pest species habitat and food sources at cargo warehouses, airports, and seaports.

Reduce site-specific BTS populations at airports and airfields on Guam and Saipan to support interdiction measures. Implement BTS control efforts at airports and airfield facilities and their surrounding areas. Such measures include but are not limited to spotlight searches and perimeter trapping. The Governments of Guam and the CNMI might consider establishing and enforcing sanitation codes as a practical means of minimizing and eliminating BTS habitat and food sources at cargo loading areas and warehouse facilities, airports, and seaports, and even establishing a regulatory basis for pre-clearance of cargo arrivals and departures; however, stable, long-term funding for enforcement is necessary.

Reduce site-specific terrestrial vertebrate pest populations at airports and airfields on Guam and Saipan. Similar to the measures in place for BTS, specific control measures for terrestrial vertebrate pests like rodents, amphibians, and lizard species should be implemented around air transportation activities to reduce local populations and decrease probability of species transport. The Governments of Guam and the CNMI might consider establishing and enforcing sanitation codes as a practical means of minimizing and eliminating pest species habitat and food sources at cargo warehouses, loading areas, airports, and seaports, and even establishing a regulatory basis for pre-clearance of cargo arrivals and departures; however, stable, long-term funding for enforcement is necessary.

Expand capacity of USDA-APHIS-WS to implement BTS control measures at airports and airfields on Guam during nighttime cargo loading and unloading. USDA-APHIS-WS should conduct BTS surveillance during nighttime military cargo loading, staging, and transferring activities. Further, USDA-APHIS-WS can coordinate BTS spotlight searches of staging areas, fence lines, and any tree lines/forest areas in proximity to runways/taxiways that are designated as drop zones. These areas should be targeted during inbound and exiting traffic times (U.S. Navy 2005a). According to Figure 2.1-1 of the FEIS, there are five aviation areas (three paved, two unpaved) where nighttime surveillance should be conducted.

All commercial air shipments inbound to the region containing agricultural items, both food and non-food, should be inspected for terrestrial vertebrate pest species. Agriculture imports are known to transport terrestrial vertebrate pest species of amphibians and reptiles (Christy et al. 2007a; Christy et al. 2007b; Vice et al. In preparation), but inspections generally look for insects and plant pathogens, and do not target terrestrial vertebrate species. Shipments typically considered elevated risk for accidental transport include ornamental plants, agricultural produce, aquaculture shipments (including eggs and fry), live Christmas trees, and construction materials and equipment (Vice et al. In preparation).

All military personnel checked baggage transported to and from Guam and the CNMI on commercial, private, and chartered planes and helicopters must be inspected in compliance with the TSA 9/11 Act. Military personnel checked baggage for commercial air transportation poses a high risk for smuggling species both into and out of the region. In the Pacific Islands, smuggling is generally very easy because of poor inspections for contraband animals conducted on arriving baggage (e.g., Kraus and Cravalho 2001). The 9/11 Act, Chapter 10, requires the TSA to establish a system for industry to conduct 100% BTS screening of cargo transported on passenger aircraft in the United States at the piece-level, commensurate with passenger baggage. By August 2010, cargo not screened in accordance TSA-approved processes and procedures cannot be uplifted by a passenger aircraft in the United States (www.TSA.gov). In compliance with the 9/11 Act, TSA is an important operating entity at A.B. Won Pat International Airport to detect smuggled contraband of terrestrial vertebrate species, and staffing should be expanded to account for increased military use of commercial air transportation pathways, and the increase in commercial air cargo associated with proposed military relocation and expected passenger plane travel.

Expand the inspection capabilities for commercial airfreight containers. Containerized cargo is the most common type of air cargo being flown in and out of Guam and the Micronesia Region. For example, United Airlines exports the bulk of commercial airfreight leaving Guam, and approximately 90% of these shipments comprised general freight (Vice and Pitzler 2008). Containerized cargo is considered high risk because: 1) Customs and Quarantine agents only inspect a portion of containers; 2) some containers are permeable to snakes; 3) containers often sit open on the tarmac outside warehouses, providing opportunities to harbor hitchhikers; 4) climate-controlled containers may be of even higher risk because they may provide optimal environmental conditions to promote the survival of a hitchhiker; and 5) there are terrestrial vertebrate species such as snakes that can survive containerized air transport. Mitigation includes use of container scanners, which are currently not available on Guam, but are available on Saipan (currently in disuse because of insufficient funds).

Monitor if seasonal peaks occur for commercial air transport, and increase inspection capabilities during these seasonal peaks. There is a need for monitoring the volume and frequency of commercial air cargo during relocation and post-relocation. If seasonal peaks are found to occur, inspections of air cargo departing Guam should be expanded, with screenings targeting BTS and other terrestrial vertebrates.

Expand inspection capabilities during seasonal peaks in commercial air passenger transportation. More commercial passenger flights depart Guam during the summer months, which may reflect peak tourist season, school summer recess, and summer holiday travel (Vice and Pitzler 2008). During these seasonal peaks, aircraft departing Guam, when inspected for BTS, should also be screened to detect terrestrial vertebrate pests, such as amphibians and other reptile species.

Create and implement protocols to reduce contamination of low-risk cargo by high-risk cargo en route as well as on the ground. Low-risk cargo may become high-risk if handling processes expose it to potential species incursion (Vice and Pitzler 2008), particularly BTS. The risk of contamination actually can stem from mail containers being handled, staged, and shipped in the same manner as general freight (Vice and Pitzler 2008), because mail is then in proximity to the high-risk cargo during the inspection process. While cargo such as air mail is considered low-risk due to its contents and processing methods, mail is less-containerized than freight and incurs a longer staging time while enough mail accumulates for a shipment. Mail destined to other Micronesian islands (Palau, Chuuk, Yap) is considerably higher risk for snake incursion; outbound mail is stored in open containers that are stored on the ramp side of the United cargo facility at A.B. Won Pat International Airport (Vice and Pitzler 2008). The potential for contamination of mail can be reduced by implementing a more-contained method of shipment and continuing the same inspection process for the mail as freight, but not within the same warehouse nor within proximity to freight so that the potential for incursion is reduced.

Inspections are constrained by resources to only inspect a portion of air freight conveyance crates and containers, therefore increase funding and feasibility of these inspections. Air cargo conveyance crates and containers tend to be inspected if shipments are labeled as containing agricultural products, have insufficient or improper documentation, or are from a country of concern. Standardized methods need to be devised and implemented to randomly search containers regardless of documentation, type of shipment, and country of origin. Allocate funding to increase the amount of containerized and crated air cargo shipments that can be inspected. Paperwork associated with arriving air cargo shipments in crates and containers needs to be automated to allow for more rapid selection of containers to be screened, and open avenues for implementing pre-clearance procedures.

Inspect cargo at both departure and arrival points if transported on open barges. Cargo is considered high risk if sent on open barges because this type of transport generally moves a high proportion of break-bulk items that originate near heavily vegetated locations such as new construction sites where heavy equipment is stored in proximity to jungle areas (Vice and Pitzler 2008). Break-bulk roughly includes those items too large to be containerized, like heavy construction equipment (e.g., cranes, bulldozers, dump trucks), building materials (e.g., rebar, lumber, pipe, scrap metal, concrete forms, cinder blocks), fuel canisters (e.g., oxygen, acetylene, propane tanks), small boats, and in some instances, private vehicles. Many inter-island shipments are on open barges where the ambient air temperature and air turnover rates increase the likelihood of species survival during transport (Vice and Pitzler 2008).

Inspect household goods before they are sealed in a conveyance. Detection probability for BTS decreases when household goods are packed, crated (in 4 x 8 x 8 foot wooden boxes), and sealed at the residence before being transported to the packing agent's facility (Vice and Pitzler 2008). Close/seal cargo containers staged overnight, or erect temporary barriers and employ control methods for terrestrial vertebrate species such as temporary barriers until containers are sealed for transport.

Change procedures for canine cargo inspections at indoor warehouse facilities. Canine inspections at indoor warehouse facilities are compromised when exhaust fumes from operating equipment such as trucks and forklifts cannot properly vent from the building, thereby influencing detection capabilities of dogs. Implement a hiatus of equipment activity and the running of ventilation fans half an hour prior to inspections, or move cargo to be inspected to outdoor staging areas.

8.7.4.4 *Sea cargo*

8.7.4.4.1 *Sea cargo Arrivals*

An estimated 90% of all imports to Guam come through the Commercial Port at Apra Harbor. This includes the majority of food, commercial goods, and many of the supplies that support the U.S. Military on Guam. The relocation on Guam will have a significant impact on container volumes during the construction phase and afterward. According to The 2008 Port Authority of Guam's Master Plan, during the construction phase, the containerized cargo volume will increase 500% above 2007 import levels. After construction, the volume will be approximately 200% greater than 2007 levels.

Increase the capacity to perform random inspections for terrestrial vertebrate species in containerized commercial cargo arriving to Guam and Saipan. GCQA does not routinely open containerized commercial cargo shipments; containers are tagged for inspection only if they arrive from a country of concern, have improper or suspect labeling, or contain items that pose an agricultural risk by potentially harboring soils, insects, and plant pathogens (Merfalen, personal communication). Similar inspection procedures are in place on Saipan and Tinian (USDA-APHIS-WS 2010). Agricultural inspections, when conducted, do not target terrestrial vertebrate pest species and therefore may miss potential hitchhikers. Further, persons involved in the intentional transport of species, such as legal imports for the pet trade or in illegal acts, may strategically ship from an origin of least concern in order to remain undetected. Inspecting for terrestrial vertebrate species and performing random inspections in addition to SOPs for inspecting containerized commercial cargo is a preventative measure against illegal acts of species transport, and increases the probability of detecting hitchhikers.

Build a centralized USDA-APHIS-WS-approved staging area for containerized commercial cargo arriving to Guam at the Port of Guam. Containerized commercial cargo arriving at the Port of Guam identified as requiring an inspection is tagged by GCQA and moved from the port to one of Guam's 78 freight stations until it is inspected at the station by USDA-APHIS-WS. This method decentralizes the inspection process of containerized cargo, with most cargo inspected in numerous warehouses

throughout the island. This presents a high risk for multiple, simultaneous introductions of terrestrial vertebrate species to Guam (USDA-APHIS-WS 2010). A centralized inspection facility at the Port of Guam for arriving cargo would reduce cargo transport, and hence species transport, from the port-of-entry.

Implement an electronic system for recording, tracking, and identifying manifests associated with containerized commercial cargo arrivals to Guam and Saipan to streamline import process while maintaining biosecurity. Although all arriving cargo is subject to inspection, containerized cargo is selected for inspection based on the shipping company's manifest that itemizes the containers contents (Merfalen, personal communication). Larger, established shippers like Matson and CSX tend to be more reliable than smaller, less established operations. The system of recording, identifying, and tracking these manifests is paper-based; these systems are vulnerable to missing or lost documentation, unregulated and recurring breaches in biosecurity, and being omitted from integration with other agencies using electronic tracking capabilities. Over the past several years, CBP required a shift to electronic access for cargo manifests for arrivals from the continental United States. In addition, USDA-APHIS recently initiated an electronic system for permits called ePermits. GCQA does not have access to either system, and still relies on paper manifests; it is expected that GCQA will have access to ePermits as soon as Guam PPQ allows, but this has not yet been decided at the time this document was written. Hand-held computerized devices (e.g., SuperTracker®) can be used by GCQA to organize manifest information for the inspection process.

Develop a system for selecting containers to be inspected for terrestrial vertebrate species. PPQ-Agriculture Quarantine Activity System is a set of sophisticated tools for selecting and monitoring containers for agricultural pests. Similar tools need to be developed to identify, monitor, and track containers for terrestrial vertebrate species inspections. Criteria would include type of cargo, origin of cargo material, shipping company, structural damage to the container, and random pick.

Expand capacity for increased random inspections for terrestrial vertebrate species in containerized cargo arrivals. Presently, USDA-APHIS and jurisdictional Customs and Quarantine agencies are unable to meet current inspection demands of containerized cargo arrivals to Guam and the CNMI. Expected increases in container cargo arrivals to the Micronesia Region will render the already burdened inspection process ineffective. If there are fewer containers targeted for agricultural inspections because of insufficient resources, and given that agricultural inspections do not focus on terrestrial vertebrate species, an even higher probability exists for transporting such species in containerized cargo. Increase the number of USDA-APHIS-WS canine inspection teams at Apra Harbor, for both the commercial port and COMNAVMAR.

Military aircraft transported as cargo (aboard an aircraft carrier or other military vessel with aircraft transport capabilities) must be inspected, cleaned, and washed down at the port-of-entry. Aircraft are considered cargo if transported to locations aboard another aircraft or vessel, and hence should be subject to inspections when unloaded from the transport conveyance. This is especially important because while some aircraft will remain unused during transport, planes and helicopters aboard an aircraft carrier can depart and arrive as their support vessel moves, increasing the probability of transporting species from different points of origin should these aircraft depart the transport conveyance and land before returning. Aircraft as cargo arriving to Saipan from Guam, or to Guam from Saipan, must be inspected for BTS if the inspection does not occur upon departure, and officials at arriving locations need to be notified with the appropriate information. Expand capability of jurisdictions to respond to notification of missed BTS inspections. In addition, military aircraft must undergo and adhere to regulations for cleaning and washdown procedures before entry to Guam (as per USDA and APHIS guidelines), and additionally inspect for terrestrial vertebrate species, which are not targeted and therefore likely missed. Perform internal inspections during general and retrograde washdowns to detect and capture terrestrial vertebrate species located within the aircraft cargo. Military procedures for washing aircraft focus solely on external cleaning, with an emphasis on soils and agricultural pests like insects. Because internal cleaning and inspections are not performed, terrestrial vertebrates hitchhiking within an aircraft being washed go undetected. This includes aircraft involved in routine flight operations, aircraft transported as cargo items (via air or water transport), or those staged upon a departing aircraft carrier.

Military amphibious vehicles arriving via water must be inspected, cleaned, and washed down at a retrograde wash facility before entry to Guam. Washdown procedures for military vehicles do not target terrestrial vertebrate species per se, and therefore cleaning of military amphibious vehicles will likely miss such hitchhikers, including amphibian and reptile species, like coqui frogs from Hawai'i. Further, cleaning is focused on external surfaces, so those species within vehicles will travel undetected. Tracked vehicles can only be cleaned on shore as long as they can be reloaded without recontamination of the treads, otherwise they must be cleaned on the ship's well deck (AFPMB 2008).

Privately owned vehicles (POVs) arriving via water through military and commercial routes must be washed down at a port facility before they are permitted entry to Guam. Personal vehicle cargo originates from numerous sources, increasing the locations from which a species may be moved, and the types of species moved. Procedures for washing vehicles imported to Guam focuses on agricultural inspections and primarily of external surfaces, thereby missing terrestrial vertebrates potentially present. Further, a small percentage of vehicles arrive contaminated with soil. Vehicles suspected of carrying species, for example if detected by visual or auditory means during transport, should be quarantined. They should be cleaned to USDA-APHIS standards (USDA-APHIS-PPQ Treatment Manual 2008) prior to being shipped from the port of departure. Vehicles may be cleaned at the port-of-entry provided wastewater soil is collected and fully drained into an approved collection system to mitigate the risk of introduction amphibian species. For certain anurans like coqui (*E. coqui),* an aural inspection during peak time of vocalizations can be conducted to detect such hitchhiking vertebrates.

Military assault vehicles arriving as cargo via water must be washed down at a retrograde wash facility before they are permitted entry to Guam. Assault vehicles have the ability to cover large and remote tracks of heavily vegetated fields, exposing them to contamination by terrestrial vertebrate species inhabiting such terrain. Vehicles small enough to drive through the ships' side ramps, such as

High Mobility Multipurpose Wheeled Vehicles, must be cleaned and washed down in designated areas in the port facility. Large trucks that are too large for the side ramps will be transported by Air Cushion or hovercraft (LCAC) to a coastal cleaning area. Vehicles must be internally inspected. The battery and battery box should be removed, cleaned, and reinstalled because the crevices of the battery box provide hiding places. Trucks that are equipped with collapsible sides should have the sides disengaged, and all recessed areas and ledges cleaned (AFPMB 2008). Common areas to be inspected include top and bottom access points, paying particular attention to crevices. Also, control efforts around the washdown facility should be in place. Construct USDA-APHIS-WS-approved species-proof barriers to secure washing and staging areas, implement trapping and perimeter searches for pest species like BTS and other terrestrial vertebrate species, and expand large-area trapping efforts to reduce local populations.

Implement inspection procedures for vehicle cargo aboard high speed-military vessels. High-speed military vessels are used for rapid delivery of cargo. Vessels like the LCAC are capable of a 60 ton payload (up to 75 tons in an overload condition) at speeds greater than 40 knots. Such rapid transit increases species survival during transport, hence these vessels and their cargo pose a risk. Cargo can include vehicles and equipment that may harbor terrestrial vertebrate species.

Construction vehicles arriving via water must be washed down and inspected before being permitted entry to Guam, Saipan, Tinian, and Rota. No specifications were provided in the FEIS/OEIS regarding the types and amounts of construction vehicles to be used in the relocation on Guam or for construction of training ranges on Saipan, Tinian, and Rota, making this a high risk for importing unwanted species. Construction vehicles include machinery like bulldozers, excavators, and bobcats, as well as forklifts, concrete mixers and their pumps, dump trucks, and ATVs (Vice and Pitzler 2008). Construction vehicles can carry species from one work site to the next. Although construction is for military purposes, equipment transport will likely be by subcontracted construction company employees. Detailed cleaning and inspection of vehicles and equipment used in construction must be conducted at the port of entry. USDA-APHIS requirements must be met and should be augmented with internal and external inspections for terrestrial vertebrate species. Delineation of responsibilities for the military meeting these requirements is presented in AFPMB Tech. No. 31 (2004).

The Importer Security Filing (CBP) system, akin to that required for imports to the United States, should be implemented and enforced for break bulk arriving in Guam. Under the Importer Security Filing and Additional Carrier Requirements (“10 +2” program), break bulk cargo imported to the United States by vessel must be electronically submitted to the CBP in the form of an Importer Security Filing. This requirement only applies to cargo arriving in the United States by ocean vessel; it does not apply to cargo arriving by other modes of transportation. Failure to do so could ultimately result in monetary penalties of $5,000, and increased inspections and delay of cargo. If goods for which an Importer Security Filing has not been filed arrive in the United States, CBP may withhold the release or transfer of the cargo; CBP may refuse to grant a permit to unlade for the merchandise; and if such cargo is unloaded without permission, it may be subject to seizure. Importer Security Filing Importers, or their agent, must provide eight data elements, no later than 24 hours before the cargo is laden aboard a vessel destined to the United States. Those data elements include: seller, buyer, applicant identification number, consignee number, manufacturer, ship of party, country of origin, and Commodity Harmonized Tariff Schedule of the United States number.

Provide written animal and plant health import and interstate movement requirements (USDA-APHIS regulations) for all break-bulk import contractors, and engage in formal, signed agreements with these bulk imports contractors, especially those operating from origins of concern. There will be substantial increases in break bulk cargo to be shipped through the Port of Guam for construction and infrastructure upgrades due to the relocation. It is vital that contractors be aware of the requirements for pre-departure inspection and pest mitigation prior to export of these countries. Enforcement is needed during relocation to ensure contractors adhere to requirements or face fines or other penalties.

Create and implement protocols to reduce contamination of low-risk cargo by high-risk cargo en route via water as well as on the ground. Low-risk cargo such as mail may become high-risk if handling processes expose it to potential species incursion (Vice and Pitzler 2008), particularly BTS. The risk of contamination actually can stem from mail containers being handled, staged, and shipped in the same manner as general freight after arrival (Vice and Pitzler 2008), because mail is then in proximity to the high-risk cargo during the transport and inspection process. Implement procedures to separate low- and high-risk cargo on arrival, for staging and inspection purposes, as well as for quarantine reasons.

WPM arriving as cargo must be accompanied by proper forms and labels. WPM can harbor myriad terrestrial vertebrate species, including amphibians, mammals, and reptiles. To prevent hitchhikers aboard such cargo, material is required to be treated and marked at the place of origin, and accompanied by authentic phytosanitary certificates on arrival in Apra Harbor. Examples of WPM include crates, pallets, dunnage, packing blocks, drums, cases, load boards, pallet collars, skids, veneer peeler cores, sawdust, wood wool, wood shavings, raw wood cut into thin pieces, and cable spools. The treatment of WPM is enforced under the ISPM (USDA-APHIS 2007; ALSC 2009). The treatment and inspection of WPM is governed under 7 CFR. The regulations allow manufacturers and shippers two options: heat treatment or treatment with methyl bromide. For materials to receive the ISPM No. 15 quality mark, materials must be inspected by an agency accredited by either the ALSC for heat treatment (ALSC 2009), or the National Wood Pallet and Container Association for methyl bromide fumigation (NWPCA 2009). Inspection procedures by both agencies must follow ISPM No. 15 regulations. Part 305 of Title 7 covers phytosanitary treatments and states that treatments are to occur at USDA-APHIS certified facilities and are to be monitored by APHIS officials (Title 7, Part 305). Part 381 of Title 7 defines regulated WPM as dunnage, crating, pallets, packing blocks, drums, cases, and skids (Title 7, Part 318). Currently all regulated WPM are required to have the International Plant Protection Convention (IPPC) quality mark, unless it is a DoD shipment (USDA-APHIS 2010). The exemption of regulations on WPM shipped by DoD leaves a risk of introduction of pests and vertebrates through untreated WPM. Fraudulent or suspected fraudulent certifications or cargo manifests should be investigated with penalties implemented. Random inspection of such cargo can prevent illegal transport of species through a legal route and incidents of smuggling.

Mandate and enforce regulations for handling palletized cargo. Contamination can occur during the packing, handling, and staging process prior to arrival as imported cargo, or after arrival when it is staged for loading for inland transport. It is optimal for packers to individually handle and pack cargo items, especially those considered high risk. Mandate and enforce regulations pertaining to palletized cargo, including procedures for labeling, packing, and transport prior to arrival, and eventual staging and loading for inland transport upon import. Personnel must be trained how to identify high-risk cargo and handle it in a manner to reduce possible contamination. Palletized cargo should be packed tightly and symmetrically, as well as wrapped with a protective covering. The probability of visually detecting species in complex cargo is lower than in cargo with few potential hiding places. This is especially true with BTS detection by canine teams (Vice and Pitzler 2008).

8.7.4.4.2 *Sea cargo Departures*

Most water-transported cargo departing Guam is shipped as surface freight out of Apra Harbor. The harbor has two sides; the Commercial Port (GovGuam) and the COMNAVMAR (military). All vessel traffic is managed by The Port Authority of Guam (GovGuam), which assigns vessels to commercial or military berthing areas.

Comply with 100% BTS inspection policy for military and civilian sea cargo departing Guam. Comply with 100% BTS inspection of military sea cargo departing Guam, per NDAA, Public Law 110-181, Section 314.

Comply with 100% BTS inspection policy for military and civilian sea cargo departing Saipan. Comply with 100% BTS inspection of military cargo departing Saipan, per NDAA, Public Law 110-181, Section 314. The presence of BTS on Saipan warrants inspection of outbound cargo to prevent spread and transport of the species from the island.

Comply with 100% BTS inspection policy for military and civilian sea cargo departing Tinian and Rota. Comply with 100% BTS inspection of military cargo departing Tinian and Rota, per NDAA, Public Law 110-181, Section 314 requiring interdiction for areas were incipient populations may be evident in the future.

Comply with 100% BTS inspection policy specified in the BTS Control Plan applicable to cargo arriving to U.S. sites other than Guam, in both military and civilian sectors. For military and commercial sectors, the BTS Technical Working Group Plan (2009) specifies 100% BTS inbound interdiction on U.S. sites other than Guam. This includes cargo arrivals from Guam and Saipan, where BTS exist, being shipped to the Hawai'ian Islands of Oahu, Maui, and Hawai'i. Interdiction measures should be expanded to include improved inter-agency coordination of communication networks to notify Hawai'ian seaports of cargo arrivals from Guam and Saipan that missed BTS inspection, and funding to increase inspection capacity for U.S.-bound cargo departing from Saipan and Guam.

Inspection of departing military containers must be focused on higher-risk container types such as open top containers. The military uses several types of containers for shipment of gear, ranging from a tricon (triple container that is a lockable, weatherproof, reusable, prefabricated container with a cargo capacity of 5,579 kg [12,300 pounds]) to standard commercial containers to open top containers (container without a permanent metal top, instead tarpaulin is used, supported by roof bows to protect cargo from the elements) (Defense Transportation Regulation Part II: Cargo Movement April 2010). Open top containers are the highest risk container type for the transport of BTS. No information was found on the staging of the open top containers. Procedures should be implemented to separate out these containers of cargo to prevent cross-contamination from adjacent cargo sources. Stage these containers separately, and perform random inspections.

Expand capacity to inspect departing freight containers including funds allotted for container scanners. The movement of invasive vertebrate species in containerized cargo is a significant pathway, and a large number of species may be moved (ANSTF and NISC 2007; USDA-APHIS-WS 2010). In addition, some transit times for ships sailing between Guam and other islands are short (less than 1 day), increasing the probability of survival for species stowed in cargo aboard. Cargo container inspections are regulated in international law under the sponsorship of the WHO. Inspection access is granted through WHA58.3 Revision of the International Health Regulations (WHO 2005). Containers and their cargo departing Guam are subject to 100% BTS inspection, in compliance with NDAA, Public Law 110-181, Section 314. Yet container scanners are currently not available on Guam. They are available on Saipan, but not used due to funding limitations even though containers are considered high risk items used in the shipping process (ANSTF and NISC 2007).

Commercial sea cargo shipping companies must comply with the 100% inspection policy, and no direct route for shipments from Guam to Hawai'i should be maintained. Surface cargo leaving Guam for the U.S. mainland is primarily shipped by two companies, the CSX Corporation and Matson. Shipments from these two companies are first routed through ports in Asia before arriving in the U.S. mainland and comprise only containerized cargo. CSX ships approximately 65 to 70 outbound containers per week containing items that originate on Guam, 25 to 30 (roughly 40%) are filled with household goods, and 7 to 8 (11%) contain vehicles; both high risk item types due to their extended exposure to the outdoors (Vice and Pitzler 2008). Matson conducts service to Hawai'i from Guam, via Oakland, California. BTS have been repeatedly found in the Hawai'ian Islands. Since 1981, eight BTS are known to have arrived on the island of Oahu through commercial and military aircraft from Guam (BTS Technical Working Group 2009). The indirect route of surface cargo from Guam to Hawai'i should be maintained. Cargo bound for Hawai'i should be inspected again prior to departure from Oakland, California, to prevent the establishment of BTS in Hawai'i.

The staging time of smaller commercial containers departing Guam needs to be reduced. Often, smaller commercial containers sit at residential lots under "door to door" services (Matson) for long periods of time before being transported to the port and sealed. Customers that use the "door to door" service are given the option of either using Matson trucking for pickup of the container at their residence, or they may hire their own trucking service approved by the Uniform Intermodal Interchange and Facilities Access Agreement. However, the staging time of the container at the residence is not heavily regulated, and the container sits unsealed for at least 1 week.

Develop procedures to reduce risks of transporting terrestrial vertebrate species in household goods containerized at the residence for shipment. Standard procedures for packing household goods within containers for shipping are currently insufficient in preventing terrestrial vertebrate species transport. Movers drop off a standard 20- or 40-foot shipping container to the residence; if packing is not done in 1 day, they may leave the container overnight. If containers are brought to the shipping facilities not full, companies will leave them open, usually outside, at shipping facilities while filling. While staged in these instances, open containers offer entry opportunities to species. Further, when containers are sealed at the residence and staged at the facility for inspection, the possibility of detecting species is greatly diminished. For example, BTS canine inspections of cargo are less effective when performed on the sealed container only.

Reduce the outdoor staging time for transporting POVs either by military personnel or the public, and construct USDA-APHIS-approved perimeter fencing around staging areas. POVs being shipped by military personnel arrive at the lot daily and often sit outside for several weeks before being containerized on site. WS agents inspect any newly arriving vehicles (interior and exterior) daily and any vehicles that are scheduled to be containerized that day (Vice and Pitzler 2008). Reducing the staging time in combination with installation of USDA-APHIS approved fencing will help prevent species such as BTS from hitchhiking onto POVs. Also, with the increase in POVs due to force flow (increase in population due to military relocation) there is a greater potential for inspections to be delayed or missed unless there is an increase in the number of WS inspectors operating at the Fleet Industrial Service Center.

Departing military amphibious vehicles being transported as sea cargo must be inspected, cleaned, and washed at a laydown area prior to departure. Amphibious vehicles will need to be deployed from Guam to neighboring islands such as Tinian, Rota, and Saipan. These vehicles must be inspected, cleaned, and washed down prior to departure to prevent the spread of BTS that may hitchhike aboard these vehicles. The amphibious vehicle laydown area created at Apra Harbor will be required to store, wash down, maintain, and deploy amphibious vehicles, such as landing craft and amphibious assault vehicles. LCACs would also utilize this laydown area. Vehicles must be vacuumed to prevent the transport of plant propagation materials and pests. Once at the retrograde washdown area, vehicles are exposed to either high pressure (minimum 90 pounds per square inch) water or steam. After vehicles are washed, they will be inspected to ensure all soil has been removed and also should be inspected for vertebrate pests (AFPMB 2008). Common areas to be inspected include top and bottom access points, paying particular attention to crevices.

Departing WPM are subject to inspection and should not be stored outdoors. Certain WPM poses a high risk of transferring BTS and other species, such that all WPM must be inspected prior to departure from Guam. If WPM is stored outdoors, it should be stored in a cage covered with insect-proof netting, vegetation should be removed from the storage site, and the storage site should be sealed with concrete and thoroughly cleaned on a regular basis.

Palletized military munitions must be inspected and should be packed tightly and symmetrically. Munitions are typically palletized and shipped as sea cargo on military vessels. The Asian Beauty snake (*Elaphe taeniura friesi)* was discovered in a shipping container holding munitions on Guam that had been shipped from Okinawa and held in storage for approximately 2 months in 2004 (Vice et al. In preparation). Munitions primarily depart Guam from Kilo Wharf in Apra Harbor. Pallets of munitions are containerized in the Munitions Storage Area on Andersen AFB or Naval Ordnance Annex and are loaded directly onboard military vessels at Kilo Wharf. In some circumstances, pallets of munitions are moved directly from either base to Kilo Wharf, for staging prior to direct loading onboard. Currently, canine inspections are conducted on all munitions as needed; however, both the pallets of munitions and the container that carries the palletized munitions should undergo canine inspections prior to departure. A caveat to this recommendation is that BTS detections by canine inspection are reduced if sealed wooden crates are used. Further, area-wide trapping and spotlight searches for BTS can reduce local populations, and routine inspections with USDA-APHIS-WS canine teams of munitions storage facilities can help prevent accidental transport.

Create and implement protocols to reduce contamination of low-risk cargo by high-risk cargo en route as well as on the ground. Surface mail delivered parcel post is picked up and processed in the same manner as air mail, up to the point it is dispersed from the main post office in Barrigada. After the sorting process, surface mail is loaded directly into a 40-foot container staged at the post office and delivered weekly to the Apra Harbor Commercial Port for shipment. Most notably, mail containers may sit open until they are filled or scheduled for shipping, offering entry opportunities for terrestrial vertebrate species. Currently there is an intensive trapping program that limits the potential for snakes to immigrate into outbound surface mail or the containers in which it is stored, and this program must be maintained and expanded with an increase in departing mail. Low-risk cargo may become high-risk if handling processes expose it to potential species incursion (Vice and Pitzler 2008). The risk of contamination can stem from mail containers being handled, staged, and shipped in the same manner as general freight (Vice and Pitzler 2008), because mail is then in physical proximity to the high-risk cargo during the inspection process. Close containers if staged outside overnight. Provide USDA-APHIS-approved temporary barriers to prevent reptiles, amphibian, and rodents from entering.

Construction equipment, vehicles, and supplies departing from work sites need to be cleaned on-site to prevent movement of terrestrial vertebrate species. Movement of construction equipment from work sites can transport species to new inter-island locations, and then off island if cleaning is not performed at port of embarkation. Proper facilities and procedures need to be in place for cleaning equipment on site for terrestrial vertebrate species in particular, prior to moving it for transport. For example, all contractors doing major construction, excavation, or earth moving are required to have a free inspection of their site and equipment by CNMI-DFW's BTS staff, with contractors also required to have their workers participate in a free, brief on-site snake prevention training workshop provided by CNMI-DFW. There is no fee to the contractor or workers for this service (http://www.dfw.gov.mp/Wildlife/Brown%20Tree%20Snake.html).

8.7.4.5 *People and Baggage*

Recommendations concerning people and baggage pertain to the travelers and their carry-on items (hereafter referred to as baggage). People tend to opt for the quickest mode of travel, making travel duration short and species survival high for this pathway. Risks associated with the recommendations for this pathway are due to intentional and unintentional transport of vertebrates, and the agencies in place for inspections do not target this pathway for the detection of vertebrates. Transport of people and their baggage can occur either by air or water, and is either commercially or military-operated, with each mode differing in the inspection process at the border. Commercial air transport of people and baggage includes commercial airlines or private charters, while commercial water transport consists of cruise ships or private charter boat passengers. On the other hand, military air transport of personnel may be involved in purely transportation from airfield to airfield, routine aviation training, or immediate departures of urgency (warfare, medical). Similarly, military water transport of personnel includes transport from one base to another, training missions, and immediate departures or urgency (warfare, rescue).

Provide a separate screening area for inspecting military personnel and their baggage at commercial airports. Due to the nature of military service travel, personnel must move quickly through ports without delay. Screening of uniformed military personnel is cumbersome; fatigues contain many pockets and folds, boots have intricate lacing, and travel bags may be difficult to unpack and inspect quickly. Similar to separate screening areas in commercial airports for inspecting persons with disabilities, a separate screening area for inspecting military personnel and their baggage should be implemented when travel is through a commercial airport. In addition, personnel are exempt from some of screening procedures imposed on the civilian passengers; personnel are not required to take off their boots unless the walk-through alarm sounds. These recommendations will facilitate compliance with 100% BTS inspection policy for military air cargo departing Guam, departing Saipan, and arriving to Tinian and Rota, and allow military to continue without delay to gate boarding.

Agricultural forms for arriving commercial passengers must be available in multiple languages, given the lingual diversity of Micronesia. Incomplete or inaccurate descriptions on agricultural forms can lead to the unknowing import of prohibited vertebrates. While some incompleteness and inaccuracies may be due to dishonesty of the traveler, it may also be due to illiteracy of the default language on the declaration form; a less complex problem that can be solved practically. In addition, multi-lingual agents will be needed to review the forms and assist passengers with filling out the forms. A communications study found when individuals are forced to use a non-native language to communicate, their overall orientation to communication may change, resulting in increased apprehension, decreased willingness to initiate communication, and decreased perceptions of communication competence (Burroughs and Marie 1995). The most commonly used languages in the region most affected by the relocation are English, Chamorro, and Chuukese. The incorporation of all of these languages into declaration forms is likely to reduce incompleteness and inaccuracies due to language. Additionally, these three languages should be spoken by the staffed agents (collectively) assisting passengers with form completion.

Penalties such as fines must be publicized, disseminated on forms, and enforced. It is difficult to enforce regulations without repercussions in place. Biological invasions are likely to increase in number and magnitude without negative reinforcement (penalties) pertaining to regulations. The agencies charged with the enforcement of inspection regulations (TSA, USDA-APHIS) and issuing of fines must use communication and coordination as well as education and training to disseminate the penalties associated with particular violations of travel. Therefore, paperwork of violations and the penalties incurred must be filed within a well-organized system, forms must prompt comprehensive information, and documentation must be easily accessible to the enforcement.

Increase surveillance measures in military and commercial airports and harbors at port entry points and screening check points. Use of surveillance equipment and procedures can help alert officials and inspection staff to transport of terrestrial vertebrate species, either smuggled or imported without knowing that the species is prohibited (Black Listed). Military uniforms have lots of pockets, folds, and baggy areas and maybe used for the concealment of transported species. Also, importing contraband items is an issue as well. Surveillance is a way of finding out if the inspection and enforcement process is working and of refining the entire biosecurity system. Implement video surveillance to monitor activity, and provide plain clothes enforcement officers for initiating rapid response measures during peak travel times.

An MCI program should be initiated on Guam. Immediate military personnel departures such as medical emergencies or rapid deployment missions may pose a higher risk of vertebrate movement because they may undergo less stringent or missed inspections. However, by mandate of the MCI, all passengers, crewmembers, accompanied baggage, and equipment boarding any DoD-sponsored ship or aircraft departing an overseas area for the CTUS must be inspected or examined prior to departure. All travelling personnel must complete U.S. Customs Accompanied Baggage Declaration, DD Form 1854 while civilian crewmember must complete Customs Form 5129. Urgent departures such as medical emergencies are still subject to MCI inspection, and expeditious inspection should not preclude taking the steps necessary to detect prohibited articles prior to departure, as stated by MCI (http://www.tpub.com/maa/137.htm). While MCI does not yet operate on Guam, the institution of this program is much needed and advocated for Guam by the U.S. Navy and PPQ.

Expand the number and sensitivity of detection equipment (x-ray) for departure checkpoints at airports in Guam and CNMI and implement x-ray machine use at Apra Harbor. It is important for inspection checkpoints to be properly equipped with an adequate number of machine vision technology devices because detection probability increases with machine sensitivity. While some inspection procedures are manual, inspection agents rely heavily on technological equipment to assist in the screening process. Currently, x-ray machines are in use for screening of departing passengers and baggage at Andersen AFB and Francisco Ada International Airport, among other airports in the region, but are not in use at harbors as of yet. The two x-ray machines for screening departing passengers and baggage at A.B. Won Pat International Airport were inoperable at the time this document was written, and awaiting replacement machines (Berringer, personal communication). While x-ray machines are in place at these locations, the models may be outdated and lacking in sensitivity, as well as in disrepair.

New advances in technology such as an image-feature based approach (Chen et al. 2002) may increase detections of vertebrate species.

8.7.5 Intentional Pathway Recommendations

Intentional transport of terrestrial vertebrate species occurs for a myriad of reasons. Intentional transport of species can pose serious risks because many animals are moved by private individuals, unregulated industry retailers, and smugglers that use both legal and illegal routes of import/export. For example, illegal species of amphibians and their eggs can be accidentally or intentionally brought in through the legal import of aquaculture products, and individuals boarding planes may smuggle species such as snakes, crocodiles, and lizards in their carry-on luggage (Bodry 2007; 2008). Overall, intentional transport of terrestrial vertebrates is difficult to monitor and track, as well as to regulate and enforce, especially through military sectors, which makes these pathways of particular concern. Of note, the only mode for intentionally transporting species not discussed is fur ranching, due to very low risk impact and lack of examples from the Micronesia Region.

8.7.5.1 *Pet Trade*

- Risk of importation 3
- Risk of establishment 3
- Hazard 3
- Total risk 9 **HIGH**

Pet trade recommendations focus on the transport of live terrestrial vertebrate species, adults and juveniles, including eggs of amphibian and bird species. Pet trade animals can be species of reptiles, amphibians, birds, and mammals, representing a diverse group of species potentially transported. Included are all acquisitions of pet animals, whether purchased from commercial pet stores, Internet dealers, or wild caught and imported by interested individuals, as well as the deliberate release of animals to establish populations that will then be harvested to sell as pets (USDA-APHIS-WS 2010). Also included are hybrid species bred specifically for the pet trade that do not normally exist in the wild.

Develop a Black List of terrestrial vertebrate species for each jurisdiction, the entire region, or both, to ban from importation and possession, and conversely develop a White List of species cleared for importation. Lists of species that are cleared or banned from importation will aid inspectors as to which species pose threats to human health and safety, the economy, and native ecology. Updating information on these lists, including regulations and policies, also helps in dealing with new and emerging pests. In the United States, species importations are viewed as “innocent until proven guilty” (Gray Listed). However this is against BMPs of implementing prevention measures. Development of a Black List is much more effective at prohibiting unwanted species (Witmer and Fantinato 2003; Pitt and Witmer 2007; Fowler et al. 2008). Lists can be updated by USDA-APHIS and utilized regularly by inspection agents.

Create training and education programs for inspectors in proper identification of species both White and Black Listed. Military personnel inspectors, and those with USFWS and USDA, act as border agents to prevent transport of terrestrial vertebrate species. Familiarity with White and Black Listed species can prevent misidentification and introduction of unwanted species. Training would include taxonomic identification of species, continued education regarding species' updates, changes to regulations, and new pest species listings. Hold regular meetings to discuss pertinent issues and needs pertaining to inspection/detection at pre-border, such as effectiveness of screening equipment to detect terrestrial vertebrate species. Develop multimedia educational material to further facilitate proper identification of species, with written descriptions, physical attributes, and animal behavior, as well as immediate human health and safety concerns (e.g., venomous snakes) and rapid response contact information (see Distance Diagnostic and Identification System [University of Florida 2010]).

Assign USFWS personnel at military and commercial air and seaports of entry. Even when import restrictions on some pets do apply, illegal importation of species occurs and poses a high risk primarily because resources are insufficient to address issues surrounding smuggling (USDA-APHIS-WS 2010). USFWS personnel can assist in preventing incidences of smuggling, help handle and process confiscated animals, be a presence for law enforcement, and be part of a rapid response plan at the border should an aircraft or vessel-related incident occur. USFWS personnel will need to be familiar with species that are White-Listed and those banned from import, as well as trained in proper taxonomic identification of species.

Utilize current available technology to monitor pet trade Internet activity. The Internet is often an unregulated pathway, thereby creating an opportunity to import and introduce terrestrial vertebrates without detection at the border point of entry. Surveillance of Internet activity in regards to the sale or trade of animals, including monitoring the frequency and popularity of specific websites, can reduce the transport of potentially unwanted species, and serves to prevent introduction. The Invasive Species Internet Monitoring System automates the process of searching the Internet for suspect sites (e.g., Internet storefronts, chat rooms) involved in the sale or trade of targeted species (Suiter and Sferrazza 2007). This information can lead to data on the most common routes and modes of transportation, and breaches in current importation bans (e.g., importing snakes to Hawai'i).

Facilitate an expansion in pet trade monitoring through a sense of community ownership regarding the negative impacts of the illegal pet trade. Implement educational programs and materials that convey the hazards associated with the import of illegal pets. Create a response network by which community members may report incidences of illegal pet trafficking, propagation of breeding stocks, sales (independent or retail), unintentional and intentional releases into the wild, and rapid response to species sightings in the wild. Coordinate community efforts with local jurisdictional governments to enhance biosecurity efforts by residents. Provide meetings and newsletters to plan and develop procedures, and answer individual questions and concerns.

Place restrictions on the transportation of psittacines. Whether species of psittacines are captive bred or wild caught, rapid and successful establishment of non-indigenous psittacine species is common worldwide, with resulting human health impacts (e.g., from bird droppings, transmitted diseases like the HPAI subtype H5N1), economic impacts (control costs), and ecological impacts (e.g., increased competition for food and nest sites, displacement of native species). Among birds, wild caught species pose a greater risk of establishment than do species that have been bred in captivity for many generations, because they retain the instinctual ability to survive after release (Carette and Tella 2008). Create agreements with pet shops and animal dealers to educate and regulate trade in psittacines; develop avenues to curtail smuggling due to restrictions and regulations that make transport of species more difficult; and create a system for tracking and monitoring species that are imported, if only via the honor system. Restrict the import by individuals in the private sector of certain psitticine species (Black List).

Follow similar procedures to those of Hawai'i Department of Agriculture for import restrictions by private sector: "Require a pre-arrival seven-day (168 hours) isolation from mosquitoes under the supervision of an accredited veterinarian and must enter the State within 36 hours of completing isolation. In addition, a Certificate of Veterinary Inspection must state that birds were not vaccinated for any disease with a vaccine containing a live agent within 60 days of shipment. The Certificate of Veterinary Inspection must also list individual bird identification numbers (leg band, wing band, or electronic microchip) and contain a statement that the birds are 'Free of external parasites.' All birds entering the State must be kept in isolation from other resident birds for a period of 30 days at the importer's premises. All shipments shall be in mosquito-proof containers that are either new or those thoroughly cleaned to the satisfaction of the accredited veterinarian issuing the Certificate of Veterinary Inspection. Importation of animals through the USPS is not allowed. All imported psittacines, whether from foreign or domestic origin, should first enter Guam via A.B. Won Pat International Airport, which should be the only entry port for imported birds, with all shipments subject to inspection and penalties for non-compliance. Inspections should be conducted at the newly constructed Airport Animal Quarantine Holding Facility prior to release. An agent of the airline will submit the birds for inspection. The hours of operations when inspections can be performed to accommodate shipment arrivals must be posted, and an 'after-hours' staff for unexpected or re-scheduled commercial shipments or chartered/private freight arrivals should be assembled. Birds not meeting entry requirements are to be returned to a port of entry in the continental United States or a foreign port in the case of international movement, with notification of contaminated cargo and proper authorization to do so.

It is imperative quarantine the birds upon entry to protect human health and safety. Construct a Quarantine Holding Facility at the A.B. Won Pat International Airport. Confounding factors include screening of cargo for species in military aircraft arriving Andersen AFB and military vessels through the COMNAVMAR, privately owned and chartered (private and commercial) aircraft imports, and unscheduled commercial airfreight imports.

Restrict imports of snakes to island nations. Native species on islands evolved without any terrestrial predators, and hence are vulnerable to terrestrial vertebrate species that prey upon them. Snakes are insidious predators that, unlike rodents or other small mammals, may be difficult to detect because of nocturnal and/or arboreal habits of some species, they don't leave obvious signs of presence or make noise, and they are difficult to control once established. Similar to regulations enforced by Hawai'i State Department of Agriculture for animal import by individuals in the private sector, at least restricting the import (Black List) of snakes should be considered.

Enforce existing regulations and expand regulatory drivers in the Pet Trade industry. Successful importation of unwanted terrestrial vertebrate pest species increases the probability of introduction and establishment, and is partly due to moderate and high public interest for importing pet species, and a lack of government regulations on the pet trade industry. Enforcement of existing regulations should be upheld, such as APHIS regulations for importing animals from foreign origin, 42 CFR § 71.51 (for dogs), Guideline for Transport from the CITES, protocols of the CDC, and the WBCA. Expand regulations for the pet trade industry to curtail acts of illegal importation, and create avenues for safe imports. Examples include developing and implementing the use of White and Black Lists, assigning a USFWS officer at borders, and coordinating voluntary agreements with pet stores and businesses in the pet trade industry.

8.7.5.2 *Aesthetic Releases*

- Risk of importation 3
- Risk of establishment 2
- Hazard 3
- Total risk 8 **HIGH**

Recommendations to prevent the unintentional and intentional release of animals for aesthetic reasons shares similarities with the Pet Trade recommendations. Animals may be intentionally released into the wild because the species is considered in some way desirable (Kraus 2009a). Examples include freshwater turtles and frogs released into backyard ponds, songbirds and some parrots because they invoke nostalgia, and lizards because of species' characteristics (e.g., eats insects, are colorful) (e.g., Long 1981; Kraus and Campbell III 2002). Mitigation is post-border, as animals released will most likely be from local residents or newly relocated persons. However, education is needed for inspectors and individuals at the border ports of entry, as an intentional release my stem from the person self-justifying the release of a 'wild' animal back into the wild, or the unintentional release of them not knowing the potential impacts the species may cause. Animals introduced via aesthetic release may be obtained legally from imported commercial stock (i.e., pet stores), Internet purchases, or illegal trading. Recommendations therefore overlap with those concerning the pet trade, including those that restrict movement of certain taxa like birds and reptiles (snakes and lizards). The availability of animals in Micronesia varies on the supply of local commercial stock, Internet purchases, illegal activity, and the frequency with which citizens travel overseas and return with animals. Military personnel travel is rarely restricted by inspection procedures, thereby making that pathway a concern for illegal imports.

Assign USFWS personnel at military and commercial air and seaports of entry. Even when import restrictions on some animals do apply, illegal importation of species occurs and poses a high risk primarily because resources are insufficient to address issues surrounding smuggling (USDA-APHIS-WS

2010). USFWS personnel can assist in preventing incidences of smuggling, help handle and process confiscated animals, be a presence for law enforcement, and be part of a rapid response plan at the border should an aircraft or vessel-related incident occur. USFWS personnel will need to be familiar with species that are White Listed and those banned from import, as well as trained in proper taxonomic identification of species.

Create cooperative agreements with pet retailers to detect bulk and repeated purchases of animals. USDA-APHIS and USFWS agents should work to create agreements with pet retailers operating in the Micronesia Region. Under such agreements, the agents will maintain open communication about topics such as noticeably large increases in sales and demand, types of species listed in inventories, and the types of clientele. An effective method of attaining such information is a routine online survey to be completed by the retailer.

Implement educational programs and materials that convey the hazards associated with the release of unwanted terrestrial vertebrate pest species. Animal releases are primarily performed by the public. Public education can help prevent intentional or accidental importation and release of pest species (USDA-APHIS-WS 2010). Provide education through the distribution of printed materials that include examples of how released animals can become human health and safety, economic, and ecological, threats once established. Target schools to educate children on the importance of preserving natural ecosystems. Adults should be targeted as they will be the group most likely to release, smuggle and inadvertently harbor pest species. The military sector and foreign contract workers should be focused upon with extra effort.

Begin to regulate against aesthetic releases of terrestrial vertebrates. While specific regulations exist regarding the importation of pets (see GARR Title 9, 1997), regulations regarding release of animals are less developed and detailed, such that release remains relatively unmonitored. The only mention of regulation to prevent release is at the pier or airport inspection areas; Section 2 of § 1103 (GARR) states that under no circumstances shall any animal be turned loose at the port, and that hogs and sheep may be confined in temporary pens or crates, cattle and horses may be tied, and dogs and cats shall be confined in crates. Require specific taxa such as birds and mammals (rodents) be quarantined immediately upon arrival in compliance with existing APHIS requirements. Therefore the regulation only restricts release at the port of entry with no regulations against releases post-border, which is when aesthetic releases are most likely to occur. Under a new regulation, if an intentional release is known to occur in the community and is reported, individuals involved should be subject to a penalty such as fines.

8.7.5.3 *Food Use*

- Risk of importation 3
- Risk of establishment 3
- Hazard 3
- Total risk 9 **HIGH**

The importation of domesticated animals as a food source is common worldwide. The continued importation of animals via this pathway makes this a high-risk pathway. As a consequence, transport and release of domesticated food species onto islands lacking them is typically viewed as simply exercising the right to feed oneself, and the practice continues around the globe (Kraus 2009b). However, some domesticated animals introduced as a farmed food source can successfully establish and some species can be highly invasive and ecologically destructive (sheep, pigs, frogs). Also, newly introduced food species often coincide with the immigration of new ethnic groups to a place making this motive both culturally and demographically linked.

Imported poultry and eggs must be quarantined, and inspected, and poultry must be vaccinated by a Territorial veterinarian for health condition prior to entry on Guam under Title 9 GARR 1997 and USDA-APHIS regulations and inspection. All poultry and hatching eggs must remain on board or be confined on the pier or airport inspection area until passed by the inspector under this regulation. With poultry being the natural host for pullorum disease, health inspections and quarantine quell human health threats, as pullorum disease can also affect humans. In addition, poultry can carry NDV, a virus that may be present in high concentrations in the bodily secretions of infected birds. The virus is spread by air, contact with body secretions, and by contaminated water and feed (UNH Extension Program, http://extension.unh.edu/resources/files/Resource000792_Rep815.pdf).

Prohibit the farming of frogs and freshwater turtles for food. Large frog species continue to be known as an easy way to raise protein in one's backyard either for direct consumption or, more often, for commercial sale (Kraus 2009b). However, frog farming remains a difficult industry with limited success and commonly leads to introductions of frogs when failed farms are abandoned (Kraus 2009b). Frog farming has not been attempted much in Micronesian countries, and therefore it remains a plausible commercial endeavor in the region. Freshwater turtles such as the Chinese soft-shelled turtles, (*Pelodiscus sinensis*) have been introduced and spread through the farming industry. The inexperience of farming of these taxa makes the risk of introduction high for the Micronesia Region and the importation of these species for farming purposes should be prohibited as a preventative measure.

Aquaculture shipments entering Guam must have an import permit, certificate of origin, and health certificate, and should undergo physical inspection for amphibians and their eggs. Aquaculture shipments are not always physically inspected, even though these shipments are a known pathway for the unintentional and intentional introduction of amphibians and their eggs (Christy et al. 2007b; Kraus 2009a). Illegal import of terrestrial vertebrate pest species can occur through legal means, such as with aquaculture imports. USFWS only has nine ports in the United States that are designated to approve shipments of live fish and fish parts for aquaculture, and these are in the Continental United States and Hawai'i. The Designated Port Exception Permit is required if Guam or CNMI is the first port of entry for a fish shipment. USFWS approval of fish shipments is intended to prevent harmful exotic species from establishing and approval is typically granted contingent on the permit being complete. Aquaculture shipments should be physically inspected upon arrival, especially those containing live freshwater species such as catfish and tilapia, which are more prone to containing tadpoles that are not clearly evident amongst the imported fish fry being shipped in nontransparent containers, which further complicates inspections.

Use digital resources to track the trade and importation of animals for food use in the Micronesia Region. The illegal import of terrestrial vertebrate pest species can occur through legal means, such as with animals imported for food use. The Internet can be used to identify the sale of prohibited or non-compliant importation of animals for food use. The Invasive Species Internet Monitoring System automates the process of searching the Internet for suspect sites (e.g., Internet storefronts, chat rooms) involved in the sale or trade of targeted species (Suiter and Sferrazza 2007) for the pet trade, and this tool may be applied to detect breaches in legal importation of animals for food use.

Educate the community about the dangers of maintaining populations of potentially invasive species for food. This education should include ensuring that overseas workers who may come to the region for construction and other projects are aware of the risks associated with such practices. Create educational materials, broadcast public service announcements on the radio, and submit newspaper articles outlining the impacts of establishing populations of species for food. These materials should include examples of species known to be introduced for food use, and also known to be highly invasive in one or more countries (e.g., rabbits [*Oryctolagus cuniculus*], banteng [*Bos javanicus*], water buffalo [*Bubalus bubalis*], Polynesian rat [*Rattus exulans*], spotted turtledove [*Streptopelia chinensis*], water frogs [*Rana ridibunda*]) (Crook 1973; Atkinson 1978; Long 1981; Lever 1994; Arano et al. 1995; Pagano and Schmeller 1999; Athens et al. 2002; Courchamp et al. 2003; Long 2003a; Pagano et al. 2003; Vorburger and Reyer 2003; Towns et al. 2006; Hunt 2007).

8.7.5.4 *Animals for Entertainment*

- Risk of importation 2
- Risk of establishment 2
- Hazard 3
- Total risk 7 **MODERATE**

Some species are imported purely to entertain members of the community. Two major examples of this in Micronesia include importation for stocking zoological facilities, and poultry importations for the popular and legal pastime of cockfighting. While the containment and display of these species is inherent to both zoological facilities and fighting cock owners, accidental releases to the wild occasionally occurs as a result of these practices.

Laws and regulations regarding zoological facilities need to be established and/or improved for all jurisdictions with the possible except of Hawai'i. Regulations for Hawai'I may in fact be an appropriate starting place for the other jurisdictions. The situation which occurred on Guam when the zoological facility in southern Guam closed last decade highlight the fact that there are gaps in existing regulations and protocols for Guam and likely other jurisdictions in this regard. In the Guam

case, some of the animals from the zoological facility which closed were never accounted for suggesting that they may have ended up in the general community or even been released.

Zoological facilities should update and maintain secure caging, as well as improve security measures at the facilities. Most records of releases at zoos are accidental due to non-secure caging, but there have also been several instances of intentional releases of animals by personnel at larger, public zoos (Shaw 1946; Long 1981). Zoological facilities should conduct and document inspections routinely of their caging structures, and weak points must be addressed immediately. The facilities should also selectively hire security staff to prevent instances of criminal animal release. Currently, there is one zoo on Guam (previously with two), one on Rota, and one on Saipan (Stanford, personal communication). A relatively low amount of activity makes the risk of importation rather low, but the rather poor maintenance standards evinced by many private zoos make risk of release into the wild rather high (Kraus 2009b).

Species in zoological facilities should be kept only in small numbers, and breeding pairs are of higher priority for cage maintenance. If large colonies or cohorts of breeding adults of both sex classes of a species are kept within the same cage, there is a higher risk of establishment if a release does occur. Cages that contain breeding pairs should be of higher priority for the inspection and maintenance of cage security.

USDA-APHIS agents, in coordination with GCQA, must verify permits and health inspections for animals being imported for the purpose of stocking zoological facilities. Importation of zoological stock animals to Guam requires an import permit obtained from Guam's office of the Director of Agriculture and animals are subject to inspection by the territorial veterinarian prior to entry to Guam (9 GARR § 1111) as well as the AWA, which is implemented by APHIS through its Enhanced Animal Welfare Act Enforcement Plan.

USDA-APHIS agents at airports throughout Guam and the CNMI must report and confiscate fighting roosters arriving from the U.S. mainland. While cockfighting events remain legal in Guam and the CNMI, the export of fighting roosters and associated cockfighting weapons from the U.S. mainland is considered a felony under the Animal Fighting Prohibition Enforcement Act of 2007. Guam is a known hotspot for cockfighting, such that all imported roosters arriving in Guam should be considered imported for cockfighting purposes. Eggs have less of a chance of surviving transport because of the higher physiological demands of eggs as compared to adult chickens. Under this recent piece of legislation, pressure has been applied to stop commercial airlines from transporting fighting roosters. Airlines such as United, Philippine, and Korean Airlines refuse to transport fighting roosters as a precautionary upholding of the Animal Fighting Prohibition Enforcement Act. This act will stop the importation of adult fighting roosters, reducing the overall number of domesticated birds entering Guam and the CNMI. People who claim their imported roosters are pets should be subject to a monitoring program using periodic paperwork and inspections to track the actual use of the roosters imported.

8.7.5.5 *Game Hunting*

- Risk of importation 1
- Risk of establishment 2
- Hazard 3
- Total risk 6 **MODERATE**

Game hunting on Guam and throughout the CNMI is a cultural practice, and also functions in game population management because it is a low-cost management tool to reduce feral animal populations; thereby reducing habitat destruction on the island (Conry 1988b). Game introductions typically include only mammals and birds; reptiles and amphibians are not moved for this purpose (Kraus 2003; 2009a). The animals hunted on Guam are all introduced species such as the Philippine deer, wild pig, and black francolin. Similar to other Pacific Islands (Hawai'i), pigs have the most negative impact on forests and agriculture on Guam (Conry 1988a). Many of the ungulates introduced for game purposes have proven very destructive of native ecosystems on Pacific Islands and elsewhere (Stone 1985; Conry 1988b; Wardle et al. 2001; Wiles 2005; Hughey and Hickling 2006; GISD 2010). This is both because of direct herbivory on native vegetation as well as trampling of the substrate (e.g., Duncan and Holdaway 1989), both of which lead to plant death and increased erosion (Kraus 2009b). Due to their negative impact on the environment (erosion, trampling vegetation), Asiatic water buffalo (carabao) can no longer be hunted, and populations are being controlled by hormone injections to reduce reproductive rates. Once popular game, the fruit bat and Phillipine turtle dove are no longer allowed to be hunted due to declining populations (http://www.guamdawr.org/wildlife/hunting/).

Regulations preventing further importation of feral animals for recreational hunting must be upheld and expanded. USDA-APHIS oversees the importation of feral animals from foreign ports through the facilitation of international trade and monitoring of animal health at the border. Uphold APHIS regulations for certain species whether feral or not for foreign origin imports to Guam; APHIS regulations take precedence when they are more restrictive than the laws and regulations of the U.S. federal government. APHIS regulations would not apply to shipments coming to Guam from the United States (non-foreign origin), but imports to Guam from the United States are not considered foreign imports. As it stands, feral animals may be imported to Guam with proper permitting and approval by the Director of the Department of Agriculture (Title 9, GARR 1997). There should be no further importation of feral animals for the purpose of recreational hunting, because the game densities are more than sufficient on Guam (e.g., wild pigs; Conry 1988a), especially if more hunting areas were to be opened for access.

Additional hunting areas should be opened for public access, and hunting by military personnel on military lands is encouraged. Guam law requires hunters to obtain written permission to hunt on private property, and public lands for hunting are often surrounded by military and private parcels, making hunting access logistics difficult (Conry 1988b). In particular, the Air Force and Navy already control large parcels of land where game is found, and Andersen AFB, NCS, and the Naval Facility have hunting programs, but access is restricted to military personnel. If personnel are not frequently hunting on these lands, herds of game will accumulate and habitat degradation becomes rampant. The military should work with GDAWR and USFWS to facilitate public hunting access on military lands of lower-level restriction during regimented times. Also, with the increase in military personnel on Guam as a result of the relocation, there lies an opportunity to increase hunting on military lands.

8.7.5.6 *Biocontrol*

- Risk of importation 1
- Risk of establishment 3
- Hazard 2
- Total risk 6 **MODERATE**

Biocontrol introductions are those made for the purpose of providing predatory control of another pest species, and typically itself is also of alien origin. Ironically, most of these releases have failed to control the pests they were intended to destroy but have become pests themselves (Kraus 2009b). Classic examples include the introduction of cats for controlling rodents that damage agriculture (Dickman et al. 2010), mongoose for controlling rats and snakes (Long 2003b, a; Watari et al. 2008), and cane toads released for controlling sugar cane pests (Lever 2001), all involving governmental support. While government-backed biocontrol has become less common due to the large amount of failed examples, biocontrol by private actions remains a risk. There is a general lack of public knowledge regarding the dangers of biocontrol and some recent introductions are initiated by private entities, under the belief that the pest can be controlled directly by the predator without any indirect, adverse effects. Attempts of biocontrol by private actions will be closely associated with the pet trade, as this is the most likely source for exotic animals for intentional release.

Place USFWS and USDA-APHIS inspectors on military bases in Guam and CNMI and initiate proper training of Military Customs personnel to recognize and prohibit importation of potential biocontrol-use species. The importation of species by military aircraft is worsened by the fact that USFWS does not have inspectors stationed at military bases in the region, so the probability of interception is unlikely. Depending upon the species, APHIS may also have import regulation requirements. The military route has led to numerous illegal importations of banned reptiles into Hawai'i (Hawai'i Department of Agriculture records), and some of these species include those released elsewhere for control of house pests. Similar activities likely occur on military bases in Micronesia and would likely increase with the relocation of military personnel on Guam and in CNMI, making this a likely source of importations for the purpose of private biocontrol initiated by individuals (Kraus 2009b).

Educate the public about regulated and scientifically proven effective control measures in place for BTS and other biting snakes. BTS and other snakes pose human health risks due to painful bites which can be life-threatening, depending on the species. Approximately one in every thousand hospital visits on Guam is due to a BTS biting incident, with victims including infants, agricultural workers, and BTS field staff (Rodda et al. 1999), leading to a large-scale economic impact as well. Many people have a deep-seated fear of snakes, and the vast majority of people resent snakes inside homes, stores, and other human environments (BTSCC 1996). Due to the high incidence of bites, it is natural for members of the community to want to protect themselves and others from snake pests, and they may resort to biocontrol under private actions. However, these attempts would be ineffective; there are no effective natural predators of BTS on Guam. Feral cats, feral pigs, and monitor lizards prey on snakes, but their effect is minimal (BTSCC 1996).

Furthermore, the introduction of the mongoose to Guam has been proposed due to its reputation as a snake predator even though they are not adapted to do so. Mongooses are diurnal and cannot climb well, unlike BTS. Previous introductions of mongooses to control the habu in Pacific Islands have failed, and resulted in additional ecological problems, including the extirpation of some native herpetofauna (BTSCC 1996).

Proposed biocontrol measures must be approached with extreme vigilance, and those considered for action must undergo long-term scientific trials. Vertebrate biocontrol releases have tended to have high probabilities of successful establishment (Long 2003b; Kraus 2009a) due to high propagule pressure. For example, the introduction of the mongoose to Pacific Islands was an early attempt of biocontrol of an agricultural pest species, with the approach rooted in predator-prey dynamics. Yet, the mongoose has proven too general of predator, causing the decline of native bird and reptile species (Simberloff 1992). In Hawai'i, 22% of 243 biocontrol agents were documented to attack organisms other than their intended targets (Funasaki et al. 1988). In application, the biocontrol attempt may often lead to unforeseen ecosystem consequences that worsen the original problem (Matthews and Turner 2009) or create new management problems.

While countries such as Australia (McFadyen 1989) and New Zealand (Fowler et al. 2000), have established effective regulatory policies for biological control, the United States does not have an integrated policy on the implementation of biocontrol, and policies can differ vastly in stringency by state (Messing and Wright 2006). For these reasons, proposed biocontrol measures must be approached with vigilance; rigorous, long-term scientific trials must be required and fielding of professional and community opinions is integral.

8.7.5.7 ***Scientific Research***

- Risk of importation 1
- Risk of establishment 3
- Hazard 3
- Total risk 7 **MODERATE**

Releases associated with scientific research can be attributed to two main types: 1) deliberate or accidental releases from medical research facilities, and 2) deliberate releases to study ecology or behavior of the released specimens (Kraus 2009b). Accidental release from inadequate caging or mishandling of species may also occur. Examples of problematic releases from research facilities include the escape of monkey species, which quickly establish in the wild given the proper environmental conditions and food availability (Long 2003), or the establishment and rapid spread of escaped frog species (e.g., *Xenopus laevis*) (Lafferty and Page 1997). The importation for scientific research will not be a common occurrence in Micronesia, because the region has few medical or research facilities, with one medical school found in FSM and various biological research labs at the University of Guam (Western Pacific Tropical Research Center, Cancer Research Center and Guam Aquaculture Development and Training Center).

Scientific research in U.S. territories that involve terrestrial vertebrates must be approved by the Institutional Animal Care and Use Committee and undergo routine inspections in compliance with the AWA. All U.S. research facilities where vertebrates are used for research must have an active Institutional Animal Care and Use Committee permit for research prior the implementation of protocols. For example, at the University of Guam, the committee inspects animal facilities at least semi-annually and reviews any practices involving pain to animals and the condition of animals to ensure compliance with the AWA, 7 U.S.C. § 2143 et seq.; 9 CFR 1, §2.31 and the standards of the United States Public Health Service as set forth in the Guide for the Care and Use of Laboratory Animals (http://www.uogonline.com/gateway/forms/rules_regs_proc_man.pdf, accessed September 30, 2010). Facility inspections will help to ensure proper secure caging is maintained and proper quarantine protocols are in place.

Caging and containment of vertebrates used in research must be routinely inspected and maintained, and security personnel must be in place at the facility. Research facilities should conduct and document inspections routinely of their caging and containment structures, and weak points must be addressed immediately. Like zoological facilities, there is a risk of accidental or intentional release by staff of captive vertebrates. The facilities should also hire security personnel to prevent instances of intentional animal release by individuals.

The importation of monkeys and *Xenopus laevis* for research use should be banned from Guam and the CNMI. Currently, the regulations on importation of vertebrates to Guam do not mention the policy on importation of vertebrates for the use of research (Title 9 GARR). However, the regulations should be updated to specifically address this motive for importation and restrict problem species such as monkeys and *Xenopus laevis*.

8.7.5.8 *Religious Ceremonies*

- Risk of importation 1
- Risk of establishment 1
- Hazard 2
- Total risk 4 **LOW**

Intentional releases of terrestrial vertebrate species can occur during religious ceremonies or because of religious beliefs. Birds and turtles are the most common terrestrial vertebrates used for release (Severinghaus and Chi 1999, Kraus 2009a), but mammals, frogs, and snakes are targeted as well

(Agoramoorthy and Hsu 2005, 2007; Corlett 2010). Many of these released animals are purchased from pet stores, with one study finding one-quarter of all birds stocked in Taipei pet stores slated for this purpose (Severinghaus and Chi 1999), making this motive tied to the pet trade and its associated risks and recommendations. Therefore, the risk of religious ceremony release can be intercepted if the recommendations suggested for the pet trade are successfully implemented.

Create agreements with groups of concern that are known to participate in religious releases of vertebrates. There are two major sources of vertebrate releases for religious purposes, the Buddhist and Taoist practice of releasing captive animals as an expression of compassion to improve one's karma (Shiu and Stokes 2008) and Christian snake-handling cults in the southern United States who release venomous snakes (Wilson and Porras 1983). The risk of establishment is high for this motive because of the typically large volume of animals released and the high frequency of release, leading to high propagule pressure. The risk from this motive is low for Micronesia at present, although this could change if larger numbers of practicing members of groups of concern immigrated to the region. Attempts should be made to create agreements with groups of concern directly regarding the release of vertebrates. This motive is very difficult to regulate, as releases occur in large numbers and may be incidental or routine, depending on the sect of the religious group. Educational materials that outline the human health and safety, economic, and ecological threats of vertebrate release should be disseminated to practicing groups of concern in Micronesia.

8.7.5.9 *Bioterrorism*

- Risk of importation 1
- Risk of establishment 1
- Hazard 3
- Total risk 5 **LOW**

Optimal characteristics for bioterrorism agents include being very small in size (microscopic), hazardous to humans, easy and inexpensive to produce, and rapid spatial dissemination. Well-known examples include anthrax, bubonic plague, and smallpox. Vertebrates do not fit these desirable characteristics themselves due to their relatively large size. One possible exception would be that a large number of venomous snakes could be introduced for such a purpose, but the numbers required for importation for the task (hundreds to thousands) could likely not easily be overlooked by a border-security system (Kraus 2009b). Therefore, the risk of this motive for vertebrates as bioterrorism agents themselves is low, and any importation for this purpose will likely be detected by inspectors. However, it must not be overlooked that bioterrorism agents may be tactically introduced via a domesticated non-human vertebrate host. Epizootic outbreaks may first be noticed in vertebrate species such as livestock, where the agent was introduced along with a host that was cleared at the border. Due to prolonged and close exposure of livestock to people, the zoonotic agent then infiltrates the human health circuit. The potential for introduction of a bioterrorist agent will be of particular concern for Guam due to projected extensive military presence on the island. In general, the increases in human population, both military and civilian, are expected to significantly increase the likelihood of wildlife pathogen introductions and spread via humans.

Health certificates (issued by the USDA Animal Health Division or by the state veterinarian for the state of origin), must accompany imported livestock, and such livestock is subject to health inspections by the territory veterinarian(s) and quarantined if needed. All animals that have been exposed to, are suffering from, or appear to have the symptoms of a contagious or infectious disease, shall in addition to the inspection be subject to quarantine under regulations of the government of Guam (2 GARR § 1110.5) and required USDA-APHIS Animal Health Permits. Depending on the species of livestock, inoculations or pathogen assay tests may be required prior to entry (e.g., horses, cattle). Bird species, especially those in the pet trade like psittacines, should be quarantined upon arrival.

Livestock operations on Guam shall undergo routine inspections by the Department of Agriculture (Guam) to determine the health condition of all animals boarded at each farm. This mandate is in compliance with § 62104.3. Standards of Care for Livestock (GCA Government Operations: http://www.justice.gov.gu/compileroflaws/GCA/05gca/5gc062.pdf).

A network must be established for the reporting of animals exhibiting symptoms of zoonotic agents. A cooperative network for communication must be made involving the CDC, USDA-APHIS, livestock owners, and local veterinarians, among others to exchange information regarding detections of symptoms caused by hazardous pathogens in livestock. The goal of such a network is to readily disseminate alerts within the region to prevent further spread of bioterrorist agents in the case they are introduced.

8.8 CONCLUSION

Biosecurity is a management process that requires a specific and appropriate framework in which to operate effectively. Additionally, a biosecurity strategy requires sustained and managed funds, the capabilities to address myriad security issues, and flexibility to undergo regular assessment and refinement as needs change and new risks are identified. This biosecurity plan accomplished the following goals: 1) identified pathways by which species may be transported, introduced, and established; 2) identified risks associated with pathways and the threats posed to human health and safety, the economy, and ecology; and 3) provided recommendations for the prevention and mitigation of the identified risks. Furthermore, a comprehensive pathway analysis was used, which accounts for the interrelatedness of pathway use and overlap of military and civilian sectors.

This plan provides guidance and instruction to prevent and mitigate risks associated with the military relocation in the Micronesia Region; comply with stringent environmental legislation; and coordinate with agencies at the federal, state, and local level.

9 PORT-PATHWAY MITIGATION ANALYSIS

9.1 GUAM MITIGATION CAPABILITIES AND INFRASTRUCTURE

Table 12-1: Mitigation Measures for Guam Airports and Maritime Ports

Mitigation Capabilities/Infrastructure	Airports	Maritime Ports Containerized (DoD)	Maritime Ports Containerized Cargo All Sources	Maritime Ports Break Bulk Cargo	Maritime Ports Bulk Cargo
Inspect	X	X	X	X	X
Identify	X	X	X	X	X
Control	X	X	X	X	X
Quarantine	X	X	X	X	X
Treat/disinfect/decontaminate	X	X	X	X	X
Review permits, licenses, sanitation certificates	X	X	X	X	X
Train	X	X	X	X	X
Monitor/transfer garbage to approved disposal company	X	X	X	X	X

9.2 GUAM CRITICAL INFRASTRUCTURE PROFILES

9.2.1 A.B. Won Pat International Airport-Guam

Table 12-2: A.B. Won Pat International Airport-Guam

Description	Current Mitigations	Impact of Military Relocation
300 flights per week. Seven international airlines and six air freight couriers operate out of the A.B. Won Pat International Airport. The airport has 21 aircraft parking positions with 18 common use terminal gates (55% commercial, 24% air taxi; 21% local general aviation; <1% transient general aviation) (AirNav 2007).	Inspection of aircraft, baggage, and cargo by GCQA–about 120 inspectors assigned to airport and seaport. Collaborate with APHIS to enforce regulations. Monitor garbage. Port control measures: Quarantine, Decontamination, Treatment/washing Arriving commercial aircraft are not usually inspected for terrestrial vertebrate species. All aircraft departing Guam, commercial or military, are inspected for BTS (EO 13112, Invasive Species). Inspections are constrained by resources to only a portion of air freight conveyance crates and containers. Container scanners are not available on Guam.	The large additional number of people arriving on Guam during the buildup will strain the already limited resources of GCQA.

9.2.1.1 *Prioritized Actions-A.B. Won Pat International Airport–Guam*

- The international airport foreign inspection area is large enough to accommodate the increased flights and to enhance inspectional needs.
- However, personnel specially trained for agricultural quarantine inspections and equipment (e.g., x-ray machines) for inspection of all baggage must be increased.
- GCQA should designate agricultural specialists on all shifts. There should be additional personnel for passenger baggage and aircraft inspection daily (assigned to all shifts).
- GCQA should have inspectors that specialize in agricultural inspections. Due to shift work and the large number of inspection sites, GCQA should plan to increase total staff with specialists dedicated to agricultural inspection. Inspectors should be available for agricultural products on all shifts at the international airport.
- X-ray machines are inoperable. Obtain adequate capacity for inspection of luggage and large boxes. Expand numbers of x-ray stations from two to four with new x-ray units that have conveyor belts at ground level on front and back.
- Detector dogs should be available at all international airport shifts. Increase staffing of agricultural detector dogs from four to eight. Agricultural detector dogs should be used in mail and cargo inspections.
- GCQA should have access to the USDA-APHIS ePermits system. Access can be provided by APHIS.
- Legislation should allow full access to GCQA to CBP targeting databases so inspectors in Guam routinely can examine manifests and hold and release cargo for 2 to 3 days prior to ship arrivals.

Funding Priorities

- GCQA must explore all opportunities to expand legislative authority to increase user fees to allow GCQA to fund the necessary increase in inspectors and equipment for more entry inspections and a reliable mitigation infrastructure.
- GCQA should consider raising these fees for biosecurity and agricultural inspections. The funding structure of USDA and CBP can be utilized as a guide.

9.2.1.2 *General Recommendations-A.B. Won Pat International Airport-Guam*

Resources

- Staffing at A.B. Won Pat International Airport for agriculture inspections should be expanded to permit GCQA inspection of all incoming passenger baggage during the increased military use of commercial air transportation pathways, the increase in commercial air cargo with the proposed military relocation, and expected passenger plane travel. Ensure adequate numbers of inspectors, identifiers, pest survey specialists, etc. to carry out mitigation measures effectively.

GCQA should be funded and staffed at optimum levels for all necessary inspection and quarantine activities.

- X-ray machines should be available and work properly to maximize baggage screening. Increase the number of detection equipment (x-ray) at airports in Guam from two to four. The sensitivity of the machines should be increased.
- There should be sufficient equipment (computers, microscopes, dissecting scope, hand-lenses and other diagnostic equipment) and supplies (e.g., reference materials, identification keys) at ports and plant and animal inspection facilities.
- Install container scanners at the port facility. Allocate funding to increase the number of containerized and crated air cargo shipments to be inspected.
- Ensure garbage collected in sterile areas are handled and processed as regulated garbage.

Inspection

- Conduct inspections on commercial/private aircraft arriving to Guam and departing.
- Inspect all arriving conveyances for illegal animals or animal products.
- Increase inspection rates of commercial air freight.
- Inspect passengers transiting to other locations in the Micronesia Region for regulated agricultural commodities.
- Air cargo conveyance crates and containers tend to be inspected if shipments are labeled as containing agricultural products, have insufficient or improper documentation, or are from a country of concern. Standardized methods should search containers randomly regardless of documentation, type of shipment, or country of origin. Paperwork with arriving air cargo shipments in crates and containers should be automated for more rapid selection of containers to be screened and for new avenues for pre-clearance procedures.
- All military personnel checked baggage transported to and from Guam and the CNMI on commercial, private, and chartered planes and helicopters must be inspected for compliance with USDA-APHIS regulations. Expand the inspection capabilities for military airfreight containers.
- A communications network for continuously shared relevant new information among inspectors is recommended.

Control

- Implement measures to control invasive species at and around washdown facilities. Control measures include barriers, trapping, and insect population reduction.
- Construct barriers around aircraft staging areas to protect aircraft from hitchhikers.

Treatment

- All military air cargo departing Guam should be cleaned, inspected, and loaded on the aircraft for transport immediately.

Surveillance

- Increase airport surveillance measures.

Rapid Response

- Improve airport rapid response capabilities.

9.2.2 Andersen Air Force Base-Guam

Table 12-3: Andersen Air Force Base-Guam

Description	Current Mitigations	Impact of Military Relocation
Air Mobility Command aircraft transports military cargo not consigned to commercial carriers. Military aircraft used in medical/emergency missions depart Guam with little or no notice for inspection. Military training operations are conducted by the Army, Marine Corps, Air Force, and Navy.	Inspection of aircraft Vector/arthropod controls Medical and agricultural quarantine Aerosol disinfection Aircraft moving between Hawai'i, Guam, Puerto Rico, Virgin Islands, and the continental U.S. must undergo USDA/GCQA inspection by inspectors with authority to board military aircraft (Section II, Subsection C of the Quarantine Regulations of the Armed Forces Section 10 of OPNAVINST 6210.2, USDA requirements for movement of animal and plant diseases and pests). With no internal inspection and cleaning, hitchhiking pests and animals go undetected. Arriving military aircraft usually are not inspected for terrestrial vertebrate species. All aircraft departing Guam, commercial or military, are inspected for BTS according to EO 13112, Invasive Species, by APHIS-WS. Planned Improvements: Additional aircraft will be housed on Andersen AFB by the Marine Corps.	Unknown schedule or frequency of military flights aside from those supporting periodic training missions on Tinian. Increase in military flights and passengers to and from Guam.

9.2.2.1 ***Prioritized Recommendations-Andersen Air Force Base-Guam***

- The present passenger facility at Andersen AFB is far too small for baggage inspection. The facility should be tripled in size and it should have an inspection table with sufficient lighting and a conveyor belt.
- GCQA coordination at flight arrivals with Andersen AFB personnel must be improved so that advance notice may be given for all flight arrivals into Guam.

9.2.2.2 *General Recommendations-Andersen Air Force Base-Guam*

Resources

- There should be an adequate number of inspectors, identifiers, surveyors, etc. to carry out mitigation measures effectively.
- Military funding for biosecurity efforts in the region should be proportionate to the increase in cargo volume expected by the military relocation.
- There should be sufficient equipment (computers, microscopes, dissecting scope, hand-lenses, and other diagnostic equipment) and supplies (e.g., reference materials, identification keys) at ports.
- Place GCQA inspectors on military bases in Guam and initiate proper training of military customs personnel to assist in smuggling prevention, animal confiscation, law enforcement and coordination with rapid response teams.

Infrastructure

- A pre-clearance staging area for all military aircraft requiring immediate departure from Guam is needed.

Inspection

- Facilitate USDA-APHIS-PPQ and WS inspections of military air embarkation procedures comparable to, compatible with, and co-located with Andersen AFB operations for loading and unloading aircraft cargo. The Quarantine Regulations of the Armed Forces state that cargo is subject to inspection by the USDA to prevent the introduction or spread of animal and plant diseases or pests. For the purposes of these regulations, Guam is part of the United States.
- Conduct internal and external inspections on military aircraft arriving at Guam.
- MCI programs should augment and improve inspectional capacity for all military arrivals and departures.
- Expand the inspection capabilities for military airfreight containers.
- A communications network for continuously sharing relevant new information among inspectors is recommended.

Control

- Implement measures to control invasive species at and around washdown facilities. Control efforts include barriers, trapping, and insect population reduction.
- Construct barriers around aircraft staging areas to protect aircraft from hitchhikers.

Treatment

- All military air cargo arriving and departing Guam should be cleaned, inspected, and loaded for immediate transport.

Surveillance

- Increase surveillance measures in military airports and screening checkpoints.

Rapid Response

- Improve airport rapid response capabilities.

9.2.3 Apra Harbor

9.2.3.1 *Apra Harbor Military Seaport-Guam*

Table 12-4: Apra Harbor-Military Seaport-Guam

Description	Current Mitigations	Impact of Military Relocation
Military Maritime Traffic MIRC is a major naval training area that includes Guam, the islands of Saipan, Tinian, Rota, and Farallon de Medinilla, and the training area W-517 (U.S. Navy 2009a). Exercises involve 3 to 30 ships and last 5 to 21 days. Training events may occur 1 to 5 times per year. The southern end of Apra Harbor on Guam has four major wharves available for docking ships: Victor Wharf, Sierra Wharf, Polaris Point, and Kilo Wharf. Navy waterfront facilities are located in both outer and inner harbors. Waterfront facilities for the U.S. Coast Guard are located in the inner harbor.	Inspection Decontamination Treatment Monitoring garbage Port control measures Quarantine Treatment / washing GCQA has authority to inspect military vessels per an MOU with USDA-APHIS-PPQ. Planned Improvements: New embarkation area for loading and unloading ships new amphibious vehicle lay-down area, four waterfront projects	Large increase in military vessel calls and cargo expected to enter through this facility.

9.2.3.2 *Prioritized Recommendations-Apra Harbor-Military Seaport-Guam*

- The military port of Guam should have centralized points of inspection of break bulk and containerized cargo.
- DoD and GCQA should cooperate in a local MOU to enhance collaboration and develop protocols for inspection of military vessels by GCQA personnel for agricultural compliance purposes.
- Institute a military customs inspector program with GCQA and DoD agreement to augment inspections of military vessels.

- Initiate military pre-clearance program for cargo and military assets moving from Okinawa to Guam. This program should be aligned with other APHIS-PPQ military training and pre-clearance initiatives.
- APHIS-PPQ should train GCQA for conducting inspections, treatments, data analysis, and safeguarding methods.
- Priority for surveillance of exotic and destructive insects should include trapping for: 1) exotic fruit flies, 2) Khapra beetle (in cargo and cargo warehouses); and 3) tropical forest pests.
- An inspection pest risk committee to analyze pest detection information should be formed with participation of GCQA, APHIS, and territorial officials.

9.2.3.3 *General Recommendations-Apra Harbor-Military Seaport-Guam*

Resources

- There should be sufficient numbers of inspectors, identifiers, surveyors, etc. to carry out mitigation measures effectively.
- Military funding for biosecurity efforts in the region should be proportionate to the increase in cargo volume expected by the military relocation.
- There should be sufficient equipment (computers, microscopes, dissecting scope, hand-lenses and other diagnostic equipment) and supplies (e.g., reference materials, identification keys) at ports and plant and animal inspection facilities.
- Station GCQA inspectors on military bases in Guam and initiate proper training of military customs personnel to assist in smuggling prevention, processing insect pests, plant and animal diseases, and confiscated animals, enforcing laws, and coordinating with rapid response teams.
- Increase the number of agriculture and WS canine inspection teams at the seaport.

Inspection

- Inspect all arriving conveyances for illegal animals or animal products.
- A communications network for continuously sharing relevant new information among inspectors is recommended.
- Visually inspect all incoming construction vehicles, equipment, and materials, including those previously treated or cleaned (due to high chance of recontamination with hitchhikers).
- Manage the grounds around military seaports and beach access point facilities to reduce populations of target invasive species, and stop existing wildlife populations from interacting with introduced wildlife at ports of entry.
- Inspect all military arriving vessels internally and externally.
- Improve protocol for inspecting the holds of military ships.

- Implement inspection procedures for vehicle cargo aboard high-speed military vessels.

Control

- Implement measures to control invasive species at and around washdown facilities. Control efforts include barriers, trapping, and insect population reduction.
- Construct barriers around cargoes and aircraft staged on land overnight to protect from hitchhikers.

Treatment

- Military aircraft transported as cargo (aboard an aircraft carrier or other military vessel with aircraft transport capabilities) must be inspected, cleaned, and washed down at the port of entry.
- Military amphibious vehicles arriving via water must be inspected, cleaned, and washed down at a retrograde wash facility before entry.
- POVs arriving via water through military routes must be washed down at a port facility before entry.
- Military assault vehicles arriving as cargo via maritime vessels must be washed down at a retrograde wash facility before entry.
- WPM should be compliant with ISPM No. 15.

Training

- Provide training to improve inspection and identification expertise for WPM pests WPM.

Surveillance

- Increase surveillance measures in military and commercial air- and seaport entry points and screening check points.

9.2.4 Apra Harbor Commercial Seaport-Guam

Table 12-5: Apra Harbor-Commercial Seaport-Guam

Description	Current Mitigations	Impact of Military Relocation
Jose D. Leon Guerrero Commercial Port of Guam is located at the northern end of Apra Harbor with commercial and recreational facilities in the outer harbor. The Commercial Port has six berths with the main cargo terminal for port access for vessels with unusual draft and cargo container handling requirements. The majority of the large ships are operated by Matson Navigation Company and Horizon Lines. The Kyowa Shipping Company also operates in the area from the ports of Busan, South Korea and Yokohama, Japan into the port on Saipan. Regional shipping from the ports of Guam and Saipan throughout the region is by Kyowa, Seabridge Marine, and Micronesia Express Service. Islands serviced by these providers in the region: Guam; Saipan and Tinian (CNMI); Majuro (RMI); Pohnpei, Chuuk, Kosrae and Yap (FSM); and Palau.	Inspection Decontamination Monitoring Port control measures Quarantine Treatment/washing GCQA inspect only a portion of containers. GCQA and USDA/APHIS/WS inspect containerized freight at Port of Guam's 78 freight stations across the island (de-centralized). Planned Improvements: The Port of Guam plans significant improvements to present facilities.	Large increase in vessel calls and maritime containers. Source: Master Plan 2008, Port Authority of Guam

9.2.4.1 *Prioritized Recommendations-Apra Harbor-Commercial Seaport-Guam*

- Improve pest exclusion by increasing GCQA staffing of inspectors significantly at the commercial seaport to inspect incoming ships and cargo for pests and invasive species.
- A significantly larger workforce is necessary without a centralized inspection area.
- There is a major risk of dissemination of pests and diseases with the present cargo/container system on Guam.
    - Ensure that GCQA can staff significantly more inspectors at the commercial seaport to inspect incoming ships and cargo fully. A significantly larger inspectional workforce is necessary without centralized inspection areas in Guam.
    - Port of Guam must develop facilities for inspection of containers and devanning of cargo. These facilities should be incorporated into the Port of Guam Master Plan and must adhere to standards for sufficient lighting and inspection tables as specified by the APHIS-PPQ Manual for Agricultural Clearance.

- Safeguarded areas for storing and staging vehicles and cargo must be maintained. Vegetation-free areas of 1.8 meters (6 feet) or more must be maintained around the area as well as physical barriers.

9.2.4.2 *General Recommendations-Apra Harbor- Commercial Seaport-Guam*

Resources

- Permanent operational wash racks for inspection and cleaning of soil-contaminated vehicles and equipment must be maintained at both the commercial and military seaports.
- There should be sufficient numbers of inspectors, identifiers, surveyors, etc., to carry out mitigation measures effectively.
- GCQA should be funded and staffed at optimum levels for all necessary inspection and quarantine activities
- Develop a reference collection of plausible insect pests and wildlife (i.e., taxidermy mounts) to aid in the identification of incoming species.
- There should be sufficient equipment (computers, microscopes, dissecting scope, hand-lenses and other diagnostic equipment) and supplies (e.g., reference materials, identification keys) at port offices.
- Increase the number of canine inspection teams stationed at Apra Harbor Commercial Port

Infrastructure

- Build a centralized USDA-APHIS-approved staging area for containerized commercial cargo arriving at the Port of Guam.

Inspection

- Inspect all arriving conveyances for insect pests and illegal animals or animal products.
- Expand the inspection capabilities for commercial containers. Containerized cargo is the most frequent type sent in and out of Guam and the Micronesia Region.
- Randomly sample imports (e.g., cargo containers) for insects, animal products, and wildlife.
- Implement x-ray detection for baggage screening.
- Improve protocol for inspecting commercial ship holds.
- Designate entry inspection requirements and personnel for construction materials.
- Visually inspect all incoming construction vehicles, equipment, and materials, including those previously treated or cleaned (due to high chance of recontamination by hitchhikers).
- Develop improved methods for inspecting timber.

- Inspect cargo at both departure and arrival points if transported on open barges moving break-bulk items that originate near heavily vegetated locations and new construction sites where heavy equipment is in proximity to jungle areas.
- A communications network for continuously sharing relevant new information among inspectors is recommended.

Control

- Manage the grounds around commercial seaports and beach access point facilities to reduce populations of target invasive species, and stop existing wildlife populations from interacting with introduced wildlife at ports of entry. Implement measures to control invasive species at and around washdown facilities. Control efforts include barriers, trapping, and insect population reduction. Construct barriers around cargoes and aircraft staged on land overnight to protect from hitchhikers.

Treatment

- POVs arriving via ships through commercial routes must be washed down at a port facility before entry.

Training

- Train inspectors in proper techniques for detecting, extracting, and recognizing pests from WPM.
- Create additional training and education programs for inspectors in proper identification of quarantine species.
- Facilitate training/education programs for inspectors in changing livestock and poultry hazards.
- Conduct background surveys at ports-of-entry so customs and quarantine personnel are familiar with the local animals.

Surveillance

- Increase surveillance measures in military and commercial airports, seaport entry points, and screening checkpoints.

9.2.5 Guam Marinas

Table 12-6: Guam Marinas

Description	Current Mitigations	Impact of Military Relocation
Guam also has two marinas, Hagatna Marina (Gregorio D. Perez Marina) and Agat Marina, administered by the Port Authority of Guam (PB International 2008). There are at least three major recreational fishing events that utilize these marinas (Guam Marianas International Fishing Derby, the Fisherman's Festival, and the Annual Marianas Underwater Fishing Federation Competition). The fishing derby averages around 70 boats and 300 fishermen. A total of 75 teams participated in the derby departing from both the Agat and Hagatna Marinas in 2009.	Both have chain link fences on their perimeters but are in generally poor condition.	Additional unscheduled maritime traffic and events.

9.2.5.1 *Prioritized Recommendations - Guam Marinas*

- Provide advance notifications of arrival to GCQA inspectors.

9.2.6 Guam Postal Station

Table 12-7: Guam Postal Station

Description	Current Mitigations	Impact of Military Relocation
Domestic mail cannot be inspected without a warrant and the presence of the postal inspector.	Guam postal authorities do not always authorize access to mail x-ray facility.	Mail volume is expected to increase with population.

9.2.6.1 *Prioritized Recommendations-Guam Postal Station*

- Install new x-ray machine for inspection of international mail.
- Canine inspection teams should have daily access to mail. Canines should be scheduled on a standard shift.
- GCQA and APHIS must collaborate with the USPS to develop more efficient mail inspection protocol.
- These entities must work closely with the U.S. Attorney's Office and the Federal Magistrate to establish, implement, and maintain a domestic mail program to enable inspectors to work with USPS to execute federal warrants for opening and inspecting first class mail.

9.2.6.2 *General Recommendations-Guam Postal Station*

Authority

- Grant GCQA the authority to inspect domestic mail from the United States with coordination of APHIS-PPQ, U.S. Attorney, and a Federal Magistrate.

Resources

- GCQA should be staffed at levels sufficient to inspect the increased number of packages expected as a result of the military relocation.
- Deploy canine inspection teams to mail facilities for faster and more efficient screening of international and domestic mail.

Inspection

- X-ray all incoming international mail parcels. The existing x-ray machine is not operable.

Survey

- Record and analyze and share with appropriate authorities and stakeholders data on pest interceptions in mail.

Collaboration

- Encourage collaboration between customs officials, agricultural officials, and mail facility staff with the overall goal of decreasing the number of quarantine plant materials introduced to Guam through the mail pathway.

9.2.7 Guam Plant Inspection Station

Table 12-8: Guam Plant Inspection Station

Description	Current Mitigations	Impact of Military Relocation
Guam Plant Inspection Station	All plants and plant materials must be inspected at a Plant Inspection Facility on Guam.	Increased shipments of propagative plant material.

9.2.7.1 *Prioritized Recommendations - Guam Plant Inspection Station*

- With increases in population and traffic, the present staffing would be overwhelmed. Staffing must be augmented by following new positions: 1) botanist, 2) data entry personnel, and 3) agriculture commodity inspectors.

9.2.7.2 *General Recommendations - Guam Plant Inspection Station*

Resources

- There should be sufficient equipment (computers, microscopes, dissecting scope, hand-lenses, and other diagnostic equipment) and supplies (e.g. reference materials, identification keys) at plant and animal inspection facilities.

9.3 MICRONESIA LOCATION PROFILES

9.3.1 Commonwealth of the Northern Mariana Islands

9.3.1.1 *Saipan-Francisco C. Ada Saipan International Airport*

Table 12-9: Francisco C. Ada Saipan International Airport

Description	Current Mitigations	Impact of Military Relocation
Several major airlines and a commuter terminal, mostly commuter flights. Direct flights from Guam, Japan, Korea, Hong Kong, Manila, and China. Tourism is an economic driver.	Cleared by Saipan Customs and Saipan Quarantine. 14 quarantine officers (24/7). Specifically trained BTS inspectors with the CNMI DFW and rapid responders including three BTS canine teams., visual inspectors, and trappers. Immigration and Customs officials are available during scheduled operations, or by prior arrangements with the chief of Immigration Saipan. Container scanners are not operable. No baggage x-ray machine available. Planned Improvements: Improvements underway at airport.	The major impact of military relocation will be increased tourism for Saipan.

9.3.1.1.1 *Prioritized Recommendations-Francisco C. Ada Saipan International Airport*

- Increase the number of inspectors to meet anticipated demands with appropriate coverage.
- Explore legislative measures for user fees to expand staffing and to procure necessary vehicles and equipment.
- Acquire one new baggage x-ray machine for more efficient baggage and box screening.
- Establish a trapping and surveillance program for exotic and injurious plant pests and diseases. Trapping should include: 1) exotic fruit flies, 2) Khapra beetle, 3) tropical wood pests, and 4) Rhinoceros Beetle. Already have a BTS trapping program at both the air and sea ports in Saipan.

9.3.1.1.2 *General Recommendations-Francisco C. Ada Saipan International Airport*

Resources

- Expand the number and sensitivity of detection equipment (x-ray) at airports in CNMI.
- Expand financial resources in the CNMI to maintain and enhance border inspection, control and eradication, and rapid response programs. Consideration legislatively-approved user fees for arriving air passengers and cargoes.
- Implement an electronic system for recording, tracking, and identifying manifests for containerized commercial cargo arrivals to Guam and Saipan to streamline import process while maintaining biosecurity.
- Install container scanners or repair those in disuse because of insufficient funds.

Inspection

- Expand the inspection capabilities for air and sea containers and increase and strengthen performance accountability.

Treatment

- Maintain permanent operational wash racks for inspection and cleaning of soil-contaminated vehicles and equipment at the seaport in Saipan.
- Wash down and inspect construction vehicles arriving via water before entry to Guam, Saipan, Tinian, or Rota.

Monitoring and Surveillance

- A Micronesian Region monitoring and surveillance program for foreign animal and plant introduction would improve communications of survey results among all island mitigation programs.

Rapid Response

- Improve airport and seaport rapid response capabilities, including training more local staff for ER/RR of potential IAS such as the BTS, Rhinoceros Beetle, and others

9.3.1.2 *Tinian-Tinian Air Transports*

Table 12-10: Tinian Air Transports

Description	Current Mitigations	Impact of Military Relocation
Mostly commuter flights. Night flights from Saipan and Guam for the hotel and casino; 90% of tourists visiting the CNMI from East and Southeast Asia. Flights to Tinian are 0.33% of Guam's flight volume.	Immigration and Customs officials are available during scheduled operations, or by prior arrangements. No baggage x-ray machine available.	Estimates will be considerably increased during military exercises in Tinian. The major impact of the military relocation for Tinian will be greatly increased use of the island for regular and frequent military exercises and other

	One BTS canine team.. and trapping for BTS with CNMI DFW. Planned Improvements: Improvements underway at airport.	purposes.

9.3.1.2.1 *Prioritized Recommendations-Tinian Air Transports*

All Micronesian island economies share similar challenges and issues (Guam less so than the other jurisdictions):

- Understaffed and underfunded agricultural quarantine/inspection programs.
- Lack of surveillance for plant and animal pests and disease.
- Lack of sufficient infrastructure for air and sea cargo inspections.
- Inadequate resources for regulated garbage.

Prioritized Actions

1. Construct and maintain a military-use washrack facility for cleaning soil-contaminated vehicles and equipment returning to Guam from regular military exercises.

2. Acquire new x-ray machine for examination of baggage and boxes.

3. Explore legislation for user fees for incoming passengers, cargo, and conveyances to fund biosecurity and agriculture quarantine/inspection.

4. Set up a trapping and surveillance program for exotic and injurious plant pests and disease. Trapping should include, but not limited to: 1) exotic fruit flies, 2) Khapra beetle, 3) tropical wood pests, and 4) Rhinoceros Beetle. Already have trapping program for BTS.

5. Ensure adequate resources for the disposal of domestic garbage (landfill) and regulated garbage (sterilizer or incinerator).

9.3.1.2.2 *General Recommendations -Tinian Air Transports*

Resource

- Expand financial resources in the CNMI to maintain border inspection, control and eradication, and rapid response programs.
- Expand the number and sensitivity of detection equipment (x-ray) at airports in the CNMI.
- Initiate proper training of military personnel to assist in smuggling prevention, animal confiscation, law enforcement, and coordination with rapid response teams.
- Establish appropriate operations for handling regulated garbage.

Inspection

- Ensure appropriate advance notice of arrival provided by military to CNMI agriculture officials.
- All military personnel baggage transported to and from Guam and the CNMI on commercial, private, and chartered planes and helicopters must be inspected in compliance with federal and territorial regulations.

Treatment

- Permanent operational wash racks for inspection and cleaning of soil-contaminated vehicles and equipment must be maintained at the commercial seaport in Tinian.
- Construction vehicles arriving via water must be washed down and inspected before entry to Guam, Saipan, Tinian, or Rota.

Monitoring and Surveillance

- A Micronesian Region monitoring and surveillance program for foreign animal and plant introduction should be established to improve communications of survey results among all island mitigation programs.

Rapid Response

- Improve airport and seaport rapid response capabilities, including training more local staff for ER/RR of potential IAS such as the BTS, Rhinoceros Beetle, and others.

9.3.1.3 *Rota-Rota Air Transports*

Table 12-11: Rota Air Transports

Description	Current Mitigations	Impact of Military Relocation
Rota has an emerging tourism industry targeting service members, increasing development, and has legalized gambling. Flights to Rota are 1.18% of Guam's flight volume.	Immigration Customs and Quarantine are available during scheduled aircraft operations and upon prior arrangements with field supervisors. No baggage x-ray machine available. One BTS canine team and trapping for BTS with CNMI DFW. Planned Improvements: Improvements underway at airport.	The major impact of military relocation will be increased tourism due to the proximity to Guam.

9.3.1.3.1 *Prioritized Recommendations-Rota Air Transports*

All Micronesian island economies (except Guam) share similar challenges and issues:

- Understaffed and underfunded agricultural quarantine/inspection programs.
- Lack of surveillance for plant and animal pests and disease.
- Lack of sufficient infrastructure for air and sea cargo inspections

With Rota building a gambling casino, there will be more traffic from Guam and other locations. Therefore, due to the proximity to Guam:

1. Enact legislation for user fees to increase staffing and inspectional capacity for prevention of spread of invasive species.

2. Set up and establish a trapping and surveillance program for exotic and injurious plant pests and disease. Trapping should include: 1) exotic fruit flies, 2) Khapra beetle, 3) tropical wood pests, and 4) Rhinoceros Beetle. Already have a trapping program for BTS (but this could be improved).

9.3.1.3.2 *General Recommendations-Rota Air Transports*

Resources

- Expand financial resources in the CNMI to maintain border inspection, control and eradication effort, and rapid response programs

Treatment

- Permanent operational wash racks for inspection and cleaning of soil-contaminated vehicles and equipment must be maintained at the Commercial Port.
- Construction vehicles arriving via water must be washed down and inspected before entry to Guam, Saipan, Tinian, or Rota.

Monitoring and Surveillance

- A Micronesian Region monitoring and surveillance program for foreign animal and plant introduction should be established to improve communications of survey results among all island mitigation programs.

Rapid Response

- Improve airport and seaport rapid response capabilities, including training more local staff for ER/RR of potential IAS such as the BTS, Rhinoceros Beetle, and others.

9.3.2 Federated States of Micronesia

Table 12-12: Federated States of Micronesia

Description	Current Mitigations	Impact of Military Relocation
The four FSM states of Micronesia: Kosrae, Pohnpei, Chuuk, and Yap, form an independent nation that has signed a Compact of Free Association with the United States.	Any aircraft or vessel entering FSM are subject to inspections by customs, immigration, agriculture, and administrative personnel (LIS). All aircraft are inspected for stowaways, presumably human. The FSM developed a National Biosecurity Biodiversity Strategy and Action Plan (NBISAP) in 2002. Each of the four FSM states has a Biodiversity Strategy Action Plan Three trained ED/RR personnel in Pohnpei	The impact of the military relocation will include: 1) some increase in tourism, 2) increased employment in Guam for FSM population, and 3) increased air travel to and from Guam.

9.3.2.1 *Prioritized Recommendations -Federated States of Micronesia*

All Micronesian island economies share similar challenges and issues (Guam less so than the other jurisdictions):

- Understaffed and underfunded agricultural quarantine/inspection programs.
- Lack of surveillance for plant and animal pests and diseases.
- Lack of sufficient infrastructure for air and sea cargo inspection activities

1. Enact legislation for user fees to fund infrastructure improvements for entry inspection
2. Establish public outreach program for workers and visitors to Guam on entry requirements to and from FSM.
3. Set up and establish a trapping and surveillance program for exotic and injurious plant pests and disease. Trapping should include: 1) exotic fruit flies, 2) Khapra beetle, 3) tropical wood pests, and 4) Rhinoceros Beetle.

9.3.2.2 *General Recommendations - Federated States of Micronesia*

Resources

- Expand FSM financial resources to maintain border inspections at their air and sea ports and expand control and eradication and rapid response capabilities.
- Obtain and maintain operability of detection equipment (x-ray) at all FSM airports for baggage screening and inspection.

- Expand the inspection capabilities for air and sea containers and for the exportation of agricultural products.

Treatment

- Permanent operational wash racks for inspection and cleaning of soil-contaminated vehicles and equipment must be maintained at the Commercial Port.

Permanent operational heat and fumigation capacity.

Monitoring and Surveillance

- A Micronesian Region monitoring and surveillance program for foreign animal and plant introduction should be established to improve communications of survey results among all island mitigation programs.

Rapid Response

- Improve airport and seaport rapid response capabilities, , including training more local staff for ER/RR of potential IAS such as the BTS, Rhinoceros Beetle, and others.

9.3.3 Republic of the Marshall Islands

Table 12-13: Republic of the Marshall Islands

Description	Current Mitigations	Impact of Military Relocation
The RMI is an independent island group that has signed a Compact of Free Association with the United States. Main ports are Kwajalein and Majuro.	All aircraft and vessels entering or leaving RMI are subject to inspections by immigration, customs, agriculture, public health, or administrative personnel. Aircraft known or suspected to harbor insects or agricultural pests must be sprayed with an insecticide. Any employee of the RMI Ports Authority may enter an aircraft for the purpose of inspection. Three trained ED/RR staff in Majuro	The impact of the military relocation will be: 1) some increase in tourism, 2) increased air travel to and from Guam and Hawai'i.

9.3.3.1 *Prioritized Recommendations-Republic of the Marshall Islands*

All Micronesian island economies share similar challenges and issues (Guam less so than the other jurisdictions):

- Understaffed and underfunded agricultural quarantine/inspection programs.
- Lack of surveillance for plant and animal pests and diseases.
- Lack of sufficient infrastructure for air and sea cargo inspections.

Prioritized Actions

1. Enact legislation to fund infrastructure improvements and increased inspections for agricultural and environmental pests and diseases.

2. Establish public outreach program for workers and visitors to Guam on entry requirements to and from RMI.

3. Set up a trapping and surveillance program for exotic and injurious plant pests and disease. Trapping should include: 1) exotic fruit flies, 2) Khapra beetle, and 3) tropical wood pests.

9.3.3.2 *General Recommendations-Republic of the Marshall Islands*

Resources

- Expand financial resources in the FSM to maintain border inspections at the airport and seaport, and control and eradication and rapid response capabilities.
- Obtain and maintain operability of detection equipment (x-ray) at all FSM airports for baggage screening and inspection.
- Expand the inspection capabilities for air and sea containers.

Treatment

- Permanent operational wash racks for inspection and cleaning of soil-contaminated vehicles and equipment must be maintained at the Commercial Port.

- Permanent operational heat and fumigation capacity.

Monitoring and Surveillance

- A Micronesian Region monitoring and surveillance program for foreign animal and plant introduction should be established to improve communications of survey results among all island mitigation programs.

Rapid Response

- Improve airport and seaport rapid response capabilities, including training more local staff for ER/RR of potential IAS such as the BTS, Rhinoceros Beetle, and others.

9.3.4 Palau

Table 12-14: Palau

Description	Current Mitigations	Impact of Military Relocation
Palau is an island nation that has signed a Compact of Free Association with the United States.	All aircraft and vessels entering or leaving Palau are subject to inspections by immigration, customs, agriculture, public health, or administrative personnel. Aircraft known or suspected to harbor insects or agricultural pests must be sprayed with an insecticide. Any employee of the Palau Ports Authority may enter an aircraft for the purpose of inspection. Two trained ED/RR staff	The impact of the military relocation will be: 1) increased tourism due to greater availability of recreational activities and interest in ecotourism activities on Palau, and 2) increased air travel to and from Guam.

9.3.4.1 *Prioritized Recommendations –Palau*

All Micronesian island economies share similar challenges and issues (Guam less so than the other jurisdictions):

- Understaffed and underfunded agricultural quarantine/inspection programs.
- Lack of surveillance for plant and animal pests and disease.
- Lack of sufficient infrastructure for air and sea cargo inspections.

Prioritized Actions

1. Enact legislation to fund infrastructure improvements and increased inspections for agricultural and environmental pests and diseases.

2. Ensure appropriate biosecurity within Palau in regards to the established Macaque Monkeys in Anguar to prevent spread to the rest of Palau as well as other locations within Micronesia.

3. Establish public outreach program for workers and visitors to Guam on entry requirements to and from Palau.

4. Set up a trapping and surveillance program for exotic and injurious plant pests and disease. Trapping should include: 1) exotic fruit flies, 2) Khapra beetle, and 3) tropical wood pests.

9.3.4.2 *General Recommendations-Palau*

Resources

- Expand Palau's financial resources to maintain border inspections at the airport and seaport and control and eradication and rapid response capabilities.
- Maintain operability of detection equipment (x-ray) at Palau's airport for baggage screening and inspection.
- Expand the inspection capabilities for air and sea containers.

Treatment

- Permanent operational wash racks for inspection and cleaning of soil-contaminated vehicles and equipment must be maintained at the Commercial Port.
- Permanent operational heat and fumigation capacity.

Monitoring and Surveillance

- A Micronesian Region monitoring and surveillance program for foreign animal and plant introduction should be established to improve communications of survey results among all island mitigation programs.

Rapid Response

- Improve airport and seaport rapid response capabilities, including training more local staff for ER/RR of potential IAS such as the BTS, Rhinoceros Beetle, and others.

9.4 AIRPORT OPERATIONAL STATISTICS FOR GUAM AND CNMI INTERNATIONAL AIRPORTS

Table 12-15: Aircraft Operational Statistics for Guam and CNMI International Airports

	Guam[a]	Tinian[b]	Saipan[c]	Rota[d]
Aircraft based on the field	83	6	22	-
Single engine airplanes	20	4	14	-
Multi-engine airplanes	10	2	8	-
Jet airplanes	52	-	-	-
Helicopters	1	-	-	-
Average aircraft operations/day	108	36	108	127

% commercial flights	55	<1	18	27
% air taxi flights	24	98	61	69
% local general aviation flights	21	1	2	3
% transient general aviation flights	<1	<1	16	<1
% military flights	<1	<1	1	<1

[a] For the 12-month period ending 04 May 2007 (AirNav 2010b);
[b] For the 12-month period ending 04 May 2009 (AirNav 2010d)
[c] For the 12-month period ending 31 December 2007 (AirNav 2010a); dFor the 12-month period ending 08 May 2008 (AirNav 2010c)

9.5 MICRONESIAN REGION AIR TRANSPORTS

Table 12-16: Micronesian Region Air Transports

Location	No. of Daily flights	Relationship to the number of Guam flights	Air Transport Companies (targets for outreach)
Guam[a]	108	--	Commuter flights include Freedom Air, Cape Air, and Pacific Island Aviation.
Tinian[b]	36	.33	Freedom Air (daily flights) and the privately chartered Star Marianas Air
Saipan[c]	108	1.0	
Rota[d]	12	1.18	Commuter flights include Freedom Air and Cape Air, primarily from Saipan and Guam
Regional			Private jet plane charters from Aviation Concepts, Airport Group International, and Guam flight services

[a] For the 12-month period ending 04 May 2007 (AirNav 2010b);
[b] For the 12-month period ending 04 May 2009 (AirNav 2010d)
[c] For the 12-month period ending 31 December 2007 (AirNav 2010a); dFor the 12-month period ending 08 May 2008 (AirNav 2010c)

9.6 MILITARY RELOCATION ESTIMATED IMPACT ON PATHWAYS

Table 12-17: Pathway Impact Factors Related to Military Relocation

Pathway	VS Risk Rating[a]	WS TV Risk Rating[a]	WS WD Risk Rating[b]	Likely Sources
Population (people)	Negligible	High		Japan, Korea, Taiwan Hong Kong and the Philippines
Baggage		High		Japan, Korea, Taiwan Hong Kong and the Philippines
Aircraft-military	Very low	High		Non-specific
Aircraft-commercial	Very low	High		Japan, Korea, Taiwan Hong Kong and the Philippines
Cargo-containers (military)		High		Okinawa, U.S. mainland, Hawai'i
Cargo-containers (all sources)	Very low	High		S. Korea, Taiwan, CNMI, Japan, United States via Hawai'i
Cargo-break bulk (all sources)	Very low	High		United States, S. Korea, Indonesia, China, Philippines, Japan, Singapore, Taiwan, Thailand, CNMI

Pathway	VS Risk Rating[a]	WS TV Risk Rating[a]	WS WD Risk Rating[b]	Likely Sources
Cargo-bulk (all sources)	Very low	High		United States, S. Korea, Indonesia, China, Philippines, Japan, Singapore, Taiwan, Thailand, CNMI
Commercial maritime vessels	Very low	High		Australia, China, Korea, Hong Kong, Japan, Malaysia, Philippines, Singapore, Taiwan, Thailand, Micronesia Region, New Zealand and the United States.
Military maritime Vessels	Very low	High		Non-specific
Construction equipment/materials	Very low	High		U.S., Indonesia, China, Philippines, Japan; wood from Palau; cement and concrete from FSM
WPM	Very low	High		Any country; possibly higher risk from CNMI, FSM, American Samoa, Palau, RMI; United States, Japan, Korea, Europe
Domestic and International mail	Very low			Malaysia, Thailand, United States, Australia, China
Regulated garbage	Low			
Imports of biological commodities (below)	Negligible to Low	Low to Moderate		Various sources
Propagative Plants				United States, Japan, S. Korea, Philippines, CNMI, FSM, Palau, Thailand, Taiwan, Costa Rica, Ecuador, and Puerto Rico
Plant Products (commodities)				United States (92%), Korea (3%), FSM (2%)
Livestock	Negligible			United States, Hawai'i
Poultry	Low			United States, Hawai'i (legal imports); Philippines, other Asian countries (smuggling)
Non-poultry birds	Very low			United States (legal imports); Mexico, Central America, and South America, Japan, Hong Kong, and Indonesia (smuggling)
Cats and dogs	Negligible			United States, Australia, Japan, CNMI
Animal products	Low			
Exotic pet		High		Pacific rim, other Micronesian Region islands
Aesthetic		High		East Asia, Pacific rim, other Micronesian Region islands
Food Use		High		East Asia, Pacific rim, other Micronesian Region islands
Animals for entertainment		Moderate		East Asia, Pacific rim, other Micronesian Region islands
Game hunting		Moderate		
Biocontrol		Moderate		
Scientific research		Moderate		
Religious ceremonies		Low		Cambodia, Hong Kong, Indonesia, Korea, Malaysia, Singapore, Taiwan, Thailand, and Vietnam, United States

Pathway	VS Risk Rating[a]	WS TV Risk Rating[a]	WS WD Risk Rating[b]	Likely Sources
Bioterrorism		Low		Nonspecific
Intentional releases (biocontrol; aesthetic)				
Wildlife disease:			Low to High	
West Nile Disease			High	U.S. mainland
HPAI			Moderate	Southeast Asia
Avian Malaria parasites			Moderate	
Henipaviruses			Moderate	Australia, Philippines
END			Moderate	
Hantavirus			Low	China, Pacific rim
Rabies virus			Low	
Yersinia pestis			Low	China, Pacific rim
Tick-borne encephalitis			Low	

Note: Pathway impact factors related to military relocation (based upon estimates from the U.S. Navy 2010a; Port of Guam Master Plan 2008)

[a] Overall (VS) or total (WSTV) risk rating

[b] Impact risk rating (WSWD)

9.7 MITIGATION REQUIREMENTS BY PATHWAY

Table 12-18: Mitigation Requirement by Pathway

Pathway	Pre-test/ certify	Permit or License	Monitor	Inspect	Identify	Quarantine	Treat-disinfect-decontaminate-dispose
Passengers				X	X	X	
Baggage				X			X
Aircraft-military			X	X			X
Aircraft-commercial			X	X			X
Cargo-containers (military)				X		X	X
Cargo-containers (all sources)				X		X	X
Cargo-break bulk (all sources)				X		X	X
Cargo-bulk (all sources)				X		X	X
Maritime vessel-military				X			X
Maritime vessel-commercial							X
Construction equipment-materials		X		X			X
WPM				X			X
Mail				X			
Regulated garbage			X	X	X		X
Plant propagative				X	X		X

Pathway	Pre-test/ certify	Permit or License	Monitor	Inspect	Identify	Quarantine	Treat-disinfect-decontaminate-dispose
materials							
Plant products	X	X		X	X		
Soil				X	X		X
Livestock	X				X	X	X
Poultry	X	X			X		
Pet birds	X	X			X		
Dogs and cats	X			X	X	X	X
Other animals		X			X	X	
Animal products				X	X		

Source: U.S. Navy 2010a; Port of Guam Master Plan 2008

9.8 PATHWAY IMPACTS AND MITIGATION PROCEDURES

Table 12-19: Pathway Impacts and Mitigation Procedures

Group	Pathway	Pathway Risks	Control Point	Military Impact on Pathway	Required mitigation
A	Military personnel/families transport from U.S. to Guam–commercial aircraft	Invasive hitchhikers/Exotic (import) plant or animal	Aircraft passenger-crew	Commercial passenger flight increases (not able to be determined due to unknown schedule/pace for relocation)	Inspection, hold of passengers, crew
			Aircraft cabin, hold		Inspection, hold of conveyance
			Aircraft exterior		Inspection, hold of conveyance
			Air baggage		Inspection, hold of baggage
			Air cargo		Inspection, hold of cargo
		Invasive plant/pest	Plant or plant product import		Permit review, inspection, identification, quarantine, treatment
		Infectious plant pathogen/vector			
		Invasive animal	Animal import		Permit review, inspection, identification, quarantine, treatment
		Animal pest or pathogen/vector	Animal or animal product import		
		Zoonotic infection	Aircraft-passenger-crew		Inspection
B	Off-island construction workers and dependents and off-island workers for Induced jobs/dependents Transport from Pacific rim to Guam–commercial aircraft	Invasive hitchhikers	Aircraft passenger-crew	Increased flights to Guam are expected to increase the transport of invasive pests and diseases.	Inspection
			Aircraft cabin		Inspection, control, treatment
			Aircraft exterior		Inspection, control, washing
			Air baggage		Inspection
			Air cargo		Inspection, control
		Invasive plant/pest	Plant or plant product (import or smuggled)		Permit review, inspection, identification, quarantine, treatment
		Infectious plant pathogen/vector			
		Invasive animal	Animal (import or smuggled)		Permit review, inspection, identification, quarantine, treatment
		Animal pest or pathogen/vector	Animal or animal product (import or smuggled)		
		Zoonotic infection	Aircraft passenger-crew		Inspection

Group	Pathway	Pathway Risks	Control Point	Military Impact on Pathway	Required mitigation
C	Military cargo transport from Okinawa to Guam–commercial or military vessel	Invasive hitchhikers	Vessel crew	Expected to increase during buildup due to relocation of military resources. (Source: Master Plan 2008, Port Authority of Guam)	Inspection
			Vessel cabin, hold		Inspection, control, treatment
			Vessel exterior		Inspection, control, washing
			Bulk cargo		Inspection, control
			Break bulk cargo		Inspection, control
			Packaged cargo		Inspection, control
			Containers		Inspection, control
			Garbage		Monitoring, disposal
			WPM		Inspection, control, treatment
		Invasive plant/pest	Plant or plant product import		Permit review, inspection, identification, quarantine, treatment
		Infectious plant pathogen/vector			
		Invasive animal	Animal import		Permit review, inspection, identification, quarantine, treatment
		Animal pest or pathogen/vector	Animal or animal product import		
		Zoonotic infection	Vessel crew		Inspection
D	Shipment construction equipment/materials from Pacific Rim or Micronesia to Guam–commercial vessel	Invasive hitchhikers	Vessel crew	Estimated cargo shipments to greatly increase during military buildup. Expected to remain well above 2011 levels after buildup for (Source: Master Plan 2008, Port Authority of Guam)	Inspection
			Vessel cabin, hold		Inspection, control, treatment
			Vessel baggage (crew)		Inspection
			Vessel exterior		Inspection, control, washing
			Stone, sand, etc.		Inspection, control, treatment
			Garbage		Monitoring, disposal
			Equipment/vehicle		Inspection, control, treatment, washing
			WPM		Inspection, control, treatment
		Invasive hitchhikers/wood boring insects/	Timber		Inspection, control, treatment
			WPM		Inspection, treatment

Group	Pathway	Pathway Risks	Control Point	Military Impact on Pathway	Required mitigation
		Zoonotic infection	Vessel crew		Inspection
E	Domestic and international mail from Hawai'i to Guam	Invasive hitchhiker (seed, insect)	Package/Post office	Larger mail volume with increased population on Guam.	X-ray inspection
		Bioterror agent (zoonotic)			X-ray inspection
		Invasive plant/pest	Plant or plant product		Permit review, inspection, identification, quarantine, treatment
		Infectious plant pathogen/vector			
		Invasive animal	Animal		Permit review, inspection, identification, quarantine, treatment
		Animal pest or pathogen/vector	Animal or animal product		
F	Military exercises from Tinian to Guam–amphibious vessels, vehicles; 1 week 12 times per year	Invasive hitchhikers	Aircraft cabin, hold	Special events	Inspection, control, treatment
			Aircraft exterior		Inspection, control, washing
			Munitions		Inspection
			Personnel		Inspection
			Gear		Inspection
G	Military exercises from Tinian to Guam–aircraft; 1 week 12 times per year	Invasive hitchhikers	Vessel cabin, hold	Special event, unscheduled	Inspection, control, treatment
			Vessel exterior		Inspection, control, washing
			Munitions		Inspection
			Personnel		Inspection
			Gear		Inspection
		Invasive plant/pest	Plant or plant product import		Permit review, inspection, identification, quarantine, treatment
		Infectious plant pathogen/vector			
		Invasive animal	Animal import		Permit review, inspection, identification, quarantine, treatment
		Animal pest or pathogen/vector	Animal or animal product import		Permit review, inspection, identification, quarantine, treatment
		Zoonotic infection	Aircraft-passenger-crew		Inspection

Group	Pathway	Pathway Risks	Control Point	Military Impact on Pathway	Required mitigation
H	Transport from Guam to Hawai'i–commercial aircraft	Invasive hitchhikers	Aircraft cabin, hold	Commercial passenger flight increases are possible from Hawai'i.	Inspection, control, treatment
			Aircraft exterior		Inspection, control, washing
			Air baggage		Inspection
			Air cargo		Inspection, control
			Aircraft passenger-crew		Inspection
		Invasive plant/pest	Plant or plant product (import or smuggled)		Permit review, inspection, identification, quarantine, treatment
		Infectious plant pathogen/vector			
		Invasive animal	Animal (import or smuggled)		Permit review, inspection, identification, quarantine, treatment
		Animal pest or pathogen/vector	Animal or animal product (import or smuggled)		
		Zoonotic infection	Aircraft-passenger-crew		Inspection
I	Domestic and international mail from Guam to Micronesia	Invasive hitchhiker (seed, insect)	Package/Post office	Insignificant increase expected.	X-ray inspection
		Bioterror agent (zoonotic)			X-ray inspection
		Invasive plant/pest	Plant or plant product import		Permit review, inspection, identification, quarantine, treatment
		Infectious plant pathogen/vector			
		Invasive animal	Animal import		Permit review, inspection, identification, quarantine, treatment
		Animal pest or pathogen/vector	Animal or animal product		
J	Civilian air travel (personnel, contractor family, friends)–to/from Guam, other Micronesian Region islands	Invasive hitchhiker	Aircraft cabin, hold	Commercial passenger flight increases are expected.	Inspection, control, treatment
			Aircraft exterior		Inspection, control, washing
			Air baggage		Inspection
			Air cargo		Inspection, control
			Aircraft-passenger-crew		Inspection
		Invasive plant/pest	Plant or plant product (import or smuggled)		Permit review, inspection, identification, quarantine, treatment
		Infectious plant pathogen/vector			
		Invasive animal	Animal (import or		Permit review, inspection,

Group	Pathway	Pathway Risks	Control Point	Military Impact on Pathway	Required mitigation
			smuggled)		identification, quarantine, treatment
		Animal pest or pathogen/vector	Animal or animal product (import or smuggled)		
		Zoonotic infection	Aircraft-passenger-crew		Inspection
K	Military exercises on Tinian–amphibious vessels, vehicles–from Guam to Tinian; 1 week 12 times per year	Invasive hitchhikers	Aircraft cabin, hold	Special event, unscheduled	Inspection, control, treatment
			Aircraft exterior		Inspection, control, washing
			Munitions		Inspection
			Personnel		Inspection
			Gear		Inspection, control,
L	Military exercises on Tinian–aircraft–from Guam to Tinian; 1 week 12 times per year	Invasive hitchhikers	Vessel cabin, hold		Inspection, control, treatment
			Vessel exterior		Inspection, control, washing
			Munitions		Inspection
			Personnel		Inspection
			Gear		Inspection, control

9.9 APHIS-VETERINARY SERVICES RISK RATINGS

Table 12-20: APHIS-VS Risk Ratings

Pathway	Release Assessment - Legal	Release Assessment - Illegal	Exposure Assessment	Consequence Assessment	Overall Risk	Likely Sources
Conveyance-Aircraft	Very low	N/A	Medium	Guam and Micronesia: Very Low U.S.: Very low	Very Low	
Conveyance-Maritime vessels	Very low	N/A	Medium	Guam and Micronesia: Very Low U.S.: Very low	Very Low	

Pathway	Release Assessment - Legal	Release Assessment - Illegal	Exposure Assessment	Consequence Assessment	Overall Risk	Likely Sources
People	Negligible	Negligible	N/A	N/A	Negligible	U.S. Mainland, Hawai'i, Philippines, China, Korea
Livestock	Negligible	Negligible	N/A	Guam and Micronesia: N/A U.S.: N/A	Negligible	
Poultry	Negligible	Very low	Medium	Guam and Micronesia: Low U.S.: Medium	Low	
Non-poultry birds	Negligible	Very low	Medium	Guam and Micronesia: Very low U.S.: Very low	Very Low	
Cats and dogs	Negligible	Negligible	N/A	Guam and Micronesia: N/A U.S. N/A	Negligible	
Animal products	Negligible	Low	Medium	Guam and Micronesia: Low U.S.: Medium	Low	
Garbage	Negligible	Very low	Medium	Guam and Micronesia: Low U.S.: Medium	Low	
Other cargo	Very low	N/A	Medium	Guam and Micronesia: Very low U.S.: Very low	Very Low	

9.10 APHIS-WS TERRESTRIAL VERTEBRATES RISK RATINGS

Table 12-21: APHIS-WS Terrestrial Vertebrates Risk Rating

Pathway	Total Risk	Likely Sources
Conveyance-Aircraft	HIGH	
Conveyance-Maritime vessels	HIGH	
Cargo	HIGH	
Construction	HIGH	
Plant products	HIGH	
WPM	HIGH	
Garbage	HIGH	

Table 12-22: APHIS-WS Terrestrial Vertebrates Risk Rating

INTENTIONAL	Importation	Establishment	Hazard	Total Risk	Likely Sources
Pet trade	3	3	3	9 HIGH	
Aesthetic releases	3	2	3	8 HIGH	
Food use	3	3	3	9 HIGH	
Animals for entertainment	2	2	3	7 MODERATE	
Game hunting	1	2	3	6 MODERATE	
Biocontrol	1	3	2	6 MODERATE	
Scientific research	1	3	3	7 MODERATE	
Religious ceremonies	1	1	2	4 LOW	
Bioterrorism	1	1	3	5 LOW	

9.11 APHIS-WS WILDLIFE DISEASES RISK RATINGS

Table 12-23: APHIS-WS Wildlife Diseases

Pathway	Probability of Infection	Alternate Probability	Impact of Infection	Alternate Impact	Likely Sources
Hantavirus	Moderate		Low		
Rabies virus	Minimal		Low		
West Nile Virus	Minimal		High		
HPAI	High		Moderate	Moderate	
Japanese Encephalitis Virus	High		Minimal	Low	
Avian Malaria Parasites	High	Minimal	Moderate	Moderate	
Henipaviruses	Minimal	High	Moderate	Moderate	
NDV	Minimal	High	Moderate	Moderate	
Yersinia pestis	Minimal		Low		
Tick-Borne Encephalitis	High		Low	Moderate	

10 QUALITY ASSURANCE AND IMPROVEMENT

Every security plan is measured by how it achieves its stated objectives. The MBP was developed to prevent the introduction of invasive species and pathogenic agents into Hawai'i, Guam and the Micronesia Region, a lofty goal with the broad range of potentially invasive species and frequency of conveyances that can transport plants, animals, pests, vectors, and pathogens to these locations. The MBP must assist biosecurity planners in doing their best to prevent unintentional introductions. The MBP must adequately describe in detail:

1. Risks for specific pathways and species
2. Compliance, inspection, treatment, and other mitigation procedures
3. Pre-clearance, monitoring, and outreach programs that can prevent introductions
4. Military relocation events that could affect the types and frequencies of releases
5. Rapid response teams, resources, and procedures for species eradication

Few security plans effectively cover all requirements, particularly early in the process. An improvement planning program is essential for continual MBP review for gaps, inconsistencies, and any other required improvement. Too often, organizations delay such review processes until a critical gap causes an unfortunate event. The MBP therefore builds in a process for continual improvement. Each of the five features listed should to be tested regularly, as should command and control, communications, funding, and resource allocation, all important support functions.

10.1 INTRODUCTION TO MBP IMPROVEMENT PLANNING PROGRAM

The MBP Improvement Planning Program is an overarching framework for planning and implementing MBP upgrades based on a concept of operations, federal authorities, best practices, and a system of capabilities-based training and tests within an overall objective of continual improvement in MBP effectiveness. The Improvement Planning Program is the foundation for all aspects and processes in MBP TT&E events and a mechanism for needed improvements.

10.2 CONCEPT OF OPERATIONS

The Concept of Operations is the foundation for TT&E Program framework. It includes major planning areas required to build the program:

- MBP scope, policies, and procedures
- Authorities and requirements
- Program objectives
- Roles and responsibilities
- Maintaining executive-level support

- Budgeting, funding allocation, and resource management
- MBP integration with partners and stakeholders
- Training on biosecurity policies, roles, and processes
- Development planning meetings and event coordination
- Multi-year TT&E schedule (calendar of events)
- Collaborative biosecurity agreements with external organizations
- TT&E program design and planning
- Corrective action plan
- Reports to headquarters, partners, and stakeholders

10.3 MBP IMPROVEMENT PLANNING DEVELOPMENT EVENTS

To develop an effective MBP improvement plan, various types of planning, training, and test events are recommended. A comprehensive improvement planning program includes:

- Training seminars
- Improvement planning conferences
- TT&E workshops
- TT&E events
- After-action conferences

10.3.1 Training Seminars

A training seminar should be scheduled annually to present current MBP policy, regulations, procedures, and responsibilities to key personnel, partners, and stakeholders. The event is an opportunity to make changes to the plan, especially in light of events in the field and observations from test exercises.

10.3.2 Improvement Planning Conferences

An improvement planning conference should be scheduled annually for an opportunity to communicate recovery objectives, identify resources, and track Improvement Plan (accomplishments and actions against current capabilities. The conference would be a forum for key personnel to review MBP actions recorded in previous year's after action reports and corrective action plans. The improvement planning conference will:

- Evaluate current MBP capabilities.
- Review progress toward achieving assigned corrective actions.
- Set new priorities for future TT&E events.

- Announce new policy, regulations, and procedures when appropriate.
- Establish biosecurity planning priorities for the current year.

The improvement planning conference would be held at least 60 days before the first TT&E event of the year. Improvement planning conference participants should be aware of their recovery planning responsibilities and be prepared to prioritize outstanding improvement planning corrective actions.

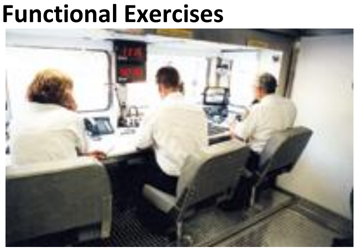
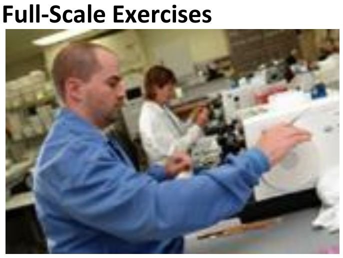
Participants should establish a multi-year training and exercise plan schedule during this conference. This living document schedules and tracks training and test exercises best planned according to a building-block process that designs test events according to current capabilities and realistic objectives.

10.3.3 TT&E Workshops

The TT&E event workshop should design a specific TT&E event in according to improvement planning conference objectives and priorities. Planning decisions for the type of exercise, event schedule, format, participants, emergency scenario, and actual content should all be influenced by improvement planning conference priorities and objectives as well as perceived capabilities. This performance and capabilities-based approach is consistent with the tiered, building-block plan for improving recoverability.

Table 13-1: Improvement Planning Events

Improvement Planning Events	
Seminar	Schedule an annual seminar to train key personnel on MBP authorities, strategies, plans, policies, procedures, protocols, response resources, and concepts for the biosecurity planning processes.
Planning Conference	Conduct regular planning conferences with the MBP Improvement Planning Committee or Working Group to determine training and testing budgets, resources, formats, objectives, and schedules and to manage the improvement plan and the Corrective Action Plan.
Workshop	Conduct a workshop with the MBP Coordinator, Planning Committee, and participating representatives to plan TT&E event objectives, agenda, formats, participants, location, and logistics. **TT&E Event Planning, Design, and Development** The important considerations for design and development of the various TT&E events include: -TT&E Format -Training and testing schedule -Test objectives -Logistics (event Information, equipment, and supplies) -Event roles and responsibilities -Emergency scenario design -Exercise documentation (guides, evaluation templates, etc.) -Review of actions for lessons learned -Metrics for assessment of biosecurity capabilities **TT&E Events**

	Test formats based upon objectives are chosen from decision- and operations-based test events.
Decision-Based Test Events	
 **Table Top Exercise**	In table top exercises, key personnel discuss hypothetical scenarios in an informal and relaxed setting. Table top exercises test knowledge and abilities to access plans, policies, and procedures; systems and operations needed to prevent, mitigate, and respond to incidents. This format depends on the engagement of participants, their assessment of current policies, procedures, and plans, and their recommendations for improvements.
Games	Games are simulations of operations involving two or more teams depicting an actual or assumed real-life situation. Games explore decision making processes and their consequences.
Operations-Based Test Events	
Drills	Drills are coordinated, supervised activities to validate a single, specific operation or function.
Functional Exercises 	Functional exercises evaluate individual capabilities, multiple functions, function activities, or interdependent functions through an exercise scenario with event updates that drive management activity. Functional exercises present complex problems that require rapid, effective responses by trained personnel in highly stressful, time-constrained environments. They utilize incident command systems, unified command, and multi-agency coordination centers (e.g. Emergency Operations Centers (EOCs)). Movement of personnel and equipment is simulated; adversarial groups can stress the incident.
Full-Scale Exercises 	Most full-scale exercises are complex, multi-agency, multi-jurisdictional, and multi-organizational exercises that validate many facets of preparedness. The focus is on implementing and analyzing plans, policies, procedures, and cooperative agreements developed in discussion-based exercises. Operational realities present complex and realistic problems that require critical thinking, rapid problem-solving, and effective responses by trained personnel. A scripted scenario has built-in flexibility for updates to drive activities. Full-scale exercises are conducted in real time, creating a stressful, time-constrained environment closely mirroring real events. They may include first responders under NIMS principles and may include functional play from multi-agency coordination centers, EOCs, or hospitals not at the exercise incident response site.

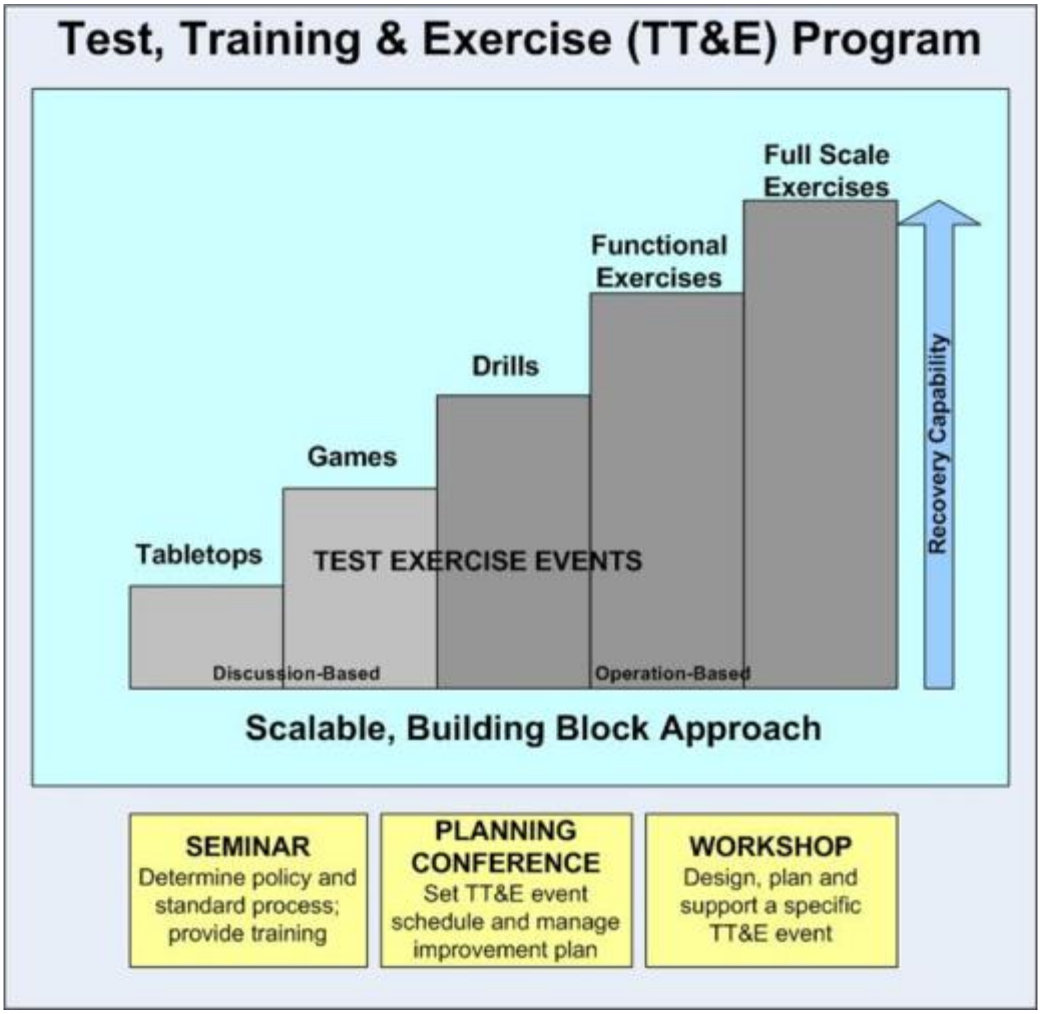
10.4 TT&E PROGRAM PLANNING PROCESS

Table 13-2 depicts the appropriate TT&E event for accomplishing each Improvement Planning Program component.

Table 13-2: Improvement Program Planning Events

TT&E Component	Seminar	Planning Conference	Planning Workshop	TE	Drill	Functional Exercise
Train in MBP policies, regulations, standards, and procedures	X					
Establish a planning and implementation framework for determining long-term objectives, policies, and processes		X				
Establish roles and responsibilities		X				
Design a multi-year MBP training and testing schedule		X				
Decide test event objectives, schedule, design, and format			X			
Discuss the effectiveness of MBP policies and procedures				X		
Test the performance of a specific function or operation					X	
Test the capability to perform comprehensive MBP operations in actual work situations and environments						X
Assign duties for plan remedies from after-action recommendations		X		X	X	X
Manage Improvement Plan		X				

Figure 13-1: Types of TT & TT&E Formats



10.5 ROLES AND RESPONSIBILITIES

Table 13-3 depicts typical roles in improvement planning events and common responsibilities for event design, production, facilitation, and reporting.

Table 13-3: Improvement Planning Roles and Responsibilities

Exercise Role	Responsibility
Improvement Planning Coordinator or Committee	This individual or committee manages all objectives, designs, plans, developments, and assessments. Sets MBP improvement planning program objectives. Develops TT&E Concept of Operations for improvement planning. Implements MBP policies and directives. Directs or oversees TT&E event planning. Approves TT&E event objectives. Manages MBP improvement planning resources and funding. Encourages participation and coordination of TT&E event activities.
Event Planner	Directs and budgets event resources. Implements event objectives received from the planning conference and event workshop. Develops a suitable test emergency scenario. Designs the TT&E format and agenda. Develops discussion topics to target test objectives. Designs and produces event documents (participant's, facilitator's, and observer's guides). Designs and produces a participant assessment survey and Exercise Evaluation Guide.
Facilitator	Provides pre-event guidance, leads the test exercise events, leads discussions, and generally guides events toward stated objectives. Executes the event plan as determined by the workshop. Directs event staff and instructs observers. Keeps proceedings to planned agenda and objectives. Inserts emergency scenario information into the test event. Keeps proceedings on schedule and within scope. Offers questions and leads discussions. Encourages input and records responses from participants, leads review of "Lessons Learned."
Controller	Directs all or a select area/component of on-site response events during functional or full-scale exercises.
Evaluator	Judges responses in real time during functional or full-scale exercises.
Observer	Observes actions and discussions during functional or full-scale exercises.
Players	Also referred to as participants, these individuals are the subjects of the training and testing; during the event, they are immersed into a fictitious emergency scenario and asked to respond appropriately according to their responsibilities.
Simulators (actors)	Actors with a script to "act out" during an functional or full-scale exercises (e.g. playing perpetrator or victim roles).

10.6 TT&E EVENT PLANNING

Improvement planning personnel adopt a "crawl-walk-run" or "building-block" approach in designing long-term objectives and event schedules. Early TT&E events focus on basic skills, knowledge, requirements, and capabilities, and successive events build in additional test demand as capabilities are proven. For all events, test design and emergency scenarios establish realistic and achievable goals for participants.

For each TT&E event, planners must ask:

- What objectives should be accomplished?
- How should these objectives be accomplished?
- Who should be responsible for the objectives?
- How effective are plans in obtaining required information and guiding planning and response actions?

The answers to these questions change as capabilities and test challenges increase.

Test event planning requires decisions on planning components:

- Event type and format
- Event date, timeframe, and location
- Person or persons designated as event planner(s)
- Personnel invited as participants
- Primary test objectives
- Personnel invited as observers
- Event documentation for reference and reporting
- Logistics (documents, refreshments, etc.)
- Evaluation of event activities and outcomes

10.7 TEST EXERCISE DOCUMENTATION

Develop effective exercise documentation for all facilitators, controllers, exercise players, and observers.

Table 13-4: Test Exercise Documentation

Document	Purpose
Situation Manual	Participant handbook for discussion-based exercises, particularly table top exercises. Includes background information on exercise scope, schedule, and objectives and presents the scenario narrative to drive participant discussion.
Exercise Plan	Used for operations-based exercises. As an exercise synopsis is distributed to players and observers in advance; addresses objectives and scope, assigns roles and responsibilities. Does NOT reveal detailed scenario information like the hazard.
Controller and Evaluator Handbook	Supplements the Exercise Plan with more detailed information about the exercise scenario and describes exercise controllers' and evaluators' roles and responsibilities. Distribution closely controlled.
Master Scenario Events List	Chronological timeline of expected actions and scripted events (i.e., injects).
Player Handout	A 1 to 2 page quick reference for exercise players (distributed before exercise) on safety procedures, logistical considerations, exercise schedule, and other essentials.
Exercise Evaluation Guides	Help evaluators collect and interpret relevant exercise observations. Briefs evaluators on tasks they should see completed or discussed during the exercise; includes space to record observations and questions to address after the exercise as a first step in the development of the After Action Report/Improvement Plan.

10.8 CORRECTIVE ACTION PLANS

The after action report documents TT&E event outcomes and incorporates observations into a formal set of recommendations for improvements. An after-action conference informs participants, planning committees, and stakeholders of after action report priority recommendations.

- Analyze strengths and areas for improvement in formally evaluating biosecurity; report in the after action report lessons learned from exercise data.
- Develop a corrective action plan to track needed improvements and related responsibilities.

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Appendix A: Terrestrial Risk Assessment Details

This is an edited version of the original appendix submitted to DoD.

The original document was a collection of four risk assessments that were completed independently by four teams of staff from the offices listed below.

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A1 INTRODUCTION

This risk analysis was developed by the U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) at the request of the U.S. Department of Defense (DoD). It is intended to serve as a basis for the development of the biosecurity plan to mitigate plant and animal health risks posed to the Micronesia Region by a planned U.S. military relocation in the Region as referred to in the Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) prepared by the Department of the Navy for the proposed military relocation (U.S. Navy 2010a). For the purposes of this risk analysis, the Micronesia Region is defined as Guam, the Commonwealth of the Northern Mariana Islands (CNMI), the Federated States of Micronesia (FSM), the Republic of the Marshall Islands (RMI), and the Republic of Palau (Figure A1-1).

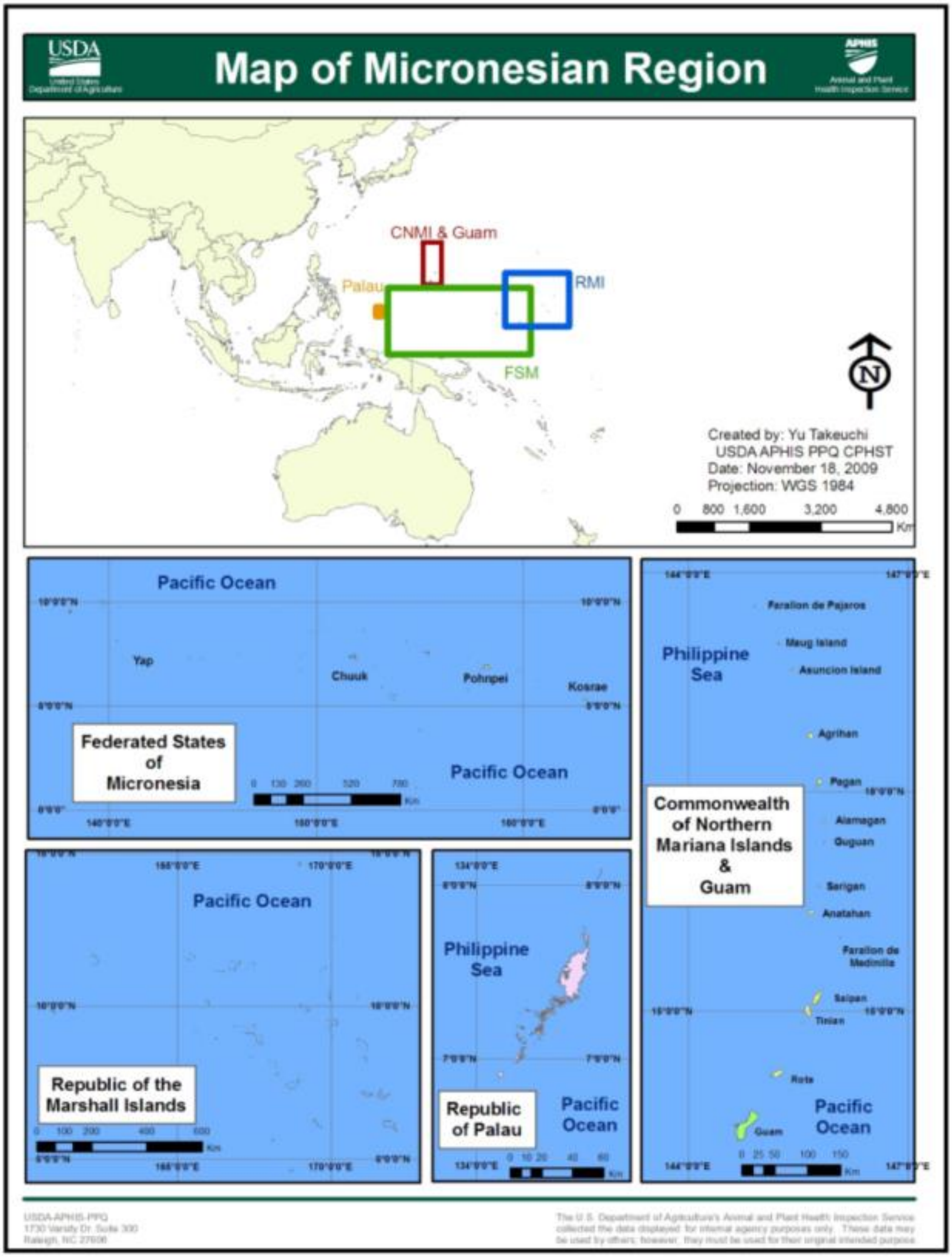
The objectives of this risk analysis are to

- Identify exotic terrestrial vertebrates, animal disease agents, and plant pests and diseases that may pose a threat to terrestrial animal and plant health if introduced into the Micronesia Region;
- Identify the pathways by which these organisms may be moved;
- Evaluate the relative importance of these pathways with regard to the likelihood that these organisms will be moved; and
- Evaluate the expected impact of pest introductions on terrestrial animal and plant health in the Micronesia Region.

This risk analysis was conducted collaboratively between APHIS-Plant Protection and Quarantine (PPQ), APHIS-Wildlife Services (WS), and APHIS-Veterinary Services (VS). The document is organized into four main sections: plant pests, terrestrial vertebrates, wildlife diseases, and livestock diseases. While a general approach was coordinated among the collaborating groups, each group selected the specific methodology most appropriate to their primary focus.

While the scope of this risk analysis includes the entire Micronesia Region, many of the perspectives presented herein focus on Guam. The majority of DoD activities will occur directly on Guam, making this the area for which the most specific information exists and where consequences will be felt most immediately. Guam is the largest point of entry for the Micronesia Region, serving as both the gateway and bellwether for the rest of the Region; one assumption of this analysis is that exotic species issues significant in Guam are relevant throughout the Micronesia Region.

Figure A1-1: Map of the Micronesia Region



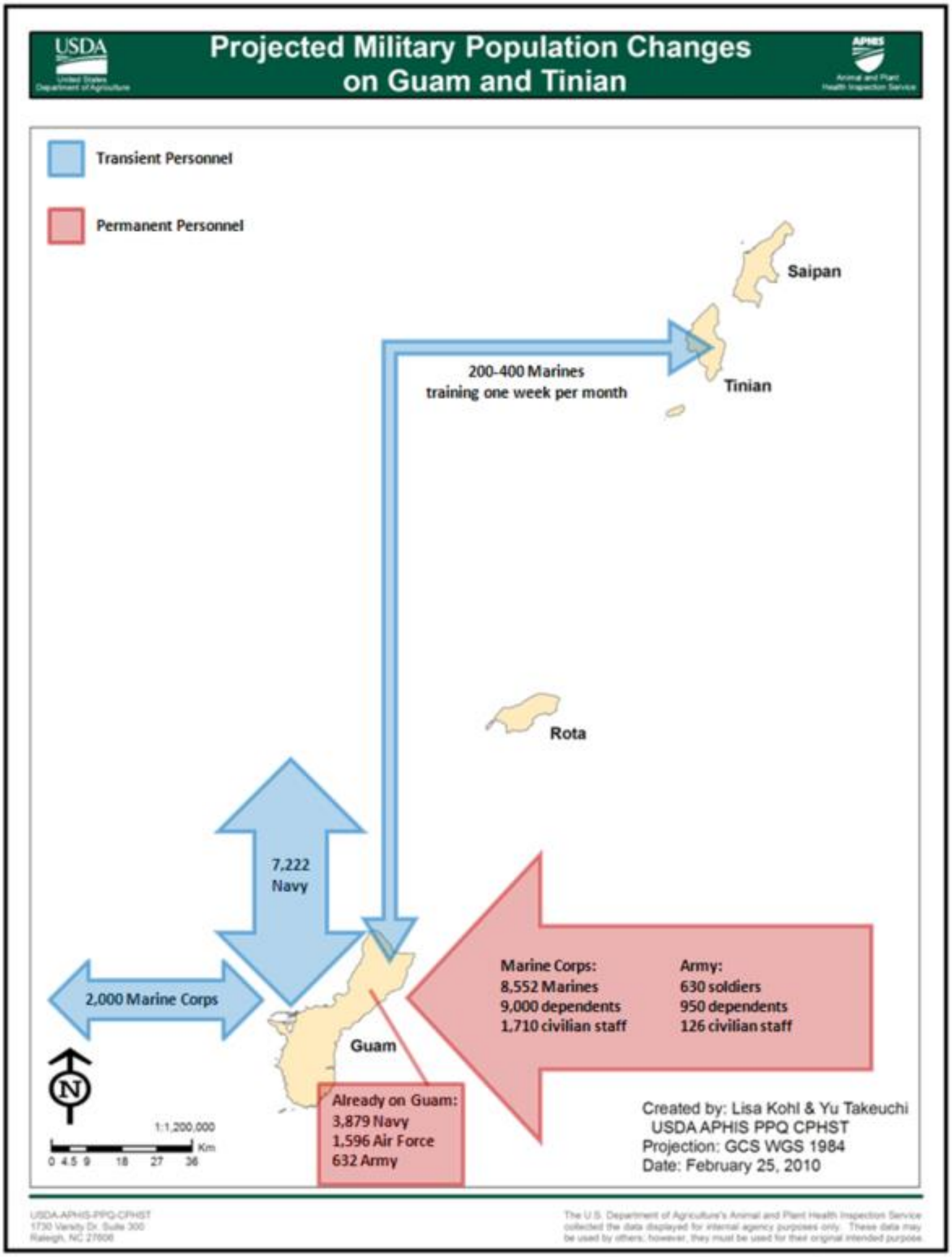
A1.1 OVERVIEW OF THE PROPOSED MILITARY RELOCATION

The three main components of the military relocation as proposed by the DoD are: 1) relocation of U.S. Marine Corps forces to Guam; 2) construction of a nuclear-powered aircraft carrier transient berthing facility in Apra Harbor, Guam; and 3) establishment of an Army Air and Missile Defense Task Force on Guam (U.S. Navy 2010a). The expected consequence of these actions is an increase in the number of people living on Guam and, consequently, increased traffic to and from Guam, increased construction activities, and increased commodity imports.

Approximately 8,600 Marines and 9,000 dependents will be relocated to Guam (Figure A1-2) (U.S. Navy 2009f). In addition, there will be a transient population of approximately 2,000 personnel (U.S. Navy 2009h). Port capacity will be expanded to accommodate transient berthing of a nuclear-powered aircraft carrier in Apra Harbor (U.S. Navy 2009b). The aircraft carrier is part of a Carrier Strike Group, which includes aircraft and escort ships. In total, a Carrier Strike Group includes more than 7,000 personnel. The Carrier Strike Group would be in port for a maximum of 63 days per year, for up to 21 days per visit (U.S. Navy 2009b). An Army Air and Missile Defense Task Force (U.S. Navy 2009e), requiring movement of approximately 630 Army personnel, 126 civilians, and 950 dependents to Guam, is also proposed. The U.S. Armed Forces personnel stationed in Guam will originate from a variety of duty stations.

Infrastructure improvements on Guam will be needed to accommodate the relocation (U.S. Navy 2009h). Utility, roadway, housing, and port expansion construction projects related to the proposed actions are expected to result in population increases due to an influx of workers. The size of the population on Guam from off-island is forecast to peak at almost 40,000 in 2014, resulting in an increase in movement of people and goods into and throughout the Micronesia Region.

Figure A1-2: Projected Military Population Changes on Guam and Tinian



Source: U.S. Navy 2009h

A1.2 POLITICAL RELATIONS AND RELEVANT LEGISLATION

Several U.S. federal laws are directly applicable to the proposed action, including the National Environmental Policy Act (Title 42, United States Code [U.S.C.] section 4321) which requires federal agencies to address the impact of invasive species on their actions; the Endangered Species Act (16 U.S.C. § 1531 et seq.) which requires federal agencies, in consultation with the U.S. Fish and Wildlife Service (USFWS) and/or the National Oceanic and Atmospheric Administration, to ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of any listed threatened or endangered species or result in the destruction or adverse modification of designated critical habitat of such species; and the Federal Noxious Weed Act (7 U.S.C. § 2814), which requires federal agencies to develop management programs for the control of weeds. The Federal Seed Act authorizes USDA to regulate the trade of seeds, and the Plant Protection Act authorizes USDA to regulate the trade of plant materials to control and minimize the economic, ecological, and human health impacts that harmful plant pests can cause. The Animal Health Protection Act (8 U.S.C. § 8301 et seq.) authorizes USDA to regulate the import, export, and interstate movement of animals and articles to prevent the introduction or dissemination of livestock pests or diseases. APHIS uses these authorities to protect U.S. agriculture, forests, and other natural resources from harmful pest species. USDA implementing regulations include those listed in Titles 7 and 9 of the U.S. Code of Federal Regulations (CFR): 7 CFR § 319.56 for regulation of agricultural commodities for consumption; 7 CFR 319.37 for regulation of plants for propagation; 7 CFR § 319.69 for regulation of agricultural packing materials, and 9 CFR § 70-99 for regulation of import, export, and interstate movement of animals and animal products.

A1.2.1 Guam and the Commonwealth of the Northern Mariana Islands

Guam is an unincorporated, organized territory of the United States, and its people are citizens of the United States. The powers of the government of Guam are set forth in the Organic Act of Guam, and part of the U.S. Constitution applies to its governance. The Act permits the Governor to establish agencies and regulations as needed to protect public health and prevent the spread of disease (Guam 2004). The Guam Department of Agriculture (GDOA) carries out pest survey and control programs (Berringer 2009). Guam law authorizes GDOA to quarantine, inspect, fumigate, disinfect, destroy, or exclude commodities infested with pests or any article that is or may be injurious to the agricultural industries and forest resources of the territory (Guam CQD 1997; 9 GARR, Division 1, Chapter1). GDOA is further authorized to enforce applicable regulations governing the importation into Guam of any agricultural commodities from anywhere outside of the territory, at any time or place within the territory (Guam CQD 1997; 9 GARR, Division 1, Chapter 1).

The Director of GDOA issues permits required for importation of regulated plants and plant products into Guam. Phytosanitary certificates are required for the importation of rooted plants and seedlings; cuttings and grafts of woody plants; ornamental plants and other horticultural plants; cut flowers; flower bulbs, corms, tubers, rhizomes, and other vegetative plant propagating materials; fresh fruits of regulated plants; seeds meant for propagation purposes; and soil. These certificates must be issued by the Plant Protection Service of the country of origin of the plants. If the country from which a consignment is imported into the territory of Guam is not the country of origin, the consignment must be accompanied by a phytosanitary certificate of the country of origin; in case of importation of fruits, the certificate may also have been issued by the country from which the consignment was last dispatched (9 GARR, Division 1, Chapter 1).

Each shipment of plants into the territory of Guam must be marked to show name and address of shipper or owner, name of consignee, contents, and the state and country where the contents were grown. Any person transporting, receiving, or importing plants, plant products, or soil must have an import permit. All shipments of plants are examined at their port of entry and, if found infested with any pest liable to be detrimental to agriculture, the shipments are destroyed, treated, or processed at the owner's expense. All plants shipped into the territory of Guam must be free of soil, and all regulated articles (9 GARR, Division 1, Chapter 1) are subject to inspection upon arrival in Guam. Shipment or transport of live insects, plant pathogenic agents, and all other plant pests into the territory of Guam is prohibited. Specific commodities from various countries are also regulated (9 GARR Division 1, Chapter 1).

All importations of domestic animals into the territory of Guam from foreign countries are subject to the regulations of, and require permits from, USDA. In general, no permits are required for animals imported from the United States. Feral animals, reptiles, insects, and birds may only be imported into the territory with a permit issued by USDA (9 GARR, Division 1, Chapter 1). All animals are subject to inspection upon their arrival in the territory; those animals that have been exposed to, are suffering from, or appear to have the symptoms of a contagious or infectious disease are subject to quarantine. Animals must enter the territory through commercial ports or the international airport. Specific animal types are further regulated (9 GARR, Division 1, Chapter 1).

The CNMI is an unincorporated, organized commonwealth, and its people are citizens of the United States. The constitution of the CNMI can be modified only with consent of both the U.S. Congress and CNMI (DOI OIA 2007; 2009b). Citizens of the CNMI elect a non-voting member to the U.S. House of Representatives, but they have no vote in the electoral college (110th Congress 2008).

Port operations in both Guam and the CNMI are guided by U.S. federal regulations. Agricultural inspectors at Guam and CNMI ports of entry have access to USDA inspection manuals that specify the percentage of cargo to be inspected and additional risk management principles. While these resources are available, specific requirements are determined by locality, not the United States. The municipalities comprising the CNMI create and enforce local laws, including laws that regulate agricultural materials; local laws do not preempt those of the Commonwealth. The GDOA Biosecurity Division, Guam Customs and Quarantine Agency (GCQA), and CNMI Department of Lands and Natural Resources Division of Agriculture are charged with preventing the introduction and establishment of alien species in their respective territories (Guam CQD 1997; GDOA 1997). GDOA, GCQA, and the CNMI Department of Lands and Natural Resources collaborate with U.S. federal agencies to prevent the introduction of invasive pests. USDA-APHIS-PPQ provides oversight and support for agricultural quarantine and inspection activities for both Guam and the CNMI. However, the actual work associated with agricultural quarantine and border inspection activities is carried out by GCQA and the CNMI Department of Lands and Natural Resources, each providing officers that serve as APHIS cooperators.

A1.2.2 The Freely Associated States: Federated States of Micronesia, Republic of the Marshall Islands, and Palau

FSM and RMI became independent nations in 1979, followed by Palau in 1994 (DOI OIA 2009c, d, a). After gaining their independence, FSM, RMI, and Palau each entered into a Compact of Free Association with the United States. As part of this agreement, the United States has unlimited access to the land and waterways belonging to each of these nations. In return, the United States provides financial assistance and defense (DOI OIA 2009c, d, a). Unlike territories or commonwealths, nations in free association are not bound by the U.S. Constitution, but they have agreed to be bound by certain U.S. laws such as the National Environmental Policy Act.

A1.2.2.1 *Federated States of Micronesia*

FSM is composed of more than 600 islands which are organized into four states: Chuuk, Kosrae, Pohnpei, and Yap (DOI OIA 2009d). The Code of the Federated States of Micronesia (FSMC) (updated 1997) describes authorities to regulate agriculture and livestock (FSMC Title 18, Chapter 2 § 206). Key provisions include authorization of a coconut development authority to engage in manufacture, processing, trading, marketing, and quality control of all products derived from the coconut tree, reflecting the importance of coconut in the Micronesia Region.

Quarantines may be used to prevent the introduction and further dissemination of injurious insects, pests, and diseases into and within FSM. The Secretary of Resources and Development issues plant and animal quarantines and regulations relating to their administration and enforcement. Agricultural quarantine inspectors appointed by the Secretary of Resources and Development enforce the provisions of plant and animal quarantine controls, quarantines, and regulations. The Secretary of Resources and Development possesses the power to deputize anyone to serve and enforce the FSM laws including customs and immigration inspections (FSMC Title 18, Chapter 2 § 206).

All animals and plants or parts thereof, including seeds, fruits, vegetables, and cuttings entering or transported within FSM are subject to inspection by agricultural quarantine inspectors and may be treated, destroyed, or refused entry into or movement within FSM if they are known to be, or are suspected of being, infected or infested with disease or pests (FSMC Title 18, Chapter 2 § 206). All aircraft and vessels or their cargoes, including baggage, ship's stores, and ballast, entering or moving within FSM are subject to inspection by agricultural quarantine inspectors; U.S. Armed Forces aircraft and vessels are subject to existing military security regulations. Vessels and aircraft traveling into or within FSM and known or suspected to be harboring plant pests are subject to spraying with insecticides or other treatment. FSM inspectors also monitor the shipment of vehicles. It is possible that the shipment of used vehicles may have assisted with the spread of Giant African Snails to Kosrae.

Any animals, plants, or other quarantine material in transit through FSM on aircraft or vessels must be kept aboard while in port. If it is necessary to transfer quarantine material from one vessel or aircraft to another, such transfer must be made under the direction of an agricultural quarantine inspector, and with safeguards as deemed necessary.

A1.2.2.2 *Republic of the Marshall Islands*

RMI consists of more than 1,200 islands and atolls, most of which are uninhabited (RMI EPPSO 2005b). The RMI Chief of Agriculture administers plant and animal quarantine controls and regulations (PacLII 2004a). Agricultural quarantine inspectors, under the direction of the Chief of Agriculture, enforce said provisions. All animals and plants or parts thereof, including seeds, fruits, vegetables, cuttings, etc., entering or transported within RMI are subject to inspection and may be treated, destroyed, or refused entry into or movement within RMI if they are known to be, or are suspected of being, infected or infested with disease or pests. All aircraft and vessels or their cargoes, including baggage, ship's stores, and ballast, entering or moving within the Republic are subject to inspection; U.S. Armed Forces aircraft and vessels are subject to existing military security regulations (PacLII 2004a). Vessels and aircraft traveling into or within RMI and known or suspected to be harboring insects or other agricultural pests are subject to spraying with insecticides or other such treatment (PacLII 2004a).

Any animals, plants, or other quarantine material in transit through RMI on aircraft or vessels must be kept aboard while in port, unless such material is otherwise enterable. If it is necessary to transfer such quarantine material from one vessel or aircraft to another, such transfer must be made under the direction of an agricultural quarantine inspector with safeguards as deemed necessary.

A1.2.2.3 *Palau*

Palau consists of more than 340 islands, nine of which are inhabited (Palau OPS 2008). Palau Animal and Plant Quarantine Regulations (Palau BAMR 2006) stipulate that every conveyance and all of its cargo, people, baggage, garbage, and provisions are subject to inspection and examination, treatment, or quarantine. Garbage is prohibited entry to Palau without express permission and may require treatment or destruction. Plants and plant material are prohibited from Palau without a permit, and plants and plant material in transit through Palau are subject to quarantine or safeguarding measures; permission to transit is required. Imported plants and plant parts must be free from soil; timber imports are subject to inspection and treatment upon arrival and timber with bark attached is prohibited entry, unless treated for pests. Grass, bamboo, and palm fronds are prohibited entry into Palau; soil, sand, and gravel must have a permit in order to be allowed entry (Palau BAMR 2002; 2006).

A2 TRAFFIC AND TRADE DATA

A2.1 PEOPLE

Below, we summarize population sizes and movement patterns of people to and within the Micronesia Region. We compiled these data from the November 2009 Guam and CNMI Military Relocation draft EIS/OEIS and final EIS/OEIS (U.S. Navy 2009a; 2010a); government tourism and statistics office reports; and other publicly available sources. Comparison of statistics among the island groups and among data sources is complicated by differences in data availability, definition of terms such as visitor and tourist, and data collection and analysis methods. However, the information that we present below should provide insight into the current and forecast volumes and patterns of people movement to and within the Micronesia Region.

A2.1.1 Micronesia Region: Population and Visitors

The total population of the Micronesia Region in 2009 was approximately 423,000 (Table A2-1) (USCB 2010). Most of the population lives in Guam or FSM (USCB 2010). The number of visitor arrivals in the island groups in recent years has totaled more than 1.7 million annually, with most accounted for by arrivals in Guam or the CNMI (RMI EPPSO 2008; SPC 2008).

Table A2-1: Population Size and Number of Visitors to the Micronesia Region

	Population[a]		Visitors[b]	
Region	**Number**	**Percent**	**Number**	**Percent**
Guam	178,430	42	1,225,323	71
FSM	107,434	25	20,150	1
RMI	64,522	15	6,959	<1
CNMI	51,484	12	389,261	22
Palau	20,796	5	93,031	5
Total	422,666	99c	1,734,724	99c

[a] Estimated midyear population, 2009 (USCB 2010).
[b] Visitor arrivals. Guam, CNMI, Palau, FSM: 2007 (SPC 2008). RMI: fiscal year (FY) 2007, visitors to Majuro (RMI EPPSO 2008).
[c] Due to rounding, total does not equal 100.

A2.1.2 Guam

Most visitors to Guam arrive by air (BSP 2009a). Of those, most are from Japan or Korea (Table A2-2), and most are traveling for pleasure (Table A2-3). Of the visitors who arrive on passenger vessels by sea, most are from Japan or the U.S. mainland (PB International 2008). Approximately 20% of international arrivals in Guam by sea are from cruise ship visits (Green 2004). In recent years, 4 to 10 cruise ships have visited Guam per year, carrying an average annual total of approximately 2,900 passengers and crew, and generally remaining in port for less than 24 hours (Table A2-4) (PAG 2010a). Most other international arrivals by sea are from military and merchant ships, including traffic from U.S. Navy ships and courtesy calls from the navies of Australia, New Zealand, and various Asian countries (Green 2004).

Table A2-2: Visitors to Guam, by Region of Residence of Visitor; Air Arrivals

	Visitors (2008)[a]	
Region of residence	**Number**	**Percent**
Japan	849,831	78
Korea	110,548	10
United States	52,797	5
CNMI/Micronesia	30,315	3
Taiwan	22,592	2
Philippines	10,867	1
Hong Kong	4,270	<1
Other	10,687	1
Total	1,091,907	100

[a] Arrivals by air; excludes transit arrivals and crew; includes civilians and military personnel (BSP 2009a).

Table A2-3: Visitors to Guam, by Purpose; Air Arrivals

	Visitors (2008)[a]	
Purpose	**Number**	**Percent**
Pleasure	749,436	69
Get married	22,711	2
Business	22,531	2
Honeymoon	21,781	2
Golf	19,791	2
Friends/relatives	19,631	2
Government/military	15,191	1
Convention	8,266	1
Medical care	1,724	<1
Employment	1,254	<1
School	321	<1
Other	24,076	3
No response	175,194	16
Total	1,091,907	100

[a] Arrivals by air; excludes transit arrivals and crew; includes civilians and military personnel (BSP 2009a).

Table A2-4: Cruise Ship Arrivals in Guam, 2005-2009

	Total number of arrivals	
Year	**People[a]**	**Cruise ships**
2005	1,749	4
2006	2,521	6
2007	3,009	7
2008	4,625	10
2009	2,433	5
Total	14,337	32

Source: PAG 2010a.

[a] Passengers and crew.

A2.1.3 Commonwealth of the Northern Mariana Islands

Most (90%) of the population of the CNMI lives on Saipan, with 5% each on Tinian and Rota (U.S. Department of Commerce 2001). Some areas within the CNMI are very sparsely populated, with a total of six individuals counted in the 2000 Census on one such area, The Northern Islands municipality.

Most visitors to the CNMI arrive in Saipan, mainly as tourists from Japan or Korea (Table A2-5) (CNMI Department of Commerce). Much of the economic activity on Tinian is associated with a casino, tourism related to the island's role in World War II, or marine activities (U.S. Navy 2010a). Most of the visitors to the casino are from Asia, mainly from China, Japan, and Korea. The comparatively few visitors to Rota are predominantly visitors from Guam or elsewhere in the United States, or from Japan.

Table A2-5: Visitors to CNMI, by Region of Origin of Visitor

	Visitors (2002)[a]	
Region of origin	**Number**	**Percent**
Japan	293,921	69
Korea	77,665	18
United States including Guam	34,306	8
Hong Kong	3,359	1
Taiwan	1,440	<1
Other	14,241	3
Total	424,932	99[b]

Source: CNMI Department of Commerce 2002

[a] Fiscal year.

[b] Due to rounding, total does not equal 100.

A large proportion of the movement of people within the CNMI occurs by sea (Green 2004). The ports of Rota and Tinian each handle a large volume of passenger ferry traffic daily. Most of the international arrivals by sea are from merchant vessels or cruise liners. In general, merchant vessels carry few people on frequent port calls, whereas cruise liners carry more people on fewer port calls.

A2.1.4 Federated States of Micronesia

Most of the population of FSM lives in Chuuk (50%) or Pohnpei (32%) (FSM Division of Statistics 2013). Most visitors to FSM are from the United States or Asia (Table A2-6), traveling as tourists or on business (Table A2-7). It is worth noting that the information in these tables may very well only be from visitors arriving via aircraft, although this has not been ascertained. Most movement of people and goods among the islands of FSM occurs by ship (Green 2004) (This may be less true in 2013 than a decade ago when this information was published). International arrivals by sea are mainly from fishing vessels and merchant ships.

Table A2-6: Visitors to FSM, by Region of Residence of Visitor

Region of residence	Visitors (2006)	
	Number	Percent
United States[a]	8,053	42
Japan	3,071	16
Europe	2,398	13
Asia (excluding Japan and Philippines)	1,525	8
Philippines	1,347	7
Pacific islands	1,158	6
Australia	1,077	6
Canada	203	1
New Zealand	183	1
Other	121	1
Total	19,136	101[b]

Source: FSM Division of Statistics 2007

[a] Whether the reported number of visitors from the United States includes visitors from Guam and the CNMI is unclear.

[b] Due to rounding, total does not equal 100.

Table A2-7: Visitors to FSM, by Purpose

Purpose	Visitors (2006)	
	Number	Percent
Tourism and visits	13,345	70
Business/employment	4,529	24
Seamen and crew	493	3
Volunteer, religious, other	626	3
Not stated	143	1
Total	19,136	100

Source: FSM Division of Statistics 2007

A2.1.5 Palau

Most of the population of Palau lives in Koror (64%) or Airai (14%) (Palau OPS 2006). Approximately 80% of visitors to Palau are from Asia, mainly from Japan and Taiwan (Table A2-8) (Palau OPS 2009b). More than 90% of visitors to Palau are tourists Table A2-9 (Palau OPS 2009a). Similar to the case for CNMI and FSM, much of the movement of people and goods among the islands of Palau occurs by sea, mostly by inter-island trading vessels and ferries (Green 2004). Most international arrivals by sea are from fishing vessels and cruise ships. The cruise ships arrive primarily from Guam and Asia.

Table A2-8: Visitors to Palau, by Region of Residence of Visitor

Region of residence	Visitors (2007)	
	Number	Percent
Japan	29,476	32
Taiwan	29,298	31
Korea	14,440	16
U.S. mainland/Canada	6,250	7
Philippines	4,009	4
Guam	1,870	2
Europe	1,818	2
People's Republic of China	970	1
Australia/New Zealand	755	1
FSM	686	1
Germany	480	1
Hong Kong	473	1
CNMI	320	<1
Other	2,186	2
Total	93,031	101[a]

Source: Palau OPS 2009b

[a] Due to rounding, total does not equal 100.

Table A2-9: Visitors to Palau, by Purpose

Purpose	Visitors (2007)	
	Number	Percent
Tourism	84,566	91
Employment	4,641	5
Business	3,610	4
Other	214	<1
Total	93,031	100

Source: Palau OPS 2009a

A2.1.6 Republic of the Marshall Islands

Most (68%) of the population of RMI lives in Majuro or Kwajelein (RMI EPPSO 2005a). Kwajalein is home to the Ronald Reagan Ballistic Missile Defense Test Site, which is owned by the U.S. government and is home to approximately 75 U.S. government personnel, 1,600 contractor staff, and 1,000 family members (GAO 2002). Approximately half of the visitors to Majuro are from Asia, mainly Japan; almost one-fourth are from the Americas (Table A2-10) (RMI EPPSO 2008). Most visits to Majuro are for business or holiday (Table A2-11) (RMI EPPSO 2008). As is the case for other island groups in the Micronesia Region, much of the domestic movement of people and goods in RMI occurs by sea (Green 2004). Most of the international arrivals by sea are from fishing vessels and merchant ships.

Table A2-10: Visitors to Majuro, RMI, by Region of Residence of Visitor

Region of residence	Visitors (2007)	
	Number	**Percent**
Americas	1,690	24
Japan	1,600	23
Other Pacific island countries	1,024	15
Australia/New Zealand	496	7
Other Asian countries	320	5
Taiwan	311	4
Europe	275	4
Philippines	255	4
People's Republic of China	157	2
Other/not stated	831	12
Total	6,959	100

Source: RMI EPPSO 2008.

Table A2-11: Visitors to Majuro, RMI, by Purpose

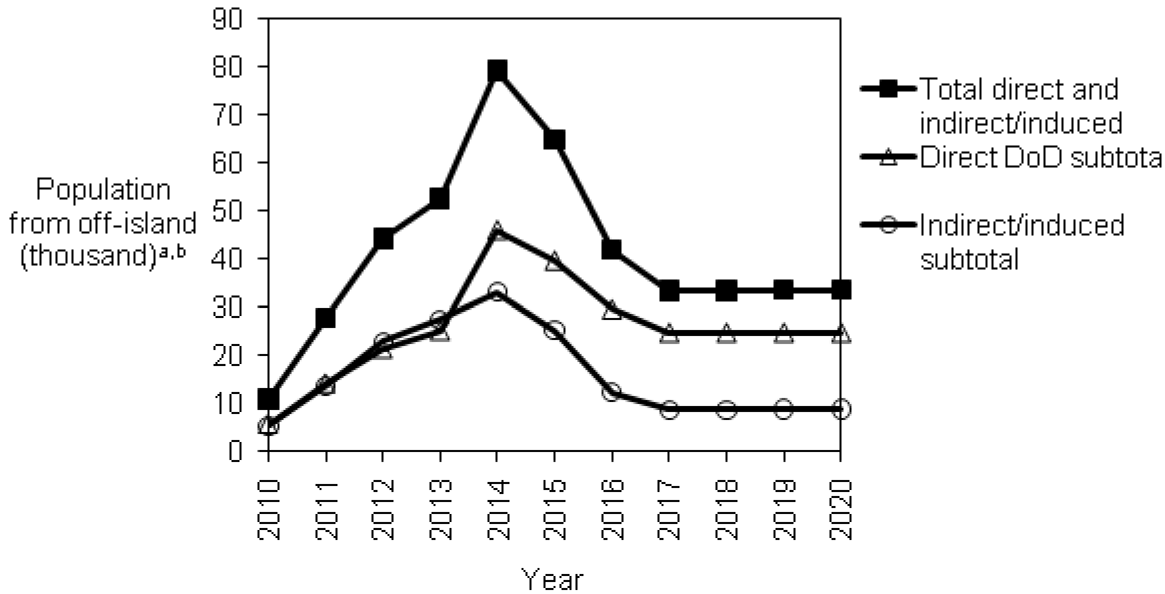
Purpose	Visitors (2007)[a]	
	Number	**Percent**
Business	2,218	32
Holiday/vacation	2,060	30
Transit/stopover	1,415	20
Visiting friends/relatives	718	10
Other/not stated	548	8
Total	6,959	100

Source: RMI EPPSO 2008

A2.1.7 Population Impacts of Proposed Actions

The estimated changes in Guam's population size from 2010 to 2020 are shown in Figure A2-1.

Figure A2-1: Estimated population on Guam from Off-Island, 2010-2020[1]



[a] Does not include transient population of up to 7,222 personnel associated with aircraft Carrier Strike Group, and transient population of up to 6,213 personnel associated with Marine Corps vessels berthed at Apra Harbor (U.S. Navy 2010a).

[b] Source: U.S. Navy 2010a

The population from off-island is forecast to grow through 2014,[7] concurrent with the planned increase in DoD project construction work and the planned arrival in 2014[7] of most of the Marines that are to be relocated to Guam (U.S. Navy 2010a). The total number of individuals from off-island is estimated to peak in 2014[7] at almost 80,000. From 20142 to 2017, the DoD and non-DoD populations from off-island are forecast to decrease with the completion of construction projects. In 2017,[7] the population from off-island is estimated to decrease to approximately 33,400. The changes in estimated population size on Guam from off-island from 2010 to 2020[7] are shown by population category in Table A2-12 (U.S. Navy 2010a).

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[1] The National Defense Authorization Act (NDAA) for Fiscal Year 2012, signed into United States law on December 31, 2011, by President Barack Obama, imposed restrictions on the Secretary of Defense's usage of funds to develop infrastructure associated with the U.S. Marine Corps relocation to Guam. Additionally, Congress did not authorize or appropriate funding for the Guam realignment in FY 12. As the pace of construction is subject to the availability of funds, it is anticipated that the realignment will proceed at a slower rate than originally anticipated.

Table A2-12: Estimated Population on Guam from Off-island, 2010-2020

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Population[a,b]											
Direct DoD											
Marines											
Active duty	510	1,570	1,570	1,570	10,552	10,552	10,552	10,552	10,552	10,552	10,552
Dependents	537	1,231	1,231	1,231	9,000	9,000	9,000	9,000	9,000	9,000	9,000
Navy											
Active duty	0	0	0	0	0	0	0	0	0	0	0
Dependents	0	0	0	0	0	0	0	0	0	0	0
Army											
Active duty	0	50	50	50	50	630	630	630	630	630	630
Dependents	0	0	0	0	0	950	950	950	950	950	950
DoD civilians											
Workers	102	244	244	244	1,720	1,836	1,836	1,836	1,836	1,836	1,836
Dependents	97	232	232	232	1,634	1,745	1,745	1,745	1,745	1,745	1,745
Non-DoD construction workers, DoD projects											
Workers	3,238	8,202	14,217	17,834	18,374	12,140	3,785	0	0	0	0
Dependents	1,162	2,583	3,800	3,964	4,721	2,832	1,047	0	0	0	0
Subtotal, direct DoD	5,646	14,112	21,344	25,125	46,051	39,685	29,545	24,713	24,713	24,713	24,713
Indirect/induced											
Workers	2,766	7,038	11,773	14,077	16,988	12,940	6,346	4,346	4,346	4,482	4,482
Dependents	2,627	6,685	11,184	13,373	16,138	12,293	6,028	4,372	4,372	4,413	4,413
Subtotal, indirect/induced	5,393	13,723	22,957	27,450	33,126	25,233	12,374	8,718	8,718	8,895	8,895
Total direct and indirect/ induced	11,038	27,835	44,301	52,575	79,178	64,918	41,919	33,431	33,431	33,608	33,608

Source: Modified from U.S. Navy 2010a

[a] Does not include transient population of up to 7,222 personnel associated with aircraft Carrier Strike Group, and transient population of up to 6,213 personnel associated with Marine Corps vessels berthed at Apra Harbor (U.S. Navy 2010a).

From 2010 to 2014,[2] the largest proportions of the estimated total population from off-island are accounted for by non-DoD workers and their dependents for DoD construction projects, and workers and their dependents for indirect and induced jobs. Most of the estimated increases from 2015 to 2020 are due to increases in the number of Marine Corps and Army personnel, DoD civilians and their dependents, and workers and their dependents for indirect and induced jobs. The non-DoD construction worker and indirect or induced populations are forecast to decrease sharply after peaking in 2014 with the peak in construction activity. These decreases might not be as sharp or as large as forecast, depending on the number of workers who remain on Guam (U.S. Navy 2010a).

The population estimates described above do not include an estimated maximum number of 7,222 personnel in port at any given time associated with the aircraft Carrier Strike Group, and a transient population of up to 2,000 personnel associated with Marine Corps vessels berthed at Apra Harbor (U.S. Navy 2010a). These two groups are not expected to be in port concurrently.

The estimates also do not include training visits to the Micronesia Region by Japan Self Defense Forces personnel. The training is expected to include various types of ground, air, and maritime training in Guam, the CNMI, and surrounding sea and airspace. Each type of training exercise could involve approximately 500 to 3,000 personnel, training for 1 to 4 weeks, 1 to 6 times per year (Table A2-13).

Table A2-13: Japan Self Defense Forces Training in the Micronesia Region

Total number of personnel[a]	Duration (weeks per visit)	Frequency (times per year)	Training Location	Military Service
3,000	4	1	Guam, Tinian, Pagan, and surrounding sea and airspace	Japan Self Defense Forces, U.S. forces
3,000	1	3		
3,000	1	3		
3,000	1	3		
3,000	1	3		
600	4	1	Beaches of Guam, Tinian, and Pagan	Japan Ground Self Defense Force, U.S. Marine Corps
1,050	2	4	Guam, Tinian, and sea and airspace surrounding Guam and CNMI	Japan Maritime Self Defense Force, U.S. Navy
490	4	1		
700	2	6	Guam and CNMI airspace, Farallon de Medinilla range, Andersen Air Force Base	Japan Air Self Defense Force, U.S. Air Force

Source: U.S. Navy 2010a

[a] Maximum training requirements for the Japan Self Defense Forces in the Micronesia Region; rough estimates prepared for the Guam and CNMI Military Relocation EIS/OEIS.

[2] Ibid. pA2-6.

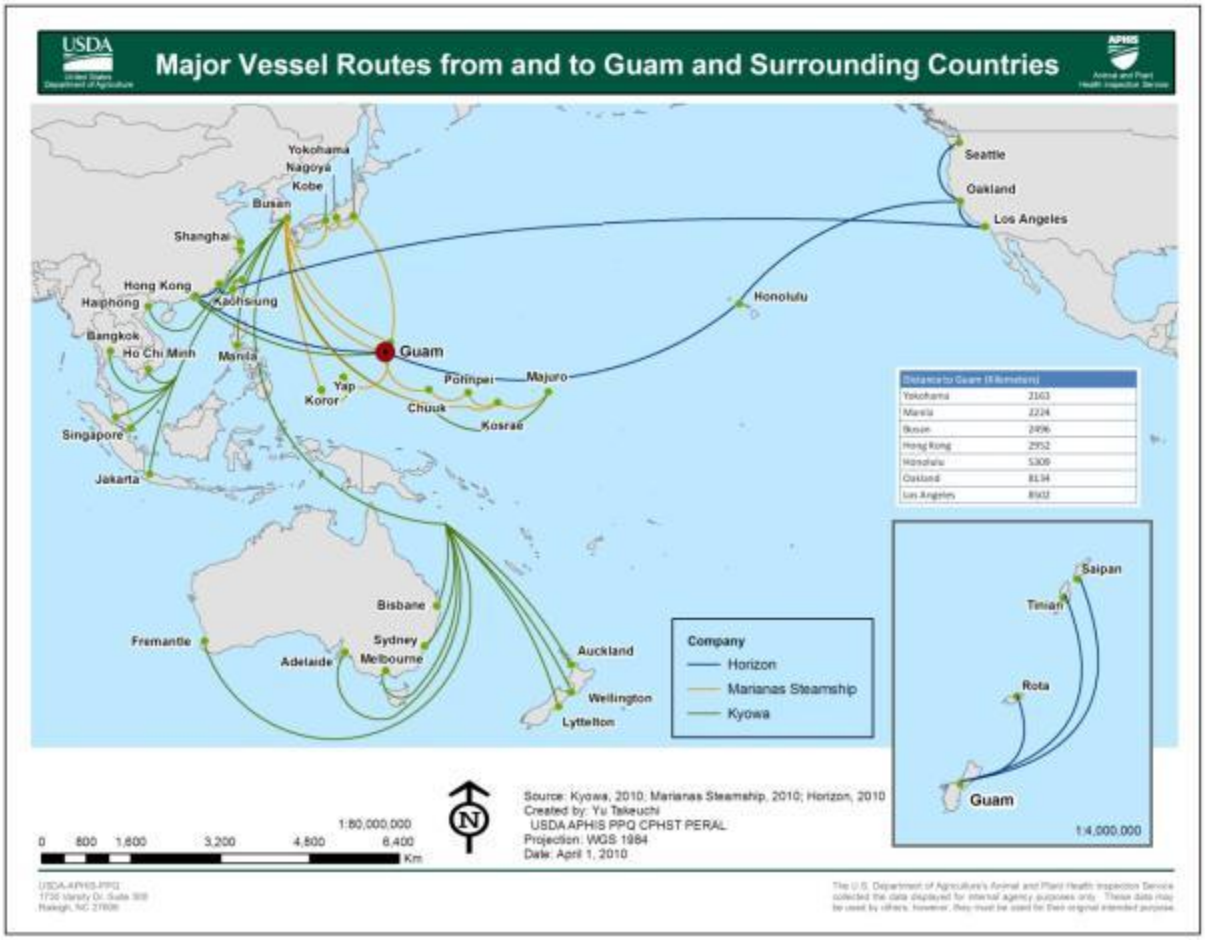
A2.2 MARITIME TRAFFIC AND CARGO

The Micronesia Region is well connected through maritime shipping routes to Asia (China, Japan, and Korea) and the United States (Figure A2-2). The majority of maritime traffic in the Region moves between the U.S. west coast and Guam, between Asia and Guam, and within the Region (Figure A2-2) (PB International 2008). On a less frequent basis, vessels operate between Australia, Papua New Guinea, and Guam (PB International 2008). Container ships, larger vessels such as break-bulk cargo ships, and smaller regional vessels usually operate on routine schedules in the Micronesia Region. Waterways to the east/northeast connect with Hawai'i and the continental United States, while the waterways running north and west connect to the CNMI and with ports in Asia. Horizon Lines and Matson Navigation Company operate large container ships that navigate the route from China to California, returning to China by way of Hawai'i and Guam, with potential stops at other Micronesian ports, such as RMI and FSM.

A2.2.1 Civilian Ports

The Jose D. Leon Guerrero Commercial (Maritime) Port of Guam is the main port in the Micronesia Region, handling almost 90% of all imports to Guam (PB International 2008) and serving as the transshipment hub for the Region; the port also receives cargo for the military bases on Guam (Table A2-14). Data availability is very limited, especially regarding military vessels, and port statistics often do not differentiate between vessel types (e.g., container vessels, break-bulk cargo vessels, and petroleum-carrying vessels). Horizon Lines and Matson Navigation Company operate the majority of large ships in the Region (Horizon Lines 2010b, c; Matson 2010a, b). The military relocation is expected to increase maritime vessel traffic to Guam (PB International 2008) by an estimated 149 container vessels per year (U.S. Navy 2009a), in addition to a substantial increase in the number of break-bulk vessels (PAG 2010b) (Table A2-14). Container volumes will also increase (Tables A2-14 and A2-15).

Figure A2-2: Shipping Routes in the Micronesia Region



Note that this is a representative figure and some ship lines are not included.

Source: Horizon Lines 2010b, c, d, a; Kyowa Shipping Company 2010a, b; Mariana Express Lines 2010a; b

Table A2-14: Vessel and Container Traffic at Jose D. Guerrero Commercial (Maritime) Port

	Fiscal year				
	2006	2007	2008	2009	2015[a]
Number of vessels (arrivals and departures)					
Container	109	151	165	161	310
Break bulk/ro-ro	299	165	171	192	-[b]
Barges	17	21	17	21	-
Cruise	6	7	10	5	20-30
Fishing	771	651	566	499	-
Number of containers handled (loaded or unloaded)					
Total	84,321	99,630	99,908	94,073	190,000
U.S. military cargo[c]	15,009	14,994	15,008	15,023	89,000

Source: PB International 2008; PAG 2010b

[a] Projected peak traffic year during the military relocation; numbers are estimates.

[b] N/A: Estimate not available.

[c] Estimates.

Table A2-15: Vessel traffic at ports in Guam, the CNMI, Palau, RMI, and FSM

	Number of port visits per year[a]				
	Guam	CNMI–Saipan	Palau–Koror	RMI–Majuro	FSM[b]
International shipping activity					
Merchantmen[c]	560	460	36	84	178
Cruise	12	8	2	0	2
Warships	-[d]	58	13	19	-
Fishing–oceanic	260	10	185	360	852
Yachts	25	25	20	20	55
Domestic shipping activity					
Inter-island traders	-	-	300	300	300
Inter-island ferries	55	750	-	-	6
Tourist charter boats	6,000	5,000	100	400	610
Fishing–local	-	1,000	500	200	4,000
Local work boats	600	600	-	250	230
Local craft	-	4,000	-	15,000	12,500

Source: Nawadra et al. 2002; Green 2004

[a] Estimates based on 2002 to 2004 data.

[b] Traffic numbers for FSM are totals for the ports of Pohnpei, Weno, Yap, and Okat. These figures may include "double-counting" if vessels were included in more than one port's total.

[c] Merchantmen vessels are those carrying commercial cargo and include container ships, bulk cargo, and roll-on roll-off vessels. In Saipan, 330 container vessels arrive per year. In Palau, mostly containerized cargo arrives from vessels originating in Guam.

[d] N/A: Data not available.

The Cargo Preference Act of 1904 (10 U.S.C. § 2631) requires that all supplies purchased for the U.S. Armed Forces be transported on U.S. flag vessels when transported by vessels at sea (US DOT 2009). Waivers for cargo moving between elsewhere in the United States and Guam can only be granted by the Secretary of the U.S. Department of Homeland Security (US DOT 2009). Of interest, Matson Navigation Company (a leading U.S. flag ship carrier operating in the Pacific) has purchased four new vessels for an Asian service that conducts weekly service to Guam (PB International 2008). The types and volumes of maritime vessel traffic at ports in the Micronesia Region are summarized in Table A2-15.

The Port of Saipan clears approximately six cargo vessels (250 cargo containers) per week; the Port of Tinian clears up to two cargo vessels per week and two daily inter-island passenger vessels (Berringer 2009). Cargo vessels occasionally arrive at the Port of Rota. Most vessels arriving in Saipan and Tinian carry transshipments from Guam. Vessels from Guam calling in Saipan often stop in Tinian first.

Palau is well connected to Asia and the mainland United States, as well as to other islands in the region. Shipping lines service Malakal Commercial Dock, operating on a 30-day interval, bringing cargo from the U.S. west coast, Japan, Australia, Taiwan, Hong Kong, the Philippines, Guam, and elsewhere. Another shipping line operates mostly in Asia and brings cargo from Korea, Japan, the Philippines, Hong Kong, Taiwan, Saipan, Guam, and Yap. Transshipments between Guam and Palau are routine (Berringer 2009).

Small vessels, including privately owned outboard motor boats, move freight between the islands of Palau. These vessels are multipurpose, moving people and freight together. The exact number of small vessels involved in transport is not known, but at least several hundred outboard motorboats operate in the area (Jimenez et al. 2009). Freight often consists of firewood and perishable commodities including fruits and vegetables.

A2.2.2 Cargo

Break-bulk cargo volumes are expected to substantially increase due to the amount of construction materials that will arrive on Guam in response to the proposed military relocation (PB International 2008). The Port of Guam processed 155,000 revenue tons of break-bulk cargo during 2007. It is anticipated that the volume of break-bulk cargo processed through the Port of Guam will increase from current levels to 270,000 to 320,000 revenue tons per year during 2010 through 2013 (PB International 2008). However, these figures may change if construction plans change.

The maritime port in Guam processes more containers than any other port in the Region and serves as the main transshipment hub. Approximately 94,000 sea cargo containers arrived at the Port of Guam in 2009. This number is expected to more than double by 2015 (approximately 95,900 more containers arriving), mostly due to the military relocation (Tables A2-14 and A2-16) (PAG 2010b). The number of containers associated with construction projects and military container shipments (e.g., household goods, private vehicles, and commissary products) is anticipated to increase and peak in 2015, after which the majority of the construction is expected to be finished and the relocation of military personnel to Guam completed (PB International 2008). DoD containers are expected to account for approximately one-fourth of total container volume processed through the Port of Guam (PB International 2008). The number of containers handled to support imports for the local/tourist market is projected to steadily increase. Little change is projected for the volume of transshipment containers coming into Guam (PB International 2008). Detailed data regarding container traffic at other maritime ports in the Micronesia Region were unavailable.

Table A2-16: Forecast Number of Sea Cargo Containers Entering Guam

	Number of containers			
		Type		
Year	Total	Transshipment	DoD	Local and tourism
2010	129,000	12,000	39,000	78,000
2011	149,000	11,000	58,000	80,000
2012	172,000	11,000	78,000	83,000
2013	178,000	11,000	81,000	86,000
2014	182,000	11,000	85,000	86,000
2015	190,000	11,000	89,000	90,000
2016	180,000	11,000	76,000	93,000
2017	152,000	11,000	46,000	95,000
2018	146,000	12,000	38,000	96,000
2019	148,000	12,000	38,000	98,000
2020	150,000	12,000	38,000	100,000
2021	151,000	12,000	38,000	101,000
2022	153,000	12,000	38,000	103,000
2023	155,000	12,000	38,000	105,000
2024	157,000	12,000	38,000	107,000
2025	158,000	12,000	38,000	108,000

Source: PAG 2010b

Transshipped containers enter a country through one port, are then loaded onto a different vessel, and exit for their final destination in a different country (PB International 2008; PAG 2010b).

A2.2.3 Military Seaport

Approximately four contract cargo vessels per week arrive at Naval Base Guam, as well as naval ships carrying personnel and cargo (Berringer 2009). Currently, the number of U.S. Navy ships operating in and around Guam at any given time ranges from 0 to 10; ship lengths range from 110 meters (361 feet) for a nuclear submarine (SSN) to 333 meters (1,093 feet) for a nuclear aircraft carrier (CVN). The number of naval ships operating in and around Guam may increase with the military relocation; specific estimates were not provided in the EIS/OEIS. Training activities involving vessel movements occur intermittently and are short in duration, ranging from several hours to several weeks (U.S. Navy 2009b).

A2.3 AIR TRAFFIC AND CARGO

A2.3.1 Civilian Air Traffic and Air Cargo

From September 2008 to September 2009, there were 20,985 flight arrivals, about 20 daily flights, at A.B. Won Pat International Airport, of which fewer than 2% were dedicated cargo flights (Table A2-17) (GIAT Operations Division Records 2009). The amounts of air cargo processed through the airport in 2003 to 2008 are summarized in Table A2-18. Passenger arrivals and departures at A.B. Won Pat International Airport are projected to increase 3% to 4% per year from 2008 to 2023 and air cargo (in metric tons), which includes shipments of agricultural commodities, is projected to increase 7% per year during the same time period (Tagawa and Torres 2007) which may increase the number of dedicated cargo flights arriving at the airport. The airport hosts several flights to Japan, Korea, China, Taiwan, the Philippines, Indonesia, Australia, and Hawai'i.

Within the Micronesia Region, A.B. Won Pat International Airport provides air service to the CNMI (Rota and Saipan), FSM (Chuuk, Kosrae, Pohnpei, and Yap), Palau (Koror), and RMI (Kwajalein and Majuro). Saipan International Airport services approximately 13 flights daily; Rota International Airport averages 2 to 3 inter-island flights per day, as well as one direct flight from Japan per month; and Tinian International Airport services inter-island flights (Berringer 2009). The Palau airport provides 7 weekly turn-around services between Guam and Palau, with stops on Yap and Saipan (Law-Byerly 2010b).

Table A2-17: Number of Flight Arrivals at A.B. Won Pat International Airport, by Month, September 2008 to September 2009

Month	Number of flight arrivals: All flights[a]	Number of flight arrivals: Dedicated cargo flights
2008		
September	1,541	29
October	1,509	34
November	1,592	1
December	1,737	1
2009		
January	1,769	45
February	1,525	0
March	1,683	31
April	1,559	34
May	1,684	29
June	1,394	33
July	1,576	27
August	1,721	34
September	1,695	26
Total	20,985	324

Source: GIAT Operations Division Records 2009

[a] Wide-body jets, standard jets, small jets, and propeller aircraft.

Table A2-18: Commercial Air Cargo Processed through A.B. Won Pat International Airport

Year	Cargo weight (metric tons)[a]		
	All cargo	Imports	Exports
2003	31,479	17,587	13,892
2004	34,266	18,837	15,429
2005	32,016	17,917	14,099
2006	31,926	16,904	15,022
2007	28,378	15,380	12,998
2008	29,144	17,528	11,616

Source: Jacobs Consultancy 2007, GIAT Operations Division Records 2009

[a] Commercial air cargo.

A2.3.2 Military Air Traffic and Cargo

Andersen Air Force Base (AFB) is located on the northern end of Guam and is home to the 734th Air Mobility Squadron, 36th Operations Group, and the Helicopter Sea Combat Squadron (HSC-25) (U.S. Navy 2009a). Aircraft arrivals at Andersen AFB include military flights, contract flights for military dependents, and approximately 10 cargo flights per week (Berringer 2009). Civilian and military air traffic will increase to accommodate the population increase associated with the military relocation. The percent increase in commercial flight traffic during the relocation is unknown. However, the number of flight operations of helicopters, jets, and propeller aircraft at Andersen AFB is projected to increase 45%

by 2014 (U.S. Navy 2009a). In addition to flight traffic, air cargo traffic will increase to accommodate the increase in population and relocation activities.

Andersen AFB supports Air Mobility Command flights for military personnel and their dependents. In 2006, 29,524 flight operations were conducted at Andersen AFB (U.S. Navy 2009a). The Air Force plans on increasing its use of the base, bringing the total number of annual airfield operations up to 68,139 by 2014. Of these airfield operations, 18,951 are expected to involve the HSC-25 Squadron's MH-60S Knighthawk helicopters, and 732 are expected to be transient operations generated by the air wing associated with the visiting aircraft carrier. The remainder will be local and transient operations.

Of the flight operations conducted in 2006, only 18,951 operations involved equipment based at Andersen AFB (all helicopters) (U.S. Navy 2009a). In addition, 602 jet operations, 52 rotary wing operations, and 78 helicopter operations were conducted with equipment associated with visiting aircraft carrier wings. Finally, 9,841 local and transient operations were conducted. Under the proposed actions, additional aircraft would be based at Andersen AFB by the Marine Corps. Equipment based at Andersen AFB would be used in 23,416 operations in 2014[3] (18,852 helicopter; 4,564 jet) (U.S. Navy 2009a). Under the proposed actions, 1,704 jet operations, 156 rotary wing operations, and 234 helicopter operations would be conducted in 2014[4] using equipment associated with visiting aircraft carrier wings. The addition of these aircraft would result in 25,510 sorties at Andersen AFB in 2014 . Under the proposed actions, up to 59 aircraft would reside at Andersen AFB on a space-available basis when a CVN is in port. A typical air wing might include 20 Hornet aircraft, 10 Super Hornet aircraft, five EA-6B aircraft, four E-2C aircraft, and six SH-60 aircraft.

A2.4 AGRICULTURAL COMMODITIES

A2.4.1 Plants and Plant Products: Imports

Some of the main types of plant products imported to Guam include fruits and vegetables, cut flowers, and wood. Because Guam is a domestic trading partner with the rest of the United States, neither the federal government nor Guam now systematically collects data regarding the specific amounts of commodity trade between the two locations. As opposed to current practices, in 2002 (and before) GDOA personnel collected such data. Data collected during these activities illustrate both the diversity of plants and plant products imported into Guam and the diversity of their origins. These data are summarized in the list below; the values in parentheses are the weight of the imported commodity in kg and pounds rounded to the nearest pound. The total weight imported in 2002 was 13,148 metric tons (28,986,463 pounds). It should be noted that these data do not include imported furniture from Indonesia. It is worth noting that while the information presented below is interesting, it is outdated, some locations which do export plant products to Guam such as Kosrae and Yap are not included and some of the information is simply incorrect, for example Pohnpei does not produce alfalfa sprouts.

[3] Ibid. p. A2-9.

[4] Ibid.

Australia–oranges (9,099/20,060); live plants (306/676); onion (24,040/53,000); strawberry (503/1,109)

China–cut flowers (354/781); china garlic (998/2,200); china ginger (5,953/13,125)

Chuuk–banana hearts (38/83); banana/plantain (43,601/96,124); kava (45/99)

CNMI–green bean (69/152); string bean (44/97); coconut (23/50); cucumber (381/841); cut flowers (5/11); eggplant (143/316); live plants (29/65); beef (18/40); pork (2,622/5,780); okra (11/24); chili pepper (28/61); sweet potato (6,355/14,010); taro (6,600/14,551)

Hong Kong–garlic (39,022/86,029)

Japan–apple (1,284/2,830); asparagus (164/362); avocado (8/18); bamboo shoots (35/78); basil (2/5); bean (49/109); blackberry (17/37); blueberry (20/45); bok choy (14/30); broccoli (30/66); burdock (446/983); green cabbage (11/24); nappa cabbage (4/9); carrot (495/1,092); cherries (18/40); chervil (5/11); chive (13/29); chrysanthemum (667/1,471); cilantro (28/62); grapefruit (4/8); kumquat (1/3); lemon (5/12); lime (3/6); oranges (2,135/4,706); tangerine (14,553/32,084); cucumber (751/1,656); dill (8/18); eggplant (808/1,782); endive (5/10); Belgian endive (23/50); garlic (33/72); ginger (22/48); grape (74/163); kale (25/55); kay choy/yu cho (71/156); lemon grass (5/10); lettuce (21/46); frisse (6/13); green lettuce (4/9); red lettuce (68/151); lily root (9/20); lotus root (20/45); mango (28/62); marjoram (0.5/1); marsh mallow (2/4); bitter melon (10/23); cantaloupe (32/70); Crenshaw melon (3/7); honeydew (3/7); mint (45/100); mizuna (0.5/1); mushrooms (4,334/9,554); mustard greens (34/74); nectarine (20/44); okra (32/71); onion (726/1,601); green onion (649/1,430); leek (135/297); shallot (34/74); oregano (0.5/1); papaya (15/32); parsley (395/870); pea pod (4/9); sugar pea (24/52); peach (120/264); bell pepper (1,356/2,989); chili pepper, (16/35); jalapeño pepper (1/2); perilla (413/910); plum (29/63); potato (45/100); sweet potato (183/404); pumpkin (556/1,226); radicchio (14/30); radish sprouts (300/661); radish/daikon (5,525/12,181); rosemary (3/6); sage (1/2); seeds (5/10); spinach (740/1,631); squash (95/210); strawberry (210/462); taro (0.5/1); tarragon (1/2); thyme (1/2); tomato (845/1,862); turnip (123/271); watercress (18/40); yam (459/1,011); *Zanthoxylum* spp. (1/2)

Korea–alfalfa sprouts (4/9); apple (27,809/61,309); apricot (40/88); bean (449/989); green bean (12/26); bean, soy (10/22); bean, sprouts (1,489/3,283); bok choy (158/349); bracken fern (24/53); burdock (239/526); green cabbage (1,501/3,310); nappa cabbage (29,460/64,948); pechay cabbage (260/573); red cabbage (49/108); carrot (50/110); Swiss chard (82/180); cherries (65/144); chestnut (315/694); chicory (239/528); Chinese bellflower (14/31); chrysanthemum (1,740/3,835); grapefruit (40/88); lemon (25/55); orange (11,513/25,382); tangerine (37,450/82,563); collard greens (2/4); corn (61/135); cucumber (21,281/46,916); cut flowers (3,965/8,741); dandelion green (28/62); eggplant (3,045/6,713); gai lon (31/68); garlic (2,120/4,674); bottled garlic (83/184); wild garlic (2/4); ginger (57/126); gingko nut (3/7); ginseng (4/9); grape (4,683/10,324); kale (2/4); kay choy/yu cho (4/9); seaweed (6/13); lettuce (4,364/9,620); frisse (20/44); green lettuce (1,329/2,930); lolla lettuce (20/44); red lettuce (1,383/3,050); lo bok (3/7); lotus root (78/171); marsh mallow (87/192); bitter melon (210/462); cantaloupe (3,703/8,163); Crenshaw melon (17/37); honeydew (80/176); mugwort (35/77); mushrooms (5,610/12,369); mustard greens (4/9); olive (16/35); onion (1,952/4,303); green onion (981/2,162); leek (117/258); shallot (9/20); parsley (75/166); green pea (6/13); peach (3,193/7,039); pear

(44,455/98,007); bell pepper (8,523/18,790); chili pepper (1,521/3,354); jalapeño pepper (260/574); perilla (1,028/2,267); persimmon (21,039/46,383); plum (1,335/2,943); potato (713/1,571); sweet potato (4,023/8,870); pumpkin (5,230/11,530); pumpkin leaf (82/180); radicchio (2,096/4,620); radish sprouts (184/405); radish/daikon (16,693/36,802); sage (5/11); sesame leaf (288/634); spinach (7,406/16,327); squash (96/211); strawberry (111,964/246,838); taro (31/68); tomato (5,904/13,015); turnip (2/4); processed vegetables (15/33); watercress (79/174); watermelon (14,032/30,936); yam (20/44)

Malaysia–wood (11,693/25,780)

Netherlands–cut flowers (20,544/45,292)

New Zealand–apple (13,679/30,156); grapefruit (154/340); lemon (272/600); cut flowers (2,442/5,384); green lettuce (169/372); cantaloupe (483/1,064); mushrooms (3,119/6,876); onion (141,074/311,015)

Palau–live plants (2/5)

Philippines–bamboo handicrafts (48/105); cut flowers (375/827); eggplant (34/75); handicrafts (57/125); live plants (15/32); mango (180,261/1,279,256)

Pohnpei–alfalfa sprouts (1,711/3,772); banana/plantain (32,795/72,300); betelnut (196/433); cucumber (49/108); cut flowers (100/220); kava (25,811/56,903); papaya (74/162); piper leaf (71/157); spinach (3/7); taro (71/156)

Singapore–cut flowers (1,855/4,090)

Taiwan–apple (11/25); bamboo shoots (16/36); bean (15/34); carrot (88/194); celery (53/117); chive (361/795); cut flowers (30,985/68,311); kale (27/59); live plants (406/894); mushrooms (167/368); onion (7/16); green onion (7/15); green pea (103/227); pea pod (80/176); snow pea (36/80); sugar snap pea (68/151); spinach (122/270); taro (2/5); processed vegetables (13/29); watercress (56/124)

Thailand–carrot (2/4); celery (5/10); chive (28/62); cut flowers (5,467/12,052); live plants (748/1,649); pea pod (21/46); spinach (5/10); processed vegetables (3/7); watercress (5/10)

United States–alfalfa sprouts (886/1,953); anise (292/644); apple (575,315/1,268,353); apricot (2,405/5,304); artichoke (1,496/3,298); arugula (2/4); asparagus (101,014/222,698); avocado (14,036/30,945); bamboo handicrafts (70/154); banana hearts (23/50); banana/plantain (929,204/2,048,544); basil (172/379); bay leaf (12/26); bean (2,279/5,020); green bean (4,214/9,291); mongo/mun bean (181/400); bean sprouts (15/34); string bean (479/1,057); beet (2,092/4,611); betelnut (412/909); blackberry (1,228/2,707); blueberry (1,510/3,328); bok choy (22,123/48,775); bracken fern (1/2); broccoli (310,839/685,282); Brussels sprout (383/844); green cabbage, (581,827/1,282,708); nappa cabbage (258,750/570,446); pechay cabbage (9,392/20,706); red cabbage (19,788/43,624); savoy cabbage (1,081/2,384); carrot (411,791/907,843); cauliflower (53,882/118,789); celery (168,996/372,572); Swiss chard (437/964); chayote (1,404/3,095); cherimoya (136/300); cherries (26,192/57,743); cherry (10,209/22,506); chervil (4/8); chicory (182/401); chive (88/195); Christmas trees (23,243/51,241); chrysanthemum (14/30); cilantro (4,564/10,062); grapefruit (96,162/212,002); kumquat (5/10); lemon (161,961/357,062); lime (12,047/26,558); orange (600,186/1,323,183); tangerine (90,323/199,129); collard greens (3,054/6,733); corn (22,168/48,872); cranberry (124/274); cucumber (46,675/102,901); cut flowers (34,741/76,590); date/jujube (57/126); dill (143/316); eggplant (2,504/5,521); endive (1,357/2,991); Belgian endive (562/1,239); chicory endive (215/475); escarole (444/979); fennel (72/159); fig (108/237); gai lon (1,163/2,565); garlic (49,841/109,880); bottled garlic (299/660); wild garlic (8/18); ginger (49,479/109,082); grape (419,840/925,589); grass stolons (327/720); guava (91/200); jicama (536/1,181); kale (1,104/2,435); kava (132/291); kay choy/yu cho (664/1,464); kiwi (26,306/57,995); lemon grass (54/120); lettuce (27,427/60,466); butter lettuce (7,845/17,295); cello lettuce (633,654/1,396,969); frisse (1,364/3,008); green lettuce (26,519/58,465); lolla lettuce (134/295); red lettuce (13,015/28,694); Romaine lettuce (311,463/686,659); live plants (76,907/169,550); lo bok (20,506/45,208); lotus root (23/51); lychee (105/231); mango (210,986/465,145); marjoram (15/34); marsh mallow (1/2); cantaloupe (499,679/1,101,604); honeydew (287,472/633,768); mice (152/336); mint (221/488); mushrooms (33,736/74,375); mustard greens (842/1,857); nectarine (19,915/43,905); nuts (680/1,500); okra (247/545); onion (991,166/2,185,147); green onion (129,404/285,287); leek (4,118/9,078); shallot (733/1,617); oregano (30/66); palm (138/304); papaya (845/1,883); parsley (40,690/89,705); parsnip (18/40); green pea (71/156); pea pod (52/115); pea shoot (7/15); snow pea (4,046/8,919); sugar snap pea (2,710/5,974); peach (13,154/29,000); peanut (1,637/3,610); pear (309,135/681,527); bell pepper (287,602/634,054); chili pepper (1,161/2,559); jalapeño pepper (1,088/2,399); perilla (22/49); persimmon (3,712/8,183); pineapple (404,374/891,491); piper leaf (5/10); plum (33,362/73,550); pomegranate (1,384/3,052); potato (1,493,325/3,292,218); sweet potato (1,872/4,128); pumello (6,953/15,329); pumpkin (11,283/24,874); pumpkin leaf (1/2); quince (5/10); radicchio (2,761/6,087); radish sprouts (1,828/4,029); radish/daikon (20,466/45,119); raspberry (1,524/3,360); rhubarb (47/104); rosemary (147/325); rutabaga (252/555); sage (16/36); sesame leaf (4/9); spinach (17,362/38,277); squash (47,062/103,755); star fruit (13/29); strawberry (57,790/127,405); taro (12,269/27,049); tarragon (12/26); thyme (59/130); tomatillo husk (271/598); tomato (474,596/1,046,305); turnip (570/1,257); turnip greens (345/760); processed vegetables (43,339/102,160); watercress (355/782); watermelon (302,733/667,412); yam (9,091/20,043); yucca (472/1,041); zucchini (2,547/5,616)

Yap–betelnut (110,647/243,935); kava (266/587); piper leaf (3,323/7,327); taro (16/36)

An important caveat to the data presented above is the omission of many cereal crops. Data regarding the volume and value of cereals imported from the United States to Guam are not available. However, imports of cereals from non-U.S. origins to Guam totaled more than $3 million in 2008, with the majority of shipments originating from Thailand, Japan, and Taiwan (Table A2-19) (GTIS 2010).

Table A2-19: Cereal Imports to Guam, 2006-2008

Reporting country or region	U.S. dollars		
	2006	2007	2008
Thailand	871,307	2,067,395	3,198,206
Japan	3,341	2,045	14,918
Taiwan	62	182	2,874

India	5,533	0	0
Philippines	136,526	0	0
South Korea	0	42	0

Source: GTIS 2010

In 2002, the United States was the largest source of live plants for propagation imported into Guam, which totaled 76,907 kg (169,550 pounds) (see above). Hawai'i and Florida are significant sources of ornamental plants. Orchids are imported primarily from Thailand and Taiwan, while most bromeliads are imported from the Philippines. As shown in the list above, relatively small amounts of live plants are imported from the FSM, CNMI, and Palau (Campbell 2010d). Cut flowers imported into Guam likely originated from South America (Colombia and Ecuador) with some originating from Asia (USDA-APHIS-PPQ 2010a).

Wood imports to Guam from foreign trading partners totaled more than $3 million in 2007 (GTIS 2010). The majority of these imports were finished products or building materials from neighboring Asian nations. In 2008, trading partners within the Micronesia Region exported fruit and vegetable commodities to Guam worth $1.3 million (GTIS 2010).

FSM imported $2 million to $4 million in cereals each year from 2007 to 2009 from the United States (GTIS 2010). Data for other areas within the Micronesia Region were not available.

Another important caveat to the list above is the lack of information regarding informal imports such as the importation of taro from Palau and the FSM. These items are typically imported by family members for home consumption or by the small scale markets that cater to the various island and Asian groups now living on Guam. As an example, the Alii Fish Market in Dededo, Guam regularly imports Colocasia and Cyrtosperma taro and other Palauan food items for sale to its mainly Palauan clientele. The same generalizations regarding food imports to the informal sector also can be made for the other Micronesian island groups who reside on Guam. The import of taro plants and fresh taro products is prohibited to Guam, in order to prevent the dissemination of taro diseases. Per regulations, the Alii Fish Market imports taro (both Colocasia and Cyrtosperma) that has been cooked, frozen and wrapped in plastic.

A2.4.2 Plants and Plant Products: Domestic Production and Exports

Guam produces a variety of fruit, including coconuts, melons, papaya, guavas, mangoes, mangosteens, and nuts (FAO 2010a) (Tables A2-20 and A2-21).

Table A2-20: Non-Animal Agricultural Production on Guam, 1998-2008, by Hectare

	Number of hectares harvested, by year		
Commodity	**1998**	**2003**	**2008**
Bananas	10	15	15
Coconuts	9,300	9,300	9,600
Cucumbers and gherkins	10	15	15
Fruit, fresh	200	300	300
Maize	10	15	15
Nuts	45	50	70

Commodity	Number of hectares harvested, by year		
Onions, dry	1	1	5
Roots and tubers	100	120	170
Sweet potatoes	4	6	10
Tomatoes	5	10	15
Vegetables, fresh	165	170	200
Total	9,850	10,002	10,415

Source: Data are estimates of FAO 2010a

Table A2-21: Non-Animal Agricultural Production on Guam, 1998-2008, by Metric Ton

Commodity	Number of metric tons harvested, by year		
	1998	2003	2008
Bananas	230	345	350
Cabbages and other Brassica	90	100	120
Citrus	80	90	110
Coconuts	51,875	52,000	53,200
Cucumbers and gherkins	260	390	400
Eggplants	20	30	35
Fruit, fresh	1,400	2,100	2,100
Maize	20	30	35
Mangoes, mangosteens, guavas	50	60	70
Nuts	114	126	180
Onions, dry	2	2	10
Oranges	60	70	90
Other melons	340	350	370
Roots and tubers	1,500	1,800	2,500
String beans	94	95	110
Sweet potatoes	50	75	130
Tomatoes	60	120	160
Vegetables, fresh	1,500	1,550	1,900
Watermelons	2,200	2,300	2,500
Total	59,945	61,633	64,370

Source: Data are estimates of FAO 2010a

Of these commodities, some percentage is exported, although the majority of production is consumed by the domestic market. Historically, the primary recipients of exported fruit and vegetable commodities are Canada, the United Kingdom, and the Netherlands (GTIS 2010). The majority of exported vegetables are legumes; Canada, Iceland, and the Netherlands are primary recipients (GTIS 2010). Wood is also exported from Guam, and is sent to India and the Philippines (GTIS 2010). The primary destination for Guam plant product exports is FSM (Table A2-22).

Table A2-22: Plant Product Exports from Guam, June 2008 to March 2010

Number of shipments		Destination	Commodity	Total weight (pounds)
3		CNMI, Rota	Fruits and vegetables	445
10		CNMI, Rota	Live plants	142
56		CNMI, Saipan	Cut flowers	11,855
8		CNMI, Saipan	Live plants	452
1		CNMI, Saipan	Seeds	10
1		CNMI, Tinian	Cut flowers	152
1		FSM	Fruits and vegetables	8,511
1		FSM, Chuuk	Cut flowers	203
13		FSM, Chuuk	Fruits and vegetables	14,774
1		FSM, Pohnpei	Cut flowers	2
7		FSM, Pohnpei	Live plants	74
1		FSM, Yap	Cut flowers	4,983
33		FSM, Yap	Fruits and vegetables	271,799
1		Massachusetts	Chilled algae	39
77		Palau	Cut flowers	4,429
10		Palau	Fruits and vegetables	9,982
1		Palau	Live plants	12
1		Philippines	Live plants	4
1		RMI, Majuro	Fruits and vegetables	960
1		Texas	Coconut	52

Source: Data provided by GCQA

Coconut is the largest crop, in number of metric tons harvested in RMI (GTIS 2010); production totaled 27,500 metric tons (60,627,122 pounds) in 2008 (FAO 2010a). Export data for FSM and RMI were not available.

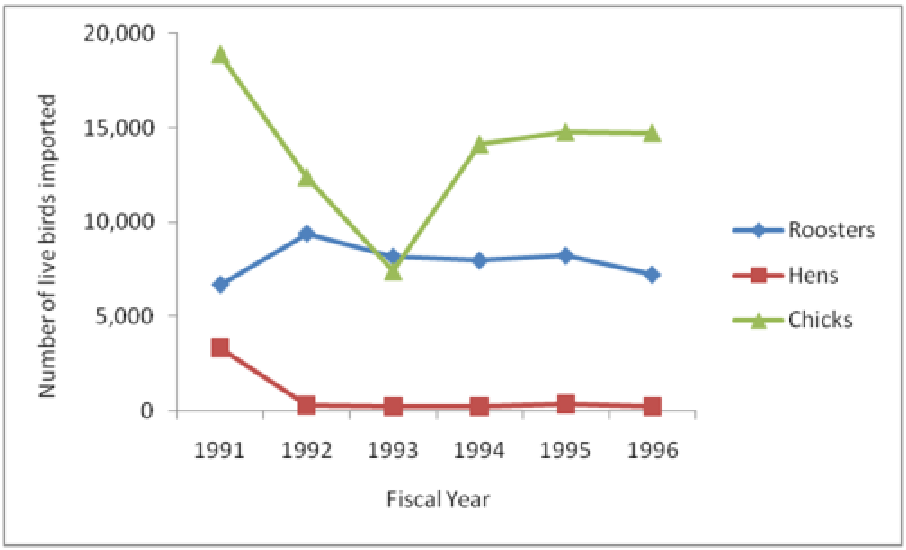
A2.4.3 Animals and Animal Products: Imports

Data on livestock imports were available from the Global Trade Atlas (GTIS 2010). Guam has experienced a decline in annual live animal imports after a peak in 2003 and 2004 totaling more than 10,000 per year. The number of animals imported dramatically declined to about 100 animals per year between 2004 and 2007 and remains below 10 per year at present. Imported animals originated primarily from Australia (84%) with the rest being sourced from Asia (the Philippines, South Korea, Thailand, Japan, Indonesia, and Singapore), Canada, and Denmark. The majority of import records in the Global Trade Atlas do not include the animal species. According to the territorial veterinarian, no livestock have been imported to Guam over the last 5 years (Poole 2009). Additionally, according to published reports, no cattle have been imported in the last two decades (Duguies et al. 2000). Swine semen has been imported in the past, but no records were found to indicate recent importations (Poole 2009).

Importation of poultry breeding stock to Guam is restricted and subject to U.S. federal regulations; most poultry breeding stock have been imported from the continental United States and Hawai’i. During fiscal years 1991 to 1996, most of the imported birds were day-old chicks, with some roosters and few hens

(Figure A2-3). The number of bird imports declined following the imposition of restrictions on transit of birds after the outbreak of West Nile fever in the continental United States. According to a GCQA 2002 report on animal imports, no chicks or hens were imported in 2002 (GovGuam 2002). Global Trade Information Services reported one shipment of 14,000 live chickens from Denmark in 2003 (GTIS 2010). No data are available from GCQA on animal importations after 2002 (Campbell 2010a). Current demand for poultry breeding stock is partially met by GDOA, which runs an experimental farm that hatches and raises poultry for local farmers. We were not able to identify data specific to the number of hatching eggs and day-old chicks imported, but nearly all of these imports are from Hawai'i and the continental United States (USDA-APHIS-PPQ 1997; GovGuam 2002; DNRL 2003; Dela Cruz 2009; Poole 2009).

Figure A2-3: Trends in the Importation of Live Birds to Guam, FY 1991 to FY 1996



Source: USDA-APHIS-PPQ 1997

The GCQA 2002 report documents animal imports and indicates that on average, 9,400 roosters were imported annually during the 1990s. These numbers have declined, starting shortly after the West Nile fever outbreak in the continental United States. Only 12 roosters were imported to Guam in 2002 from CNMI (GovGuam 2002). While more current data are not available from GCQA, there is reason to believe that the trend reversed shortly after, with increasing numbers of roosters brought in and used to supply a burgeoning cock fighting industry (Poole 2009). In unpublished reports, Guam Animals In Need indicated that approximately 6,000 roosters were imported between 2003 and 2005; these increasing numbers of rooster imports are also consistent with the increasing popularity of cock fighting on Guam as discussed in a 2008 Honolulu newspaper article (Boylan 2008). However, in 2002, a federal law was implemented that prohibits the interstate transit of birds used for fighting, and United Airlines recently banned the air freight transportation of adult poultry (Huemer 2007), suggesting the trend will be reversed once again with far fewer roosters imported.

In the past, the annual number of pet birds imported ranged from 42 to 6,505 (FY 1991 to FY 1996) (USDA-APHIS-PPQ 1997). These numbers drastically declined after the implementation of importation and quarantine requirements designed to prevent the introduction of West Nile virus (WNV) from the continental United States. Based on the last available Guam-specific animal import data, there are no records of pet birds having been imported into Guam in 2002 (GovGuam 2002). Since GCQA took over inspection responsibilities in 2003, animal import numbers have not been reported. However, according to the territorial veterinarian on Guam the approximate number of pet birds coming to Guam is currently less than a dozen per year (Poole 2009).

The number of dogs and cats imported into Guam annually is low, with estimates ranging from 10 to 100 animals a year (Poole 2009). In the GCQA 2002 animal report, 113 dogs and 29 cats were imported to Guam in 2002 (GovGuam 2002). The majority of imports originated from the continental United States and Australia, with a few animals imported from Japan and CNMI (USDA-APHIS-PPQ 1997).

Most food imports originate in the continental United States. In FY 2009, imports from the rest of the United States accounted for more than 85% of meat products, 98% of egg products, and 75% of dairy products imported into Guam. Data for imports of animal products and byproducts from foreign sources over the period 2005 to 2009 were obtained from the Global Trade Atlas (GTIS 2010) and are categorized by the harmonized schedule (HS) codes. The volume of foreign meat imports increased from 2005 to 2009, mostly due to a steady annual increase in the volume of imported pork over the last 5 years as shown in Table A2-24, and in Figure A2-4 and Figure A2-5.

Table A2-24: Annual Percent Volume of Foreign Meat Imports to Guam, 2005-2009

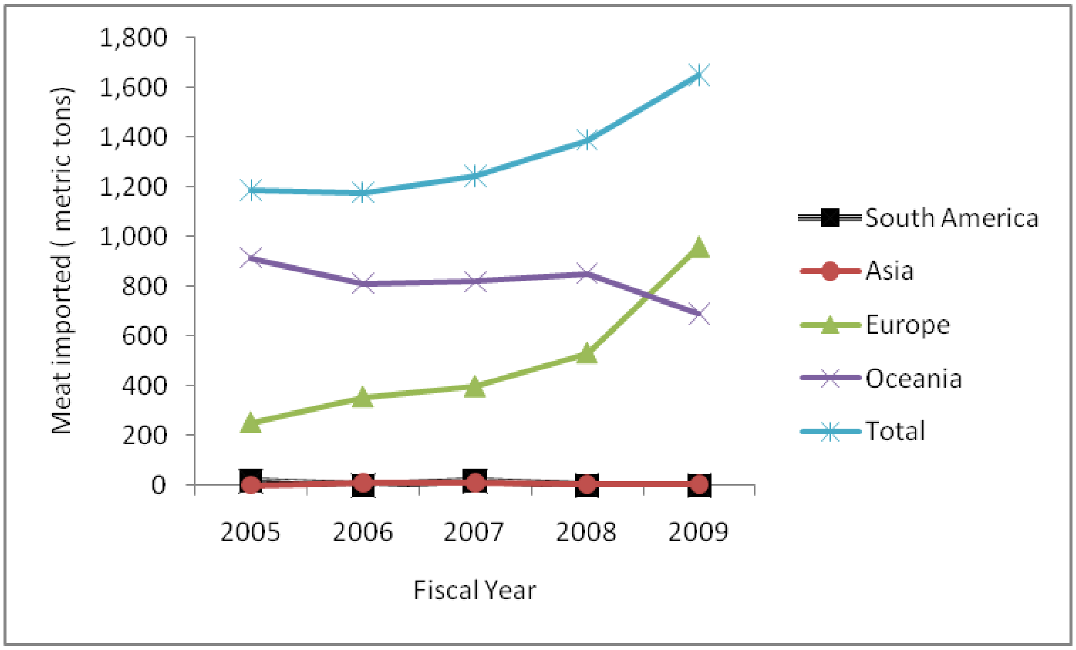
HS code	Commodity	Year					Countries or regions of origin
		2005	2006	2007	2008	2009	
Percent of total foreign meat imports, by weight[a]							
0201	Bovine meat, fresh and chilled	<1	0	<1	<1	<1	Australia, Japan
0202	Bovine meat, frozen	50	39	38	36	20	Australia, New Zealand
0206	Bovine, edible offal (also from swine, sheep, goats, equines)	3	2	3	2	1	Australia, New Zealand, Japan
0210	Bovine meat and edible offal salted, dried and flour and meal	1	<1	<1	<1	<1	Australia
0203	Swine meat, fresh and chilled	11	21	26	34	53	Australia, Denmark, Sweden
0204	Sheep and goat, meat, fresh and chilled	3	2	1	1	2	Australia, New Zealand
0207	Poultry, meat and offal, edible	0	0	0	0	0	None
0208	NESOI[b]	0	<1	<1	<1	<1	Taiwan
1601	Sausages and similar products	<1	<1	<1	0	0	Philippines, Denmark, South Korea
1602	NESOI, meat, offal or blood, prepared or preserved	31	35	32	27	24	Australia, New Zealand, Denmark, Brazil
Total imports (metric tons)		1,188,131	1,178,731	1,246,523	1,390,422	1,651,126	

Source: Official trade data for partner countries exporting to Guam; GTIS 2010

[a] Due to rounding, not all totals equal 100.

[b] NESOI: Not elsewhere specified or indicated.

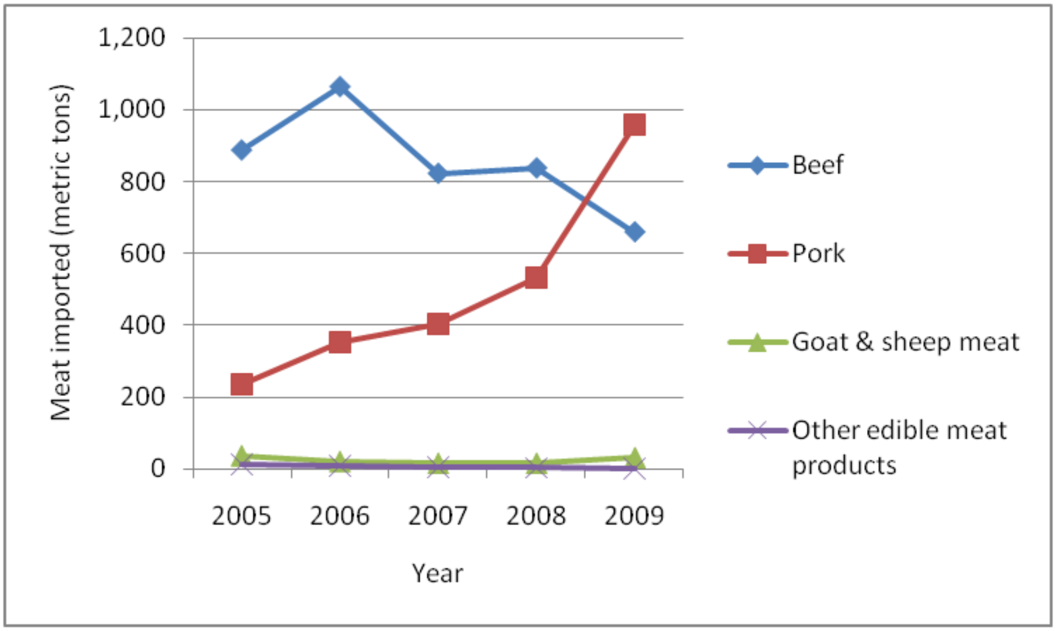
Figure A2-4: Foreign Meat Imports To Guam By Continent of Origin, 2005-2009



Source: Official trade data for partner countries exporting to Guam; GTIS 2010

Volumes of beef imports decreased from 2006 to 2009 (GTIS 2010). No foreign imports of poultry products were recorded, indicating that all or nearly all poultry products were sourced from the United States. Meat from goats and sheep constituted less than 5% of total meat imports and was imported exclusively from Australia and New Zealand. Other edible preparations, including preserved or prepared meat, blood, sausages, and similar products, represented 24% of total meat imports for 2009. Most foreign-origin meat was imported from Denmark (58%), Australia (21.8%), and New Zealand (19.9%), with less than 1% imported from elsewhere (the Philippines, Japan, and Taiwan) (Table A2-25). Imports of beef came primarily from New Zealand and Australia (99%) and less than 1% from Japan.

Figure A2-5: Annual Volumes of Foreign Meat Imports to Guam, 2005-2009



Source: Official trade data for partner countries exporting to Guam; GTIS 2010
Includes: HS codes for bovine (0201, 0202, 0206, 0210), pork (0203), and sheep (0204) sources. No poultry product imports were reported for the period. Other edible meat products include HS codes 160220, 160290, and 1601.

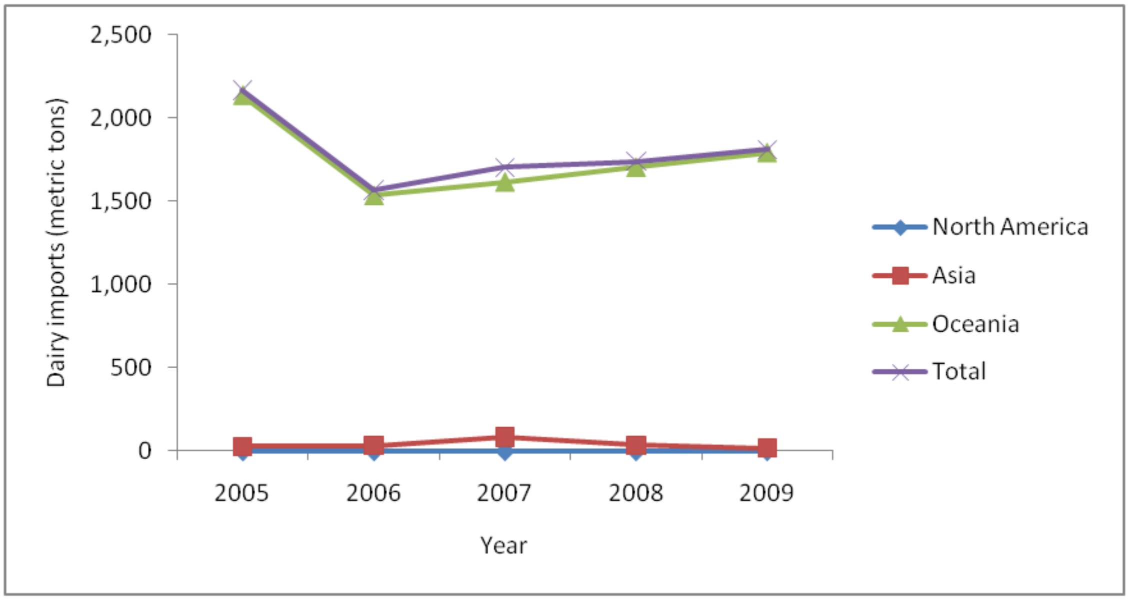
Table A2 25: Annual Percent Volume of Foreign Meat and Other Edible Animal Product Imports To Guam By Country and Continent of Origin, 2005-2009

		Year				
Continent	**Reporting country or region**	**2005**	**2006**	**2007**	**2008**	**2009**
Percent of total meat imports, by weight[a]						
Americas	Brazil	2	0	1	0	0
	Total	*2*	*0*	*1*	*0*	*0*
Asia	Philippines	<1	<1	<1	<1	<1
	Japan	0	0	0	<1	<1
	South Korea	<1	0	0	0	0
	Taiwan	0	<1	<1	<1	<1
	Total	*<1*	*<1*	*<1*	*<1*	*<1*
Europe	Denmark	21	30	32	34	58
	Netherlands	0	0	0	4	0
	Total	*21*	*30*	*32*	*38*	*58*
Oceania	Australia	38	39	32	33	22
	New Zealand	39	29	36	29	20
	Total	*77*	*68*	*68*	*62*	*42*
Total, all countries (kilograms)[kg]		1,188,131	1,178,731	1,246,523	1,390,422	1,651,126

Source: Official trade data for partner countries exporting to Guam; GTIS 2010
Volumes of imports of meat (includes HS codes for meat (160210, 160220, 160239, 160241, 160242, 160249, 160250, 160290) and other edible animal products (160100).
[a] Due to rounding, not all totals equal 100.

Non-U.S. imports of dairy products have remained relatively stable over the last 4 years, with annual volumes averaging approximately 1800 metric tons (Figure A2-6).

Figure A2-6: Annual Volumes Foreign Dairy Imports to Guam by Continent of Origin, 2005-2009



Source: Official trade data for partner countries exporting to Guam; GTIS 2010

Each year from 2005 to 2009, New Zealand and Australia supplied more than 95% by weight of all dairy imports to Guam from foreign origins. During the same time period, 1% or less of all dairy imports were from each of several other regions, including the Philippines, Japan, Taiwan, and Canada (Table A2-26).

Table A2-26: Annual Percent Volume Dairy Imports to Guam By Country and Continent of Origin, 2005-2009

		Year				
Continent	**Reporting country or region**	**2005**	**2006**	**2007**	**2008**	**2009**
Percent of total dairy imports, by weight[a]						
Americas	Canada	0	0	1	<1	<1
	Total	*0*	*0*	*1*	*<1*	*<1*
Asia	Philippines	1	2	4	1	1
	Japan	<1	<1	<1	<1	<1
	Taiwan	<1	<1	0	0	0
	South Korea	0	0	<1	<1	<1
	Total	*2*	*2*	*4*	*1*	*<2*
Oceania	New Zealand	77	83	87	89	90
	Australia	21	15	9	9	9
	Total	*98*	*98*	*96*	*98*	*99*
Total, all countries (kg)		2,167,695	1,568,790	1,703,495	1,741,506	1,812,721

Source: Official trade data for partner countries exporting to Guam; GTIS 2010

[a] Due to rounding, not all totals equal 100.

From 2005 to 2009, 80% to 90% of dairy imports were non-sweetened and non-concentrated dairy products; the rest were cheeses and sweetened or concentrated milk products (Table A2-27). Sweetened and concentrated milk products and cheese represented on average 12 and 4% of imports from Asia respectively.

Table A2-27: Foreign Dairy Product Imports to Guam, 2005-2009

HS code	Commodity	Year					Countries of Origin
		2005	2006	2007	2008	2009	
Percent of foreign dairy product imports, by weight[a]							
0401	Milk and cream, not concentrated or sweetened	62	78	82	74	88	Australia, New Zealand, South Korea, Philippines, Thailand
0402	Milk and cream, concentrated or sweetened	20	11	12	15	7	Australia, New Zealand, Japan, South Korea, Philippines, Thailand, Canada
0406	Cheese and curd	18	11	7	10	6	Australia, New Zealand, Japan, Philippines
Total product imports (kg)		2,167,695	1,568,790	1,703,495	1,741,506	1,812,721	

Source: Official trade data for partner countries exporting to Guam; GTIS 2010

[a] Due to rounding, not all totals equal 100.

In the last 5 years, all foreign imports of egg products have come from Asia (Thailand, Japan, and occasionally from Taiwan) with the volume of imported egg products oscillating between 20 and 30 metric tons. In 2005, almost 80% of foreign imports of egg products were from Japan (Table A2-28). However, from 2007 to 2009 an increasingly large proportion of egg product imports have come from Thailand (Table A2-28).

Table A2-28: Percent of Egg Product Imports to Guam by Country of Origin, 2005-2009

Reporting country or region	Year				
	2005	2006	2007	2008	2009
Percent of egg product imports, by weight[a]					
Thailand	21	22	61	81	100
Japan	79	75	31	19	0
Taiwan	0	3	7	0	0
Total egg product imports (kg)	35,476	31,347	21,567	31,778	22,134

Source: Official trade data for partner countries exporting to Guam; GTIS 2010

[a] Due to rounding, not all totals equal 100. The volumes of egg product imports for years with no reported imports are assumed to equal zero.

Limited veterinary services throughout Micronesia and lack of inspection for slaughter activities preclude the possibility of commercial trade of locally produced animal products, including meat, eggs, and milk.

A2.4.3.1 *Animal Product Imports by the U.S. Armed Forces*

The Defense Commissary Agency provides groceries to military personnel, retirees, and their dependents (Melton 2009). All perishable food products procured by the Defense Commissary Agency, including meat, eggs, and fresh dairy products, come into Guam from other parts of the United States. All meat products procured by the Defense Commissary Agency require USDA certification (Melton 2009). Military food comes into the military port where it is inspected by military veterinarians prior to distribution. These food commodities are inspected to assure the product matches the paperwork, and for quantity and approved source. Most of the distributors are based in California.

Currently there are over 200 domestic and foreign sources of food for which the U.S. Army Veterinary Corps must provide inspection services for the military bases on Guam (VETCOM 2009). In 2010, there will be an increase in the number of approved foreign sources. Some of the new suppliers will be located in Vietnam and China. Locally sourced food items are limited to some fruits and vegetables and are provided by less than 20 local retailers or businesses. Animal products are not sourced from local suppliers. Most suppliers of locally procured food products are located in CNMI (Saipan and Rota) (DeCA 2009; Melton 2009).

To accommodate the expected increase in the number of military personnel on Guam, the Defense Commissary Agency expects to increase business operations to 7 days a week and increase the quantities of imported products procured from current suppliers (Melton 2009). It is important to note that the Defense Commissary Agency does not resupply the Carrier Group, which is expected to harbor in Guam for up to 120 days each year. However, the commissary would be available to military personnel disembarking from these ships.

A2.4.3.2 *Animal Byproducts*

The value of hide and skin imports to Guam has increased significantly during the last decade, with most products coming from Europe and Asia (Table A2-29). The highest import value was recorded in 2003 from Colombia. All imports were of treated products. The importation of leather and treated hides, skins, and capes is permitted without restriction (Poole 2009, 9 CFR § 95).

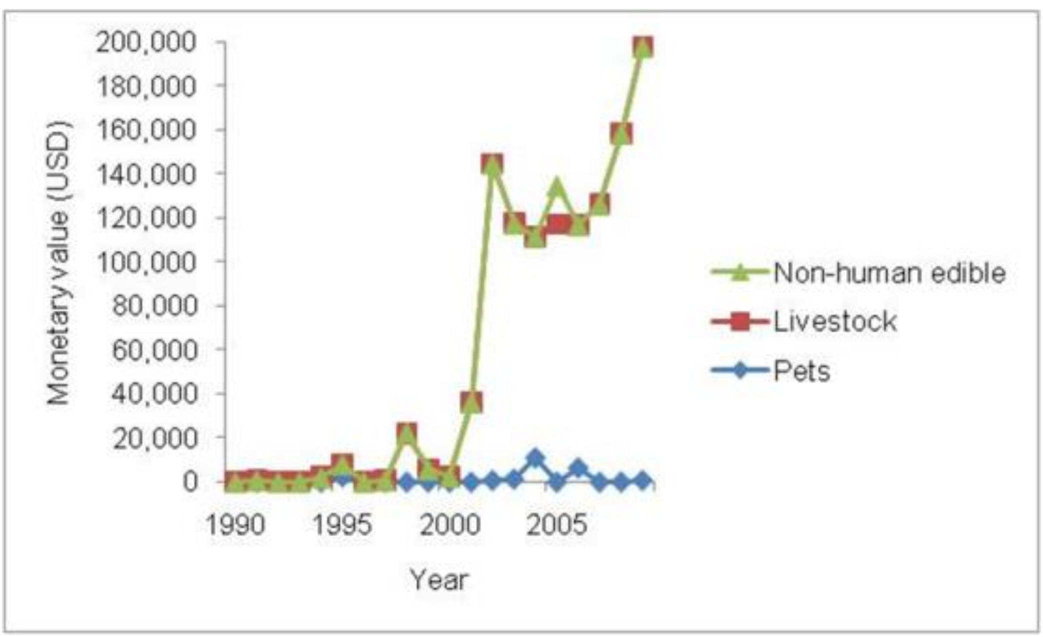
Table A2-29: Value (USD) Foreign Imports of Raw Hides, Skins, and Leathers to Guam, 1997-2008

Continent	Country	Value (USD) of imports, by year					
		1997	1999	2003	2006	2007	2008
Asia	Thailand	0	0	0	0	0	315
	Indonesia	0	622	0	0	0	0
Europe	France	0	0	0	2,281	2,562	0
	Italy	0	0	0	0	0	5,975
	United Kingdom	0	0	0	0	4,496	0
America	Colombia	0	0	101,015	0	0	0
Oceania	Australia	704	0	0	0	0	0
Total		704	622	101,015	2,281	7,058	6,290

Source: Official trade data for partner countries exporting to Guam; GTIS 2010
Data restricted to the years for which importations were recorded; HS codes for the commodities included in this list are 4113 (leather of other animals, no hair); 4114 (chamois leather, patent, laminated, and metallized leather); 4106 (goat or kidskin leather, no hair); 4107 (leather of bovine/equine, no hair). HTSTUS, chapter 41: raw hides, skins, and leather.

Most commercial pet food and livestock feed sold in Guam is produced in the United States and is a domestic import (Poole 2009). Only a small portion is imported from foreign sources. In Figure A2-7, we present the amounts, in U.S. dollars, of animal feed and intermediary products imported to Guam for the last two decades.

Figure A2-7: Annual Value of Imported Animal Feed and Intermediary Products to Guam, 1990-2009



Source: Global Trade Atlas (GTIS 2010)

Most foreign imports of pet food and animal feed during the last 5 years were preparations for animals other than dogs and cats. Commercial food for dogs and cats and animal products unfit for human consumption represent less than 0.1% of the total volume of foreign feed imports from 2000 to 2009, with the exception of 2005 where they accounted for approximately 15%. Foreign imports of dog and cat food started in 2002, but dropped after 2005, reflecting a preference for U.S.-produced feed. Taiwan was the main foreign source for dog and cat food, with one importation each from the Philippines (2003) and Australia (2004).

A2.4.4 Animals and Animal Products: Domestic Production and Exports

The livestock inventory for Guam was obtained from the U.S. Census of Agriculture (2007) (USDA NASS 2009a). Over the last decade, both the number of farms and the total number of livestock have declined. The biggest declines have been in the pig and goat populations with reductions of 70% and 30%, respectively. Cattle and carabaos (water buffalo) are less important as production animals and their populations have always been relatively small (Table A2-30). Swine are the most important production animal for Guam, with around 600 domestic pigs on the island.

Table A2-30: Guam Livestock Inventory, 1998-2007

Livestock	1998		2002		2007		Percent change 1998 to 2007	
	Farms	Animals	Farms	Animals	Farms	Animals	Farms	Animals
Carabaos	4	60	8	97	4	12	0	-80
Cattle	18	(D)[a]	12	154	13	112	-28	N/A[b]
Dairy	1	(D)	2	(D)	1	(D)	0	N/A
Non-dairy	18	150	12	134	13	110	-28	-27
Hogs and pigs	75	2,287	34	675	22	635	-71	-72
Goats	19	179	6	81	10	124	-47	-31
Horses	1	(D)	1	(D)	2	(D)	100	N/A

Source: 2007 Census of Agriculture, 1998 Census of Agriculture
[a] (D): data withheld to avoid disclosing data for individual farms.
[b] N/A indicates data withheld and thus unavailable for calculation.

Semi-feral and feral pigs are distributed island-wide with greater numbers found in the secondary limestone forests of the north and ravine forest of the south (Conry 1988a). The estimated feral pig density in Northwest Field on Andersen AFB was 110 pigs/square kilometer (km^2) in 1987 (0.44 pigs/acre) (Conry 1988a), and had not significantly changed by the late 1990s (Lujan and Wiles 1997).

Approximately 300 wild carabaos inhabit Guam (U.S. Navy 2009f). To control the carabao population, the Navy, in cooperation with the U.S. Geological Survey and the Wildlife Defense Fund, has in the past used a contraceptive drug and supported an adoption program, and the Navy culled 126 animals (U.S. Navy 2009f). Other wildlife species include the Philippine deer. Recent surveys estimate deer density 15.3 deer/km^2 at the Naval Magazine and around the Andersen munitions storage area, respectively (Brooke 2009).

In the Micronesia Region, most poultry farming consists of small commercial or backyard operations (Duguies et al. 2000). Guam limits residents to no more than 20 birds in residential areas (GCA 2010c). Chickens comprise the largest poultry population on Guam (Table A2-31). Most poultry for human consumption is imported from the continental United States (Jimenez et al. 2009). Small flocks of feral chickens are commonly seen on Guam. The number of feral chickens is high, although there are no precise estimates of population size (USDA-APHIS WS 2009).

Table A2-31: Numbers of Poultry and Poultry Farms in Guam, 1998-2007

	1998		2002		2007		Percent change, 1998 to 2007	
Poultry	**Farms**	**Animals**	**Farms**	**Animals**	**Farms**	**Animals**	**Farms**	**Animals**
Chicken hens, 4 months old or older	42	11,540	26	1,046	8	182	-81	-98
Chickens, less than 4 months old	28	2,002	17	1,657	6	272	-79	-86
Roosters and pullets	32	805	17	271	6	79	-81	-90
Fighting roosters	20	445	11	224	2	(D)[a]	-90	N/A[b]
Ducks	25	2,021	11	450	2	(D)	-92	N/A
Pigeons	10	459	1	(D)	1	(D)	-90	N/A
Other poultry	6	252	–	–	–	–	N/A	N/A
Total	163	17,524	83	3,648	25	533	-85	-97

Source: 1998 Census of Agriculture, USDA-NASS 2009a

Note that data referred to as 1998 data were for the 12-month period of July 1, 1997, through June 20, 1998.

[a] (D): data withheld to avoid disclosing data for individual farms. Data indicated by dashes were not reported.

[b] N/A indicates data withheld and thus unavailable for calculation.

No published reports exist on the number of pet bird owners or pet birds on Guam. Based on American Veterinary Medical Association estimates for areas of similar size, there may be approximately 4,000 pet birds on Guam (AVMA 2007). We could not find estimates for the number of pet dogs and cats on Guam, nor could we find estimates of the current size of the stray population. The number of stray dogs and cats on Guam was last estimated in 1967 as between 20,000 and 60,000 (Glosser and Yarnell 1970).

The numbers of livestock and poultry in CNMI in 1998 to 2007 were larger than those in Guam. They are summarized in Table A2-32 and Table A2-33.

Table A2-32: Numbers of Livestock and Livestock Farms in CNMI, 1998-2007

	1998		2002		2007		Percent change, 1998 to 2007	
Livestock	**Farms**	**Animals**	**Farms**	**Animals**	**Farms**	**Animals**	**Farms**	**Animals**
Cattle	29	1,789	55	1,319	63	1,395	117	-22
Dairy	3	14	–[a]	–	7	83	133	493
Non-dairy	28	1,775	55	1,319	62	1,312	121	-26
Hogs and pigs	24	831	61	2,242	62	1,483	158	78
Goats	10	249	15	198	19	276	90	11
Horses	1	(D)[b]	2	(D)	1	(D)	0	N/A[c]

Source: 1998 Census of Agriculture, USDA-NASS 2009a

Note that data referred to as 1998 data were for the 12-month period of July 1, 1997, through June 20, 1998.

[a] Data for dairy were unavailable for the year 2002.

[b] (D): data withheld to avoid disclosing data for individual farms.

[c] N/A indicates data withheld and thus unavailable for calculation.

Table A2-33: Number of Poultry and Poultry Farms in CNMI, 1998-2007

	1998		2002		2007		Percent change, 1998 to 2007	
Poultry	**Farms**	**Animals**	**Farms**	**Animals**	**Farms**	**Animals**	**Farms**	**Animals**
Chicken hens,								
4 months old or older	14	29,409	68	7,027	41	6,381	193	-78
Chickens,								
less than 4 months old	8	4,885	52	4,463	46	3,319	475	-32
Roosters and pullets	5	228	57	884	41	951	720	317
Fighting roosters	6	60	41	898	26	1,025	333	1,608
Ducks	4	460	12	186	10	351	150	-24
Pigeons	4	251	17	711	9	343	125	37
Other poultry	–[a]	–	5	21	3	20	N/A[b]	N/A
Total	41	35,293	252	14,190	176	12,390	329	-65

Source: 1998 Census of Agriculture, USDA-NASS 2009b
Note that data referred to as 1998 data were for the 12-month period of July 1, 1997, through June 20, 1998.
[a] Data for other poultry were not available in the 1998 census.
[b] N/A: data were not available for 1998 and thus not available for calculation of the percent change for the period 1998 to 2007.

A2.5 CONSTRUCTION

A2.5.1 Equipment

Equipment in excess of what is currently available will be needed on Guam to complete construction of new military facilities, civilian infrastructure, and port improvement and expansion. Approximately 50 logistics elements (bulldozers, trucks, and forklifts, for example) will be transported to Guam to support relocation and post-relocation activities (U.S. Navy 2009h) A range of equipment will be imported for commercial port improvements (Table A2-34); some of this equipment is currently available and some will be moved onto Guam.

Table A2-34: Equipment Needed for the Commercial Port Improvements

Type	Quantity
Container quay cranes	4
Top picks	5
Yard tractors	22
Yard chassis	50
Side picks (empties)	6
Break bulk ship cranes	2
Mafi trailers	8
Forklifts, 30 ton	1
Forklifts, 10 ton	1
Forklifts, 7.5 ton	2
Forklifts, 5 ton	6

Source: PB International 2008

Grading equipment, trucks, cranes, and specialty hopper trucks used to move cement will likely be imported to accomplish land clearing and construction goals (U.S. Navy 2009h). Specifically, equipment will be needed for clearing, grading, grubbing, and demolition of existing road pavement, earthwork, and landscaping (U.S. Navy 2009f). In addition to equipment used for clearing land, equipment will also be needed for building construction.

A2.5.2 Housing

Housing demand estimates we consider here represent an approximation of the number of housing units required for the Guam civilian population (U.S. Navy 2009h) under the proposed action. We assume temporary foreign construction workers will live in the dormitory housing provided by contractors and active-duty military personnel will be housed on base or on ships (U.S. Navy 2009i).

The forecast housing demand for the relocation is large. One source suggests that housing demand will significantly increase during the relocation, to 11,893 units by 2014, and decrease to 3,205 units after construction ceases in 2017 (U.S. Navy 2009i). At an earlier date, Guam was thought to have available housing (approximately 2,800 units) to offset some of this anticipated housing demand, which was thought to be sufficient for private-sector housing needs during 2010 (U.S. Navy 2009i). If additional housing is developed, large quantities of excess housing may be realized when the construction phase is completed (U.S. Navy 2009i).

For much of the construction for the proposed relocation, foundations, walls, and roofs would be primarily made from concrete (U.S. Navy 2009h). Concrete batch plants may be established on large construction sites for cast-in-place construction, although precast facilities at additional sites may also be utilized (U.S. Navy 2009h). Some wall construction may use concrete masonry units, which would be produced at an offsite facility and subsequently moved to the construction sites (U.S. Navy 2009h). For family housing (presumably military), one source suggests that the military may favor the use of precast concrete panels that will be transported to Guam as needed for new housing units (PB International 2008).

A2.5.3 Apra Harbor

Approximately 1.1 million cubic yards of dredged material will need to be removed from Apra Harbor to accommodate military vessels (U.S. Navy 2009h). As part of the overall construction process for the harbor, some fill could be mixed with stone that could be used to support the shoreline and the wharf piles (U.S. Navy 2009h). In addition, the Port Authority of Guam recently proposed filling several acres of currently submerged land to provide space for port expansion (U.S. Navy 2009b). Should this expansion project be conducted, the U.S. Navy has a memorandum of agreement with the Port Authority of Guam to provide fill from proposed dredging projects, dependent on material suitability and logistics (U.S. Navy 2009h). Nonetheless, due to concerns over the potential of liability from this material, the preferred use of dredged material has been proposed to have it be stored on DoD lands (U.S. Navy 2009d).

A2.6 MAIL

The U.S. Postal Service (USPS) provides public mail service to the Micronesia Region. Mail sent between the United States, Guam, CNMI, RMI, Palau, and FSM is considered domestic (USPS 2009).

Approximately 95% of Guam’s incoming mail is domestic (Berthoud 2009) originating from Hawai’i and the mainland United States (Ericksen 2010). Several private shipping companies also operate in the Micronesia Region. These companies consider mail traveling between the United States and the Micronesia Region to be international mail.

Guam’s main post office, located in Barrigada, is the service hub for USPS mail in the Micronesia Region. Surface mail and airmail destined for the Micronesia Region are sorted at this facility for Guam, CNMI, RMI, Palau, and FSM. The majority of international mail destined for Guam arrives from Japan and the Philippines. All domestic mail from the mainland United States and most international mail destined for the Micronesia Region is processed in Honolulu, Hawai’i, before being sent to Guam (Ericksen 2010).

Military personnel stationed in Guam receive mail through one of the four USPS post office branches that are located within military installations (Law-Byerly 2010a). Military mail is sent to Army Post Office (APO) or Fleet Post Office (FPO) addresses through the USPS distribution network and through the Military Postal Service Agency (MPSA) 2010).

In 2008, approximately 1,104 metric tons (2,433,903 pounds) and 4,111 metric tons (9,063,204 pounds) of mail were sent from and received in Guam, respectively (BSP 2009a). Approximately 20,000 to 30,000 packages arrive in Guam each week, and the majority of parcels are addressed to businesses in Guam (Ericksen 2010). The USPS does not keep records of mail volumes for any of the other locations in the Micronesia Region (USPS 2010a), but these locations likely receive and send much smaller volumes of mail. For example, RMI received 0.238 metric tons (525 pounds) of mail during the 2008 fiscal year (Marshall Islands Journal 2008). The APO/FPO addresses in Okinawa currently receive about 1,587.5 metric tons (3,499,838 pounds) of mail total per year from the United States and Japan (Berthoud 2009). Mail volumes on Guam are expected to greatly increase as a result of the military relocation; an additional 18,000 packages per week, or 900,000 packages per year, may be delivered to the Naval Base alone (Ericksen 2010).

A2.7 REGULATED GARBAGE AND SOLID WASTE

To protect against the introduction of exotic animal and plant pests and diseases, importation of garbage from all foreign countries except Canada into the United States is prohibited. Movement of garbage from Hawai’i, Puerto Rico, American Samoa, CNMI, FSM, Guam, the U.S. Virgin Islands, RMI, and Palau to any other state is prohibited with few exceptions. As discussed below, the term “garbage” refers to all waste material that is derived in whole or in part from fruits, vegetables, meats, or other plant or animal (including poultry) material, and other refuse that has been associated with any such material. The term “agricultural waste” refers to byproducts generated by the rearing of animals and the production and harvest of crops or trees. Animal waste, a large component of agricultural waste, includes waste (feed waste, bedding and litter, and feedlot and paddock runoff, for example) from livestock, dairy, and other animal-related agricultural and farming practices (9 CFR § 94).

Garbage is regulated if it is on or removed from a conveyance that has been in any port outside the United States and Canada within the previous 2 years. Garbage generated during international or interstate transit including food scraps, table refuse, galley refuse, food wrappers or packaging materials, and other waste material from stores, food preparation areas, passengers' or crews' quarters, or dining rooms, is regulated; this also includes meals and other food that were available for consumption by passengers and crew on an aircraft but were not consumed (9 CFR § 94).

All regulated garbage must be contained in tight, covered, leak-proof receptacles during storage on board a conveyance while in the territorial waters, or while otherwise within the territory of the United States. Per Presidential Proclamation 5928 (1988), territorial seas extend 12 nautical miles offshore, while the Submerged Lands Act places state property boundaries 3 miles offshore for most states. Given the unique relationship between the United States, Guam, and countries within the Micronesia Region, alternate interpretation of these different boundaries may occur. If unloaded, regulated garbage must be moved under the direction of an inspector to an approved facility for incineration, sterilization, or grinding into an approved sewage system. Any person or entity engaged in the business of handling or disposing of regulated garbage must first enter into a compliance agreement with APHIS unless the regulated garbage is handled under the direct supervision of an APHIS inspector (9 CFR § 94).

Garbage management practices can affect the likelihood that pests in waste will escape into the environment, or that the waste will serve as a source of disease transmission (Novak 1995; Gale 2004; Auclair et al. 2005; Gould and Huamán Maldonado 2006; McCullough et al. 2007; Wichuk and McCartney 2007; Graiver et al. 2009; Jacobson et al. 2009). Garbage management options at sea include disposal at sea, incineration, shredding, compaction, and storage for disposal on land (Nawadra et al. 2002). Within the Micronesia Region, port demand for waste reception facilities is highest in Guam (Nawadra et al. 2002). Most of this demand is accounted for by domestic inter-island passenger and cargo vessels, tourist boats, and commercial fishing boats. Waste, including regulated garbage, from large merchant vessels is generally not accepted in Guam, and the commercial port generally does not accept waste from international vessels. At the commercial port, commercial marinas, and fisheries wharves in Guam, waste is collected by private waste collection companies under compliance agreements with APHIS and is subject to Port Authority and government policies and regulations. In general in the Micronesia Region, waste from international vessels that contains food waste is treated as quarantine garbage. In Guam, regulated garbage and rejected cargo seized from international vessels are incinerated.

Solid waste generated on land can be broadly categorized as municipal, commercial, or industrial. Detailed, reliable data regarding the composition of each of these waste streams in the Micronesia Region, and waste generation rates for each stream, are not available. However, domestic solid waste generated on Pacific islands, including islands of the Micronesia Region, has been estimated to include large proportions of packaging waste, food waste, and garden waste (WHO 1996). Municipal, commercial, and industrial waste in Guam is disposed of at Ordot Dump, an unlined, uncapped landfill that is scheduled to be closed in 2011 (GSWRIC 2010). A new landfill is under construction. The civilian solid waste management system includes waste collection services, three waste transfer stations, and two hardfills for disposal of demolition debris (U.S. Navy 2010a). Household food waste is fed to pigs and chickens, or used as fertilizer (Nawadra et al. 2002). Quarantine and hospital waste is incinerated (Nawadra et al. 2002).

DoD waste is disposed of at the Navy Sanitary Landfill located on the Navy base, or at the landfill located at Andersen AFB (U.S. Navy 2010a). At both of these landfills, waste is buried daily. Wood, such as crates, and other green waste at the Andersen AFB landfill is shredded; the shredded waste is used for landscaping on and off base. Waste from Navy ships berthed at Apra Harbor is disposed of at the Navy Sanitary Landfill.

The U.S. Navy is responsible for all waste reception and disposal at the naval port. Commercial garbage skips are used for waste reception, and the naval facility has its own landfill for all garbage. All items must be disposed of in accordance with U.S. federal laws (7 CFR § 330.400). Garbage is separated for recycling at the ports and all items for recycling are stored separately at the military landfill site (located on the base) and, in general, are shipped off island on military vessels. Oil, metals, plastics, batteries, and paper wastes are recycled. Toxic wastes are stored while awaiting removal from the island.

A3 PLANT PESTS

This section of Micronesian Biosecurity Plan—Methods and Strategies to Manage Invasive Species Impacts to Agriculture, Natural Resources, and Human Health and Safety Project—was prepared by APHIS-PPQ, Center for Plant Health Science and Technology; APHIS Policy and Program Development, Environmental and Risk Analysis Services; and North Carolina State University. The suggested citation for this section is: Meissner, H., R. Ahern, T. Culliney, A. Lemay, A. Hiser, L. Kohl, O. Lenahan, A. Suazo, and Y. Takeuchi. 2010. Plant pests. In Terrestrial plant and animal health risks associated with the U.S. military relocation in the Micronesia Region. United States Department of Agriculture, Animal and Plant Health Inspection Service. Washington, D.C.

A3.1 SUMMARY

Our objective was to evaluate the risk of exotic plant pest introduction into the Micronesia Region as a result of the planned military relocation on Guam, identify safeguarding gaps, and provide suggestions for improved safeguarding. We evaluated pest risk based on pathways of introduction. The pathways discussed are: people; containers, conveyances, and equipment; wood packaging material (WPM); construction materials; plant propagative material; mail; agricultural commodity imports; and garbage.

Our evaluation is qualitative. Due to an overall lack of quantitative data, we did not consider it scientifically justifiable to rate risk, even in semi-quantitative terms (e.g., by assigning “high”, “medium”, and “low” ratings). Such ratings are only meaningful when they are clearly defined and assigned with legitimate confidence. If these conditions cannot be met, such ratings are likely to mislead the reader and promote poor decision-making.

We do not expect the military relocation to lead to a fundamental change in the types of pests introduced into the Micronesia Region. Similar types of pests to those that currently enter the Region could potentialy be introduced more frequently and may thus establish sooner than they would have otherwise.

A3.2 INTRODUCTION

The introduction of exotic plant pests can have enormous economic and ecological consequences. Exotic plant pests may destroy crops, change landscapes, and drive native species to extinction. Not only agricultural production but also forestry, tourism, and even local climate can be impacted by exotic species. Most exotic species introductions have been facilitated by humans, either inadvertently or deliberately (Baker 1986b; Mack et al. 2000; Ruiz et al. 2000; Mack and Lonsdale 2001; Naylor et al. 2001; Reichard and White 2001; Fuller 2003; Kraus 2003).

Agriculture is not a particularly large economic sector in Guam or the rest of the Micronesia Region, but many subsistence farmers rely on crop production and various plant species have great cultural value. Most notable among these plants are coconut, numerous varieties of banana, taro, papaya, avocado, breadfruit, and mango. The introduction of pests affecting any of these plant species may have a serious impact on the people and the culture of the Region.

Guam has undergone extensive development, particularly over the last 60 years. Numerous exotic species have been introduced over the years and have taken their toll on Guam's native fauna and flora. The rest of the Micronesia Region, however, possesses a more intact natural environment, with numerous indigenous plant and animal species existing on many of the islands. Guam serves as a gateway to the Micronesia Region, and any exotic species introduced into Guam may from there reach other parts of the Region.

The objective of this section was to assess the risk of exotic plant pest introductions into the Micronesia Region associated with the planned military relocation on Guam. In the context of this section, we define plant pests as all terrestrial invertebrates, plant pathogens, and weeds that affect plants of economic, ecological, or cultural significance. Thus, plant pests include arthropods, mollusks, nematodes, fungi, viruses, viroids, bacteria, phytoplasmas, and weeds.

Approach

This is a qualitative risk assessment, organized by pathways of introduction through which plant pests may enter the Micronesia Region. While it was not feasible to address every possible pathway, we discuss those of likely importance, as identified through expert solicitation and preliminary literature research. The pathways discussed are movement of people; containers, conveyances, and equipment; WPM; construction materials; plant propagative material; mail; agricultural commodity imports; and garbage. Soil contamination (on containers, vehicles, etc.), while a very important and common means of spreading plant pests, was not considered an independent pathway, but was instead discussed in the context of the other pathways. For each of these pathways, we describe pest risk in general terms and then evaluate the additional pest risk created as a direct or indirect result of the military relocation (both during and after the relocation activities).

For the evaluation of pest risk, we used information from a variety of sources, including published scientific literature, public and government-internal databases, expert interviews, and our personal observations during site visits to the Micronesia Region. In general, relevant data were scarce, especially data specific to the Micronesia Region and data suitable for quantitative analysis. Because of this lack of information, we did not consider it meaningful to formally employ a quantitative or semi-quantitative rating system to categorize any components of pest risk (likelihood of introduction, likelihood of establishment, severity of impact).

Based on our assessment of pest risk and biosecurity challenges associated with each pathway, we offer a list of suggested safeguarding measures. The purpose of these suggestions is not to provide detailed operational guidance but, rather, to contribute insights as a basis for developing a comprehensive biosecurity plan.

Due to the large number of plant pests potentially threatening the Micronesia Region, it was not feasible to discuss each individual pest in detail. Instead, we present an annotated list of potential pest threats (Section A7). While we identified the most obvious potential invaders, it is important to note that the universe of plant pests that may enter the Micronesia Region is largely unknown.

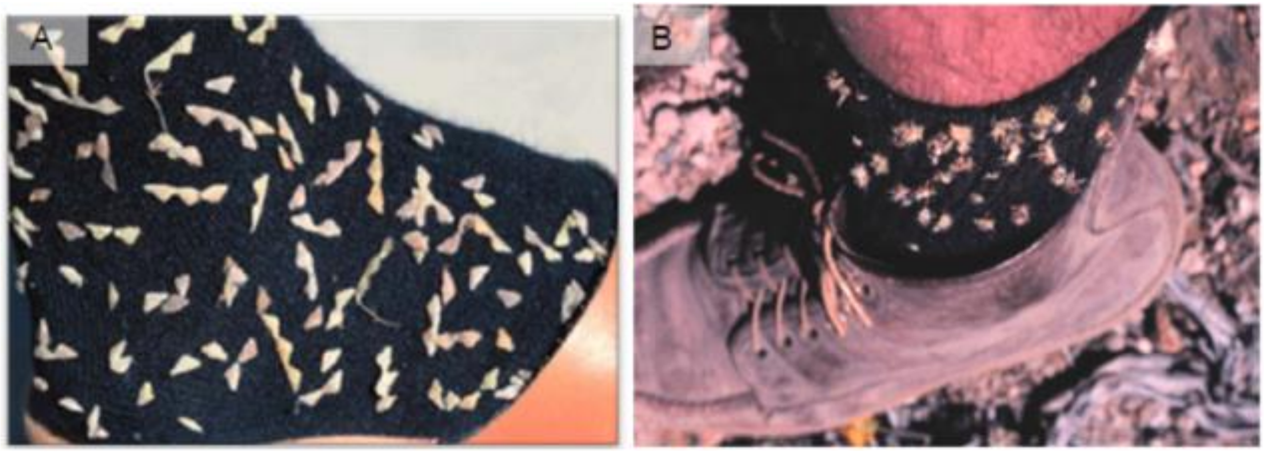
A3.3 RISK ASSESSMENT

A3.3.1 Pathway: People

The likelihood of pest introduction increases with the number of visitors to a location (Lonsdale 1999). People may spread plant pests by unknowingly carrying pests on themselves, their clothing, or their shoes; by inadvertently transporting pests on objects such as household items, handicrafts, or agricultural products; or by moving pests deliberately. A large number of people will enter the Micronesia Region as a result of the proposed military relocation (Figure A3-1), increasing the frequency of plant pest introductions. Specifically, DoD estimates that the number of people on Guam from off-island will increase eight-fold to almost 80,000 by 2014 . While some of these people will leave again after the relocation phase, an estimated 33,000 will remain on the island permanently (Table A3-1). Because the majority of these people will be military and their dependents, there will be a turnover of people approximately every 2 years. This turnover has a potential multiplying effect on pest pressure.

Plant pathogens are easily transported on clothing and boots (Wellings et al. 1987; Cushman and Meentemeyer 2008), where they can remain viable for several months (Norman and Strandberg 1997). Young et al. (2007) reported a large number of fungi and bacteria in soil on air passengers' shoes. Soil on shoes can facilitate the spread of nematodes (Boag 1985), mollusks (Cowie 2001), and weeds (DiTomaso 2000; Wichmann et al. 2009). Many plant seeds are adapted to adhere to the fur of animals (Bullock and Primack 1977); these adaptations also facilitate adherence to clothing (Vibrans 1999) (Figure A3-1). Whinam et al. (2005) list 981 propagules (seeds and fruits) and five moss shoots representing 90 plant species from 15 families that were transported to overseas locations on the clothing and equipment of 44 Australian expeditioners; clothing and outdoor items with Velcro® fasteners were identified as the highest risk items. Mount and Pickering (2009) also found seeds adhering to uncovered socks, boots, and laces. Some of the most aggressive introduced grasses on Guam, *Cenchrus echinatus*, *C. browneri*, *Paspalum conjugatum*, and *Triumfetta semitriloba* (Space and Falanruw 1999; Motooka et al. 2003), are thought to have spread throughout Guam and CNMI on military personnel' clothing during World War II (Fosberg 1960).

Figure A3-1: Weed Seeds Found on Airline Passengers Entering Hawai'i from New Zealand (A, B)



Photos courtesy of USDA-APHIS-PPQ

Military training exercises, as well as popular outdoor activities like hiking and bicycling, facilitate pest spread by bringing people into close contact with the natural environment. Military training exercises are of special concern as they often cause movement of relatively large numbers of people over extensive areas, involve frequent changes of location, and extend over relatively long time periods. In addition, military exercises tend to create large areas of disturbed land, which may facilitate the establishment of introduced species. Studies of disturbed military training sites have shown that exotic plant species can rapidly colonize these areas (Lozon and MacIsaac 1997; Hirst et al. 2003; Leis et al. 2005; Yager et al. 2009). Space et al. (2000) list 69 species of invasive plants that are present on Guam but not on Tinian. Tinian is the main site for planned military exercises, and propagules of these plants could potentially be carried there by military personnel.

People often transport plant pests or plant materials deliberately,although usually without being aware of the potential biological consequences of their actions. For example, seeds, plants, and flower bulbs are frequently intercepted in airline passenger baggage (Liebhold et al. 2006; McCullough et al. 2006; USDA-APHIS-PPQ 2010a). These items may themselves be pests (if they are invasive plants), or they may be infested with pests. Table A3-1 lists quarantine pests intercepted from the baggage of commercial airline passengers traveling to Hawai'i from Japan, South Korea, and the Philippines, among the main origins of visitors to Guam and CNMI. Table A3-2 lists interceptions from the baggage of airline passengers traveling to Hawai'i from within the Micronesia Region (USDA-APHIS-PPQ 2010a), demonstrating the possibility of pest introductions to Hawai'i from Micronesia. Among the intercepted pests were organisms that would almost certainly have severe negative impacts if introduced into the Micronesia Region, such as certain ants and fruit flies. Agricultural materials have also been found in the duffle bags of military personnel traveling to Guam (Jimenez et al. 2009).

Table A3-1: Pest Interceptions From Airline Passenger Baggage of Visitors Traveling From Japan, South Korea, and the Philippines to Honolulu, Hawai'i in 2009

Origin	Plant inspected	Plant part	Associated pest	Pest type
Japan	*Brassica* species	leaves	Thysanoptera, species of	thrips
Japan	*Citrus* sp.	fruit	*Aonidiella* sp.	scale insect
Japan	*Citrus reticulata*	fruit	*Unaspis yanonensis*	scale insect
Japan	*Diospyros kaki*	fruit	Aphididae, species of	aphid
Japan	*Diospyros kaki*	fruit	*Tetranychus* sp.	mite
Japan	*Diospyros kaki*	fruit	Pyralidae, species of	moth
Japan	*Diospyros kaki*	fruit	Aleyrodidae, species of	whitefly
Japan	*Diospyros kaki*	fruit	Pseudococcidae, species of	scale insect
Japan	*Spinacia oleracea*	leaves	Coleoptera, species of	beetle
Japan	*Pyrus pyrifolia*	fruit	Pseudococcidae, species of	scale insect
Japan	*Spinacia oleracea*	leaves	Thysanoptera, species of	thrips
Japan	*Zea mays*		*Thrips* sp.	thrips
Philippines	*Adenium* sp.	propagative material	Coccidae, species of	scale insect
Philippines	*Allium sativum*	bulb	Acari, species of	mite
Philippines	*Allium sativum*	bulb	*Frankliniella* sp.	thrips
Philippines	brooms	dried leaves	*Phoma* sp.	fungus
Philippines	brooms	dried leaves	*Pestalotiopsis* sp.	fungus
Philippines	*Citrus maxima*	fruit	*Unaspis* sp.	scale insect
Philippines	*Citrus reticulata*	fruit	Diaspididae, species of	scale insect
Philippines	*Euphorbia* sp.	propagative material	Phlaeothripidae, species of	thrips
Philippines	*Euphorbia* sp.	propagative material	Prostigmata, species of	mite
Philippines	*Euphorbia* sp.	propagative material	Cicadellidae, species of	leafhopper
Philippines	*Ipomoea aquatica*	seed	*Ipomoea aquatica*	weed
Philippines	*Ipomoea batatas*	tuber	Curculionidae, species of	weevil
Philippines	*Lansium domesticum*	fruit	Thysanoptera, species of	thrips
Philippines	*Lansium domesticum*	fruit	Pseudococcidae, species of	scale insect
Philippines	*Lansium domesticum*	fruit	Diptera, species of	fly
Philippines	*Lansium domesticum*	fruit	Heteroptera, species of	insect
Philippines	*Lansium domesticum*	fruit	*Phomopsis* sp.	fungus
Philippines	*Lansium domesticum*	fruit	Bostrichidae, species of	beetle
Philippines	*Mangifera indica*	fruit	Diaspididae, species of	scale insect
Philippines	*Manilkara zapota*	fruit	Diaspididae, species of	scale insect
Philippines	*Momordica charantia*	fruit	*Bactrocera cucurbitae*	fruit fly
Philippines	*Momordica cochinchinensis*	fruit	Tephritidae, species of	fruit fly
Philippines	*Musa acuminata*	fruit	*Dysmicoccus* sp.	scale insect
Philippines	*Nephelium* sp.		Formicidae, species of	ant
Philippines	*Pachyrhizus erosus*	leaves	Formicidae, species of	ant
Philippines	*Pandanus* sp.	leaves	Pseudococcidae, species of	scale insect
Philippines	*Pandanus* sp.	leaves	Thysanoptera, species of	thrips
Philippines	*Pandanus* sp.	leaves	Formicidae, species of	ant
Philippines	*Psidium guajava*	fruit	Tephritidae, species of	fruit fly

Origin	Plant inspected	Plant part	Associated pest	Pest type
Philippines	*Solanum melongena*	fruit	*Frankliniella* sp.	thrips
South Korea	*Artemisia* sp.	leaves	*Thrips* sp.	thrips
South Korea	*Artemisia* sp.	leaves	Diptera, species of	fly
South Korea	*Castanea sativa*	seeds	*Cydia* sp.	moth
South Korea	*Castanea sativa*	seeds	*Curculio* sp.	weevil

Source: USDA-APHIS-PPQ 2010a

Table A3-2: Pest Interceptions From Airline Passenger Baggage of Visitors Traveling From Within the Micronesia Region to Honolulu, Hawai'i in 2009

Origin	Plant inspected	Plant part	Associated pest	Pest type
Guam	*Areca catechu*	fruit	*Frankliniella* sp.	thrips
Guam	*Areca catechu*	fruit	Formicidae, species of	ant
Guam	*Citrus aurantifolia*	fruit	Diaspididae, species of	scale insect
CNMI	*Areca catechu*	fruit	Pseudococcidae, species of	scale insect
CNMI	*Capsicum* sp.	fruit	Thysanoptera, species of	thrips
CNMI	*Capsicum* sp.	fruit	Diptera, species of	fly
FSM	*Anthurium* sp.	propagative material	*Vinsonia stellifera*	scale insect
FSM	*Areca catechu*	fruit	Aphididae, species of	aphid
FSM	*Areca catechu*	fruit	Pseudococcidae, species of	scale insect
FSM	*Areca catechu*	fruit	Formicidae, species of	ant
FSM	*Areca catechu*	fruit	*Frankliniella* sp.	thrips
FSM	*Areca catechu*	fruit	Diaspididae, species of	scale insect
FSM	*Areca catechu*	fruit	*Fiorinia* sp.	scale insect
FSM	*Areca catechu*	fruit	*Pinnaspis* sp.	scale insect
FSM	*Cananga odorata*	flower	Pseudococcidae, species of	scale insect
FSM	*Cananga odorata*	flower	Formicidae, species of	ant
FSM	*Cananga odorata*	flower	Heteroptera, species of	insect
FSM	*Capsicum* sp.	fruit	Thysanoptera, species of	thrips
FSM	*Capsicum* sp.	fruit	Diptera, species of	fly
FSM	*Citrus* sp.	fruit	Diaspididae, species of	scale insect
FSM	*Citrus* sp.	fruit	*Lepidosaphes* sp.	scale insect
FSM	*Citrus* sp.	fruit	*Pinnaspis* sp.	scale insect
FSM	*Cocos nucifera*	leaves	*Phyllosticta* sp.	fungus
FSM	*Ixora* sp.		Phlaeothripidae, species of	thrips
FSM	*Ixora* sp.		Aphididae, species of	aphid
FSM	*Plumeria* sp.		*Thrips* sp.	thrips
FSM	*Piper betle*	leaves	Pseudococcidae, species of	scale insect
FSM	*Piper betle*	leaves	Formicidae, species of	ant
FSM	*Tabernaemontana* sp.		Thysanoptera, species of	thrips
FSM	Unidentified plant	leaves	Thysanoptera, species of	thrips
FSM	Unidentified plant	flower	Pseudococcidae, species of	scale insect
RMI	*Citrus* sp.	fruit	Diaspididae, species of	scale insect
RMI	*Cocos nucifera*	fruit	Diaspididae, species of	scale insect
RMI	*Pandanus* sp.	propagative material	Tineidae, species of	moth
RMI	Unidentified plant	leaves	Thysanoptera, species of	thrips
Palau	*Areca catechu*	fruit	Thysanoptera, species of	thrips

Origin	Plant inspected	Plant part	Associated pest	Pest type
Palau	*Piper betle*	leaves	Lepidoptera, species of	moth/butterfly
Palau	Unidentified plant	leaves	Thripidae, species of	thrips
			Thysanoptera, species of	thrips

Source: USDA-APHIS-PPQ 2010a

People moving to new areas often bring plants with them to provide a sense of familiarity and home. Plants and other organisms may also be brought along to maintain a customary diet (McNeely 2001). In countries such as Japan and the Philippines, insects are commonly reared as pets (Kabuto 1997; Endo 1998) and may be very valuable. For example, four live giant rhinoceros beetles, *Trypoxylus dichotomus* (Coleoptera: Scarabaeidae) intercepted in Portland, Oregon, in passenger baggage from Japan (Figure A3-2) were valued at about U.S.$2,500 each (Nelson 2010).

Figure A3-2: Live Giant Rhinoceros Beetles, *Trypoxylus dichotomus* (Coleoptera: Scarabaeidae) Intercepted in Portland, Oregon, in Passenger Baggage from Japan

Source: Customs and Border Protection

Personal effects that will be brought to Guam by the military and the civilian workforce may be contaminated with pests or pest-containing soil, especially items that have been stored or used outdoors, for example barbeque grills, outdoor furniture, bicycles, boats, cars, trailers, motorcycles, outdoor play sets, or yard decorations (USDA-APHIS 2007a). In addition, wooden objects such as outdoor furniture can harbor wood-boring pests (Mauldin 1984; Brown et al. 2004), which easily escape detection and cannot be removed by standard sanitation procedures, such as power washing.

Handicrafts such as baskets, floor mats, figurines, and hats, made from natural materials (e.g., coconut and Pandanus fibers or local woods) may be infested with pests. Wood-boring pests have been found in decorative wood carvings (Haugen and Lede 2001), and the red palm mite, *Raoiella indica* (Acari: Tenuipalpidae), was brought from the Dominican Republic to Florida on palm frond hats purchased by cruise ship passengers (Apgar 2007; Welbourn 2009). Hats are of particular concern because people may wear them during their travels and thus may spread plant pests between locations.

The proposed military relocation in Guam will move an estimated 11,000 permanent military personnel along with 10,000 dependents to Guam by 2014 (U.S. Navy 2009h) . These people will arrive on Guam with their baggage and household items, including outdoor equipment and vehicles (cars, motorbikes, etc.). Up to 8,164 kg (18,000 pounds) of household items are allowed per person (DoD 2010b). The associated potential for introducing pests is significant. Standard practice in military relocations is to allow military personnel to complete their assignment in their current location, and then have their replacement report to the new duty station (Fiedler 2010). This means there will not be a mass movement of military personnel from Okinawa to Guam; rather, most military personnel to be stationed on Guam will move there from the United States (including Hawai'i). Therefore, any pests brought along in the baggage or personal effects of arriving military personnel will more likely originate in the United States than in Japan or other foreign countries.

DoD currently relies on individual military personnel to clean and inspect their own clothing and personal property in order to prevent the introduction of plant pests (U.S. Navy 2009j; DoD 2010f; Houston 2010). While military personnel receive some information about the risks of moving plant pests into Guam and around the Micronesia Region, this information may not be sufficient. For example, military personnel do not generally receive training in pest detection, and thus may not know how to search for pests, nor to recognize pests if found. A DoD guide for military personnel relocating to Guam does not make any mention of plant pests (DoD 2010b). In addition, no oversight, compliance checks, or quality control processes seem to exist to ensure that military personnel are following guidelines and that procedures are effective in removing pests (Meissner et al. 2010).

GCQA inspects some portion of civilian and military passenger baggage for prohibited items, including agricultural items; however, opening and searching every bag is not feasible, and functional x-ray machines are not always available to screen passenger baggage (Meissner et al. 2010). In addition, as for similar agencies elsewhere, drugs and weapons take priority over agricultural threats for GCQA.

Expected impact of military relocation. Apart from the additional military personnel stationed on Guam, military exercises will lead to movement of military personnel within the Micronesia Region and a temporary influx of foreign and U.S. Armed Forces for joint operations. Approximately 200 to 400 Marines are expected to train for 1 week at a time, 12 times per year on the island of Tinian (CNMI) (U.S. Navy 2009g). In addition, the Japan Self Defense Forces plan to send 500 to 3,000 military personnel to train on Guam, Tinian, and Pagan for 1 to 4 weeks, one to six times per year (U.S. Navy 2009c). While USDA-APHIS has in the past set up cleaning operations on Tinian for military equipment returning to Guam, no comparable phytosanitary efforts have been carried out for equipment moving from Guam to Tinian or other locations within the Micronesia Region.

In addition to military personnel arriving on Guam, approximately 20,000 temporary workers are expected to enter Guam for employment in construction (U.S. Navy 2009h), and approximately 17,000 workers will be hired for jobs in other fields such as healthcare (GMANews.TV 2009; U.S. Navy 2009h). More than 20,000 dependents are expected to accompany these workers. The majority of the workers will likely come from the Philippines, with smaller percentages coming from other Asian countries, from elsewhere in the United States, and from within the Micronesia Region (U.S. Navy 2009h).

While these people are unlikely to bring large amounts of personal belongings, there are few safeguards in place to ensure that what they do bring is free of pests. An overall elevated demand for specialty ethnic items has the potential to increase the amount of plants and plant pests smuggled into the Micronesia Region. Additionally, some of the temporary workers moving to Guam from within the Micronesia Region may travel home regularly to visit family and friends, potentially facilitating the spread of plant pests throughout the Micronesia Region. No processes are in place for educating incoming workers about biosecurity and the potential impacts of introducing plant pests (Martinez 2010).

The effects the military relocation will have on tourism are unknown. Currently, Guam receives more than a million tourists annually, mainly families and young couples from Japan. While the majority of the temporary workforce on Guam would not be very likely to engage in tourist activities outside of Guam, a small part of the workforce may travel around the Micronesia Region or visit Hawai'i on the way to the U.S. mainland. In addition, military personnel stationed on Guam may be visited by friends and family who would not otherwise travel to Micronesia. At the same time, it is possible that an increased military presence on Guam may make Guam less attractive to its traditional visitors.

A3.3.2 Pathway: Conveyances, Containers, and Equipment

Many types of organisms can be inadvertently transported as contaminating pests on or in conveyances (aircraft, maritime vessels, personal vehicles) and shipping containers, as well as on equipment and machinery. Plant pests may get onto or into a conveyance, container, or piece of equipment either accidentally (e.g., weed seeds blown in by the wind) or because they are attracted by certain conditions. For example, flying insects may be attracted by lights during nighttime loading (Caton et al. 2006; Fowler et al. 2008), and arthropods or mollusks may find shelter on or in cargo containers. In addition, pests that were originally associated with an agricultural commodity may be left behind in a container or conveyance after unloading. Conveyances and containers tend to be relatively unmitigated and unregulated as pathways for plant pests, in part because they are notoriously difficult to inspect and to clean. Guam is the major hub for cargo and passengers entering and leaving the Micronesia Region. Most cargo arrives from the U.S. mainland and Hawai'i, China, Korea, and Japan.

A3.3.2.1 *Pests on Aircraft*

Live pests have been intercepted in aircraft cabins and cargo holds (Evans et al. 1963; Rainwater 1963; Russell et al. 1984; Goh et al. 1985). Aircraft cargo holds may be cooled to accommodate perishable cargo, such as fruits, vegetables, and live plants, but these temperatures are not lethal to most plant pests. Russell (1987) reported very high survival rates of mosquitoes, *Culex quinquefasciatus* (Diptera: Culicidae); house flies, *Musca domestica* (Diptera: Muscidae); and flour beetles, *Tribolium confusum* (Coleoptera: Tenebrionidae) in unpressurized wheel bays of a Boeing 747B at altitudes greater than 10,500 meters. Caton (2003) reported an average of two flights daily arriving in Miami from Central and South America with quarantine pests in their cargo holds, estimating that one pest species per year may become established in Florida as a result of this pathway. A large proportion of the interceptions were species attracted to light. Dobbs and Brodel (2004) estimated that pest contamination occurs in about 10% of cargo aircraft arriving at Miami International Airport (MIA), Florida; this percentage accounts for live pests found in aircraft cockpits, galleys, compartments, and the surfaces of cargo. Between 2006 and 2009, U.S. Customs and Border Protection (CBP) officers intercepted almost 1,500 live insects from 82 taxonomic families from aircraft cargo stores, quarters, or holds, demonstrating the large variety of pests that are associated with this pathway (USDA-APHIS-PPQ 2010a).

A3.3.2.2 *Pests on Maritime Vessels*

Ships are not usually inspected for pest organisms; thus, most pest organisms present on ships remain undetected. Nevertheless, close to 1,000 live plant pests, mostly insects, were intercepted from ships at U.S. ports of entry between 2006 and 2009 (USDA-APHIS-PPQ 2010a). We do not know how many ship inspections were carried out during this time, nor how they were performed. In July of 2010, a ship arriving in Guam from Korea with cargo supporting the military relocation was found to be infested with thousands of exotic spiders belonging to at least two different species (University of Guam ANRP 2010).

While data regarding the prevalence of plant pests on maritime vessels are very limited, several characteristics of maritime vessels make it likely that they play a role in spreading plant pests: maritime vessels often move or anchor close to shore, allowing an exchange between ship and land of flying insects and organisms blown in the wind; maritime vessels may be loaded with huge amounts of diverse cargo, presenting ample opportunity for plant pests to enter or leave the ship; movement of crew and passengers between vessel and land provides a pathway for pests; and, because of the immense size and complex shape of maritime vessels, pests are very difficult or impossible to detect.

A3.3.2.3 *Pests on Shipping Containers*

Like conveyances, shipping containers may harbor plant pests. The type of shipping container used depends on the mode of transportation. Standard 20- and 40-foot metal containers (Figure A3-3) are used in maritime shipping and have a long documented history of carrying pests. Air cargo containers can be specialized to fit a particular type of aircraft and are typically smaller (Figure A3-4); however, some aircraft can accommodate standard 20- or 40-foot containers.

Figure A3-3: Shipping Containers Stored at Maritime Ports in Kosrae (A, B) and in Palau (C)

Containers stored on bare ground and weeds growing close by increase the chance of contamination with plant pests.

Figure A3-4: Air Cargo Containers

In a survey of the exterior sides (not the top or bottom) of maritime containers arriving in New Zealand, soil was the main external contaminant and was found on about 4% of loaded and 1% of empty containers (Border Management Group 2003). Gadgil et al. (2000) also inspected the exterior of maritime containers arriving in New Zealand. The amount of contaminating soil found was low (10 to 50 grams [0.3 to 2 ounces]) in 63%, medium (50 to 500 grams [2 to 18 ounces]) in 29%, and large (greater than 500 grams [18 ounces]) in 8% of all contaminated containers. Fungi of taxa containing plant pathogens were isolated from 83%, and nematodes were isolated from 81% of the soil samples. Foliage and woody material were also common contaminants. Overall, quarantinable contaminants (contaminants containing plant pests, plant parasitic nematodes, or fungi of genera that contain plant pathogens) were found on 23% of the containers. Containers from the Pacific Islands had one of the highest contamination rates (47.5%); containers from Korea, Taiwan, and Japan had a contamination rate of 13.7%. The authors concluded that the nature and frequency of contaminants on shipping containers represents a pest risk to New Zealand.

Contamination of the interior (soil, seeds, live arthropods, plant material) was found in approximately 21% of loaded and 18% of empty sea cargo containers; live insects were present in 15% of loaded and 7% of empty containers (Border Management Group 2003). In another study, plant pathogenic bacteria were isolated from soil on sea cargo containers entering New Zealand (Godfrey and Marshall 2002).

In contrast to sea cargo containers, only about 1% of air cargo containers arriving in New Zealand were contaminated on the outside. However, 24% of these containers had contaminants on the inside, mostly fresh plant materials such as leaves and twigs. Potentially quarantinable organisms (live fungi belonging to genera that include plant pathogens, or live insects) were found in 13% of the containers. The detection of fresh plant material containing pests, coupled with the fact that newly introduced pests have been found in close vicinity to airport sheds, led the authors to conclude that air cargo containers may provide a pathway by which exotic organisms can become established (Gadgil et al. 2002).

Between 2006 and 2009, insects belonging to 14 families, mollusks belonging to three families, and weeds belonging to two families were intercepted on or in cargo containers entering the United States. The refrigeration units on temperature-controlled containers are frequently contaminated with weed seeds. For example, seeds of cogongrass, *Imperata cylindrica* (Poaeceae), an introduced invasive throughout much of the Micronesia Region, have been intercepted on the refrigeration components of containers entering the United States (CBP 2010a). Terrestrial mollusks are frequently intercepted on civilian and military cargo containers worldwide (Cofrancesco Jr. et al. 2007) (Figure A3-5).

Figure A3-5: Snails on a Maritime Container

Source: David Robinson

The Argentine ant, *Linepithema humile* (Hymenoptera: Formicidae), was brought to Hawai'i on military equipment (Krushelnycky 2009), and species of Solenopsis and Linepithema have been intercepted at U.S. ports of entry on maritime vessels (USDA-APHIS-PPQ 2010a). These and other ant species are an important concern to the Micronesia Region, as they quickly colonize new areas, causing significant ecological, human health, and economic impacts (Sherley and Lowe 2000; PIAG 2004).

A3.3.2.4 *Pests on Equipment, Machinery, and Personal Vehicles*

Weed seeds, insects, mollusks, and soil frequently become attached to equipment and vehicles in the course of military operations, and are difficult to remove (Moerkerk 2006). Between 2006 and 2009, pests belonging to the insect families Cerambycidae, Cochlicellidae, Lymantriidae, Miridae, Pentatomidae, and Scarabaeidae; the mollusk family Hygromiidae; and the plant families Poaceae and Asteraceae were intercepted at U.S. ports of entry on equipment and vehicles. Cogongrass is believed to have been introduced into the Micronesia Region on heavy equipment (Hawley et al. 2006), and the Argentine ant, Linepithema humile, was introduced into Hawai'i with military equipment (ISSG 2010). Vehicles and equipment imported into New Zealand were found to be contaminated with soil containing viable plant pathogenic fungi and nematodes (Biosecurity New Zealand 2007); of used vehicles inspected, almost half were found to be contaminated with soil, some of it containing intact plant material. In another study, soil 132 kilograms (kg) (291 pounds) was removed from wheels, tracks, body work, and attachments of four construction vehicles, and an estimated 40,000 seeds were found in that soil, in addition to bacteria, fungi, and intact plants (Hughes et al. 2010). The spread of the plant pathogen *Phytophthora lateralis* (Oomycetes: Pythiales) in Oregon has been linked to vehicular movement, including equipment used in logging activities (Jules et al. 2002). Ecologically disturbed sites, such as those caused by military and construction activities, tend to provide good establishment opportunities for pests, and especially weeds (Hobbs and Huenneke 1992).

A3.3.2.5 *Safeguards*

Per a compliance agreement with USDA, GCQA has the authority to inspect any incoming containers, equipment, and conveyances for pests. However, some disagreement exists about naval ships, and it is not clear whether GCQA officers (rather than only federal officers) will be permitted by the DoD to conduct inspections (U.S. Navy 2009k). Regardless, thorough inspection for pests on containers and conveyances very rarely occurs. This is due to the logistical difficulty and the time intensiveness of such inspections and is consistent with the situation at most other U.S. ports of entry.

In addition, because of limited space at the maritime port in Guam, inspection of incoming sea cargo does not take place at the port itself, but at various off-site locations (Meissner et al. 2010). It is unclear if these off-site locations are sufficiently equipped to prevent the escape of pests (Jimenez et al. 2009). It is also unknown what safeguards, if any, are in place to prevent the escape of pests during transit between port and off-site locations. While Guam's commercial air and maritime ports have sealed surfaces, reducing the likelihood that containers become contaminated with soil and other pests, off-site locations and other ports in the Region may not.

DoD protocols require equipment and machinery to be cleaned prior to entry (AFPMB 2008; DoD 2009b) (Figure A3-6). DoD protocols also instruct Marines to clean their own personal vehicles and equipment (such as bikes and lawnmowers) before moving them into Guam (DoD 2010b, c). However, DoD does not seem to have a functioning quality control program in place on Hawai'i and Micronesia installations to ensure compliance with and effectiveness of these protocols, and no records of pests or contaminations detected are available (Meissner et al. 2010). It also appears there may be differences in the interpretation and application of DoD guidelines, as pointed out in a study on the transfer of exotic species on U.S. Armed Forces equipment from U.S. bases in foreign countries to the United States, which found that not all military bases cleaned outgoing material and equipment or inspected and cleaned incoming material and equipment (Cofrancesco Jr. et al. 2007)

Figure A3-6 Marines Decontaminating Military Equipment Returning from Kuwait at a Special Quarantine Decontamination site in Guam

Source: USDA-APHIS-PPQ

A3.3.2.6 *Expected Impact of Military Relocation.*

Given that the number of pest interceptions is positively correlated with traffic volumes (Liebhold et al. 2006), expected increases in the number of incoming airplanes, maritime vessels, cargo containers, military and construction equipment, and personal vehicles and equipment will lead to more frequent exotic pest introductions.

In 2009, close to 100,000 containers were processed at Guam's maritime port; during the peak year of the military relocation, the number of arriving containers is expected to be twice that number (see Table A2-14 and Table A2-16) (PB International 2008). If approximately one quarter of arriving sea cargo containers are contaminated with pest organisms (based on Gadgil et al. 2000; Border Management Group 2003), we estimate that between 2010 and 2025, one quarter of a million contaminated sea cargo containers will arrive in Guam as a direct or indirect result of the military relocation (Table A3-3). The proportion of containers accounted for by the military sector is expected to increase from currently 15% to 50% during the peak of the military relocation, and to remain at between 30% and 40% after the relocation (PB International 2008). Data regarding container traffic at other maritime ports in the Micronesia Region were unavailable.

The number of air cargo containers entering Guam's international airport will rise to accommodate the projected annual 7% increase (in metric tons) of air cargo from 2008 to 2023 (Tagawa and Torres 2007). While we do not know the exact numerical increases in airplanes, maritime vessels, equipment, and vehicles entering Guam and the Micronesia Region as a result of the military relocation, there is little doubt that the increases will be considerable.

Table A3-3: Estimated Number of Sea Cargo Containers and of Sea Cargo Containers With Contamination (Pests, Pathogens, Soil, Weeds) entering Guam[5]

Year	Containers	Contaminated Containers[a]	Contaminated containers by type			Contaminated containers due to military relocation[c]
			Transshipment[b]	DoD	Non-DoD	
2010	129,000	30,186	2,760	8,970	17,940	8,019
2011	149,000	34,866	2,530	13,340	18,400	12,699
2012	172,000	40,248	2,530	17.940	19,090	18,081
2013	178,000	41,652	2,530	18,630	19,780	19,485
2014	182,000	42,588	2,530	19,550	19,780	20,421
2015	190,000	44,460	2,530	20,470	20,700	22,293
2016	180,000	42,120	2,530	17,480	21,390	19,953
2017	152,000	35,568	2,530	10,580	21,850	13,401
2018	146,000	34,164	2,760	8,740	22,080	11,997
2019	148,000	34,632	2,760	8,740	98,000	12,465
2020	150,000	35,100	2,760	8,740	23,000	12,933
2021	151,000	35,334	2,760	8,740	23,230	13,167
2022	153,000	35,802	2,760	8,740	23,690	13,635
2023	155,000	36,270	2,760	8,740	24,150	14,103
2024	157,000	36,738	2,760	8,740	24,610	14,571
2025	158,000	36,972	2,760	8,740	24,840	14,805

[a] Estimated based on a 0.23 container contamination rate (Gadgil et al. 2000).

[b] Transshipped containers enter a country only to be loaded onto a different vessel and then shipped to a different country.

[c] Calculated by subtracting the number of containers in 2009 from the forecast number and multiplying by the contamination rate (0.23). The 2009 container traffic volume is assumed to represent what the traffic volume would have been in Guam if there was no military relocation; thus, increases in container traffic are assumed to be due to the military relocation and do not take into account regular growth in trade. Source: PB International 2008. Contaminated container values are based solely on historical contamination rates and do not consider change in inpectiopn protocols, personel, or technology.

A3.3.3 Pathway: Wood Packaging Material

WPM such as pallets, crates, and dunnage is widely used for shipping a large variety of cargo, including military cargo. WPM is a known pathway for exotic species introductions (Pasek 2000; Allen and Humble 2002). In addition to wood-boring pests found inside WPM, a broad range of plant pests are routinely detected as contaminants on WPM, including arthropods, nematodes, mollusks, weed seeds, and fungi (Gu et al. 2006; USDA-APHIS-PPQ 2010a).

WPM is a circulating product, routinely reused, reconditioned, and reimported (Bush et al. 1997); thus, the origin of WPM often differs from the origin of the commodity with which it is being moved. To reduce the pest risk associated with WPM worldwide, the International Plant Protection Convention (IPPC) developed the International Standards for Phytosanitary Measures (ISPM) No. 15, “Guidelines for Regulating Wood Packaging Material in International Trade” (IPPC 2009), which prescribes either

[5] Ibid.

fumigation or heat treatment according to specific treatment schedules for all WPM entering a country. Treated WPM must display a specified ISPM No. 15 stamp in a visible location to facilitate compliance checks at ports of entry. There is no requirement to repeat the treatment each time the WPM is re-used. The United States began enforcement of regulations in accordance with ISPM No. 15 on July 5, 2006 (USDA-APHIS-PPQ 2006). However, even though ISPM No. 15 stipulates that the wood used for the WPM be debarked , U.S. regulations do not require debarking for WPM entering the United States (USDA-APHIS 2007b).

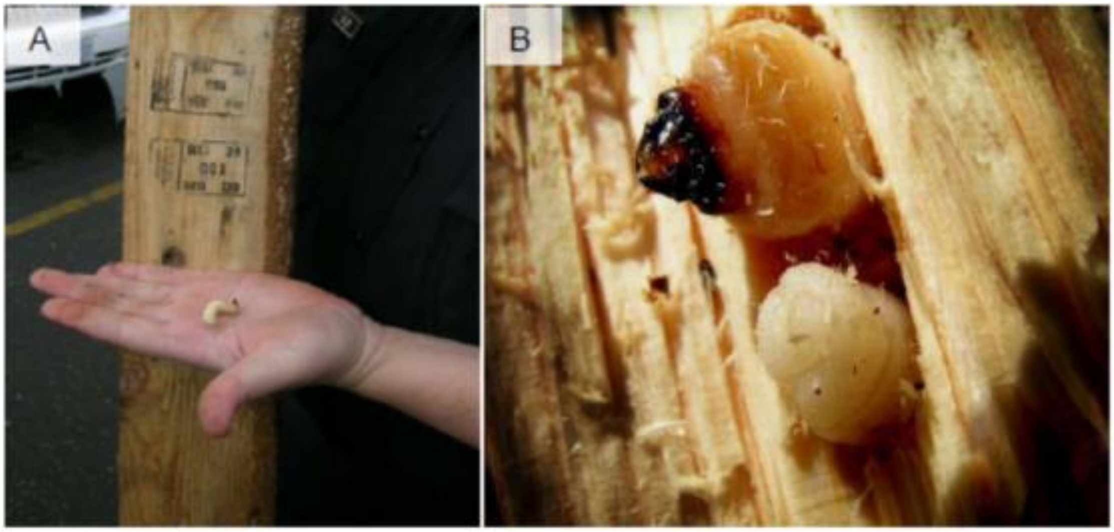
U.S. regulations apply to WPM imported from foreign origins into Guam, FSM, CNMI, and American Samoa, in addition to the 50 U.S. States, Puerto Rico, and the U.S. Virgin Islands. However, movement of WPM between the above-mentioned states and territories is considered domestic and is thus not subject to these regulations (USDA-APHIS 2007b). Because the majority of cargo entering Guam is from domestic locations (GovGuam 1995; 1999; 2000; 2002), this represents a potentially significant gap in safeguarding. Palau and RMI are not following ISPM No. 15. In Palau, WPM is “subject to inspection and treatment as prescribed, re-shipment or destruction at the expense of the importer or agent”; in addition, packing materials that have been previously used for the transport of plant or animal materials are not allowed to enter (Palau BAMR 1999). It is not known to what degree these regulations are enforced or even can be enforced (ALSC 2010).

Beyond what is imposed by U.S. regulations, DoD stipulates that all new WPM under DoD contracts or otherwise acquired by DoD must meet ISPM No. 15 requirements for shipments both inside and outside of the United States (DSCC 2008). In addition, companies providing WPM to DoD are required to comply with a quality control program administered by the American Lumber Standard Committee, Inc., through an agreement with APHIS (ALSC 2010). The purpose of this program is to ensure proper treatment application and record keeping through audits and oversight.

While this is a laudable policy, DoD has large amounts of stores inside and outside of the United States packaged on or in old WPM not compliant with ISPM No. 15. We do not know if this WPM will be moved to Guam and other parts of the Micronesia Region; we also do not know if and how this WPM is inspected by DoD. Regardless, a certain percentage of WPM–both military and commercial shipments–will always bypass existing regulations and guidelines. While we do not know how large this percentage is, random inspections carried out by USDA revealed that approximately 1% of the WPM accompanying maritime shipments and approximately 5% of the WPM in air shipments arrived without the required ISPM No.15 stamp (Meissner et al. 2009).

It is generally assumed that WPM marked with the ISPM No. 15 stamp is compliant with ISPM No. 15 requirements. However, treatments may be applied incorrectly or treatment stamps may be used fraudulently. For example, in 2008, CBP found live wood borers in the ISPM No. 15-stamped WPM accompanying 14 separate shipments from a single shipper and concluded that the shipper was using the stamp fraudulently (CBP 2008) (Figure A3-7).

Figure A3-7: ISPM No. 15-stamped WPM with live cerambycid larvae (A) and *Monochamus* sp. detected in dunnage (B)



Source: Photo A courtesy of CBP. Photo B courtesy of M. Hitchcox

There is general agreement that non-compliant WPM carries a considerable pest risk. For example, in a USDA pest risk assessment, Pasek (2000) rated 19 insects and fungi known to be associated with WPM and assigned a high pest risk potential to 17 of them. A New Zealand Ministry of Agriculture and Forestry review of sea containers prior to the implementation of ISPM No.15 found that of 5,000 containers with WPM, about 30% contained WPM infested with pests (Border Management Group 2003). Before China implemented regulations according to ISPM No. 15, a survey focusing on nematodes, conducted between 2000 and 2005, found that batches of WPM imported into China from Japan, the United States, Korea, and the European Union exhibited infestation with various species of nematodes of 21, 17, 24, and 17%, respectively; 6% of batches were infested with species of Bursaphelenchus (Nematoda: Aphelenchoididae)–serious plant pests known for their longevity in dead wood (Gu et al. 2006). Finally, Allen and Humble (2002) examined dunnage entering Canada from Norway and recovered over 2,500 adult insects representing more than 40 species of bark beetles, wood borers and their associated parasitoids, predators and scavengers, blue-stain fungi, and nematodes from 29 log bolts. These studies underscore the significant pest risk associated with non-compliant WPM that may enter Guam.

In addition to the pest risk presented by non-compliant WPM, live pests are also found on a regular basis on WPM bearing the ISPM No. 15 stamp. Subsequent to implementing ISPM No.15, the Australian Quarantine and Inspection Service sampled close to 20,000 pieces of WPM and found about 0.5% infested with live, wood-boring insects and 0.5% had fungi and/or mold (Biosecurity Australia 2006). A survey carried out at several U.S. ports of entry concluded that 0.1% of all WPM marked with the ISPM No.15 stamp was infested with live wood-boring insects (Haack 2006). Apart from the possibility of incorrectly applied treatments and fraudulent use of the seal, pests may be present in the WPM because the prescribed treatments are not completely effective against all pests (Qi et al. 2005), especially plant pathogens, and because WPM may be re-infested by pests after treatment (ALSC 2009; Haack and Petrice 2009).

Pest interception records from routine port-of-entry inspections are not statistically rigorous enough to be used for quantifying pest risk, but they can provide qualitative information on the types of pests found on WPM. Pests intercepted on WPM at U.S. ports of entry between July 5, 2006 (date of full enforcement of ISPM No.15) and February 26, 2010, include a large variety of taxa. More than 2,200 specimens were collected in about 1,000 interceptions. The majority of the interceptions were insects, most frequently cerambycid and curculionid woodborers. Many other taxa were also found. Overall, 80 families of insects from seven different orders, seven families of mollusks, seeds of 27 plant families, as well as mites, spiders, and a scorpion were intercepted (USDA-APHIS-PPQ 2010a); most of the intercepted specimens were not identified to the family level. The pest taxa intercepted no doubt represent a subset of the taxa actually present in the WPM. Some groups of organisms may be overlooked because of their small size and lack of extraction and identification methods. For example, no nematodes or fungi were intercepted, but these pests are likely to be present on WPM, as shown by Braasch, Gu et al. (2007) and Biosecurity Australia (2006). Similarly, no plant pathogenic bacteria or viruses have been reported from WPM, but it is possible that these types of organisms would also be present.

It is important to note that not all species present on WPM truly infest the wood. Many are contaminating pests, which means that they are on the WPM but have no biological association with it. For example, mollusks may seek shelter in WPM, weed seeds may get stuck on WPM, pests may fall from agricultural commodities transported on WPM, and nematodes and soil-borne pathogens may be present in soil on WPM. Outdoor storage of WPM, a common practice at many shipyards and warehouses, facilitates pest infestation, especially if the WPM is stored in direct contact with the soil, if weeds are growing close by, and if nighttime lighting attracts flying insects to the site. Contaminating pests can settle on WPM after treatment and thus may not be affected by ISPM No. 15 measures.

Almost any pest species may potentially be present on WPM, and WPM may originate from or may have been in almost any country. To identify species that may present a threat to the Micronesia Region, we compiled a list of species that have been found associated with WPM, are absent from all or some parts of Micronesia, have a distribution range that includes tropical areas, and have host plants that occur in the Micronesia Region. The list is based on the assumption that WPM origin cannot be determined with certainty; thus it encompasses a pest universe of worldwide origin. This list contains numerous species from a variety of taxonomic groups, including wood-boring beetles, ants, fungi, nematodes, and mollusks.

While a discussion of the introduction and impact potential for each of these species is beyond the scope of this report, there is little doubt that many of these species, if introduced, could cause severe damage to the native fauna and flora and/or agricultural production of the Micronesia Region. In particular, the introduction of certain ants is extremely worrisome because of their severe ecological and human health impacts (PIAG 2004); similarly, the introduction of terrestrial mollusks, usually generalist feeders, is likely to have very undesirable consequences for agriculture and biodiversity (Cowie 2000); damage caused by wood-boring beetles in many parts of the world is well known; and nematodes and fungi, although knowledge about their biology is very limited, are doubtlessly of concern.

As previously stated, some amount of non-compliant WPM will enter Guam, and even compliant WPM presents a pest risk. We found that port-of-entry inspection is the only means by which WPM may currently be monitored, although in actuality WPM seems to be rarely inspected in Guam and the rest of the Micronesia Region due to workload and logistical challenges. When inspection of WPM occurs, it is often limited to a verification of the ISPM No.15 stamp rather than a thorough search for pests. This seems to be true for both military and non-military shipments. If ports of entry in the Micronesia Region are currently understaffed, this situation is only expected to worsen during the military relocation.

While port-of-entry inspection is a potentially important safeguarding measure, it is not reliable as a sole measure for preventing pest entry. For a thorough inspection, cargo must be removed from a pallet or crate and repackaged, presenting a considerable logistical challenge. Even thorough inspection will miss many of the pests that are present. Wood-boring pests are usually hidden inside the wood and are very difficult to find. For some pests, such as nematodes and fungi, special extraction methods and identification expertise are needed, and port inspectors are not always sufficiently trained for the detection of wood-boring pests.

We know neither the quantity of WPM currently entering Guam and the Micronesia Region nor the quantity that will enter during the military relocation. No precise information on the amount of WPM moved in trade exists, and little information is available to make any estimates.

Expected impact of military relocation. The military relocation will lead to a considerable population increase on Guam (see Table A-12). As a result, more consumer goods and construction materials will be imported, often on or in WPM. In addition, the increased workload for inspection personnel during and after the military relocation may place further strain on the safeguarding system. As a result, the frequency of pest introduction through the WPM pathway is likely to increase. However, we do not expect a fundamental change in the types of pests introduced; rather, we expect that the same types of pests will enter Guam more frequently and may thus establish sooner than they would have otherwise. WPM presents a considerable pest risk and strong measures should be taken to protect the Micronesia Region against pests introduced through this pathway.

A3.3.4 Pathway: Construction Materials and Equipment

Construction projects have been implicated in the introduction of exotic species. For example, the introduction of snails into French Polynesia was linked to the construction of a hydro-electric station; and road construction in the Marquesa Islands and water tank construction in the Austral Islands have purportedly led to the introduction of exotic plants to these island groups (Shine et al. 2003). On Guam, the coconut rhinoceros beetle, *Oryctes rhinoceros* (Coleoptera: Scarabaeidae), a devastating pest of coconut palms, is thought to have been introduced on construction material from Asia (Smith and Moore 2008). Seeds of cogongrass, *Imperata cylindrica*, and the giant African snail, *Achatina fulica* (Gastropoda: Achatinidae), both highly invasive species in the Micronesia Region, are known to spread via the movement of construction equipment (Hawley et al. 2006).

Apart from construction materials and equipment being a pathway for pest introduction, construction activities create disturbed environments, where the establishment of exotic pests may be more likely

(Mulugeta and Stoltenberg 1997). For example, the highly invasive Argentine ant (*Linepithema humile*), a species with potentially devastating consequences to the Micronesia Region, preferentially invades disturbed sites (Mulugeta and Stoltenberg 1997, Kennedy 1998)

We do not have precise information on the types and amounts of construction material currently entering Guam or expected to enter Guam in the future. The projected peak housing demand of between 3,500 and 10,000 homes (PB International 2008, U.S. Navy 2009j) cannot be met by the currently available housing on Guam. In addition, a number of utility and training facilities will be built (CMTF 2007), and much of the existing infrastructure (roads, landfills, municipal and port buildings) will be expanded. Significant construction is also planned at Apra Harbor (CMTF 2007). Construction at Andersen AFB alone is estimated to require between 60 and 70 loads of steel weighing approximately 22,680 kg (50,000 pounds) per load (PB International 2008). Very few construction materials are available locally on Guam. In spite of plans to reuse soil, rocks, and other materials (U.S. Navy 2009j), the majority of the necessary construction materials such as timber, gravel, sand, steel, tile, granite, cement, and concrete will need to be imported. Construction equipment will also be imported in large quantities. Overall, it is clear that construction material and equipment imports will increase significantly as a result of the relocation and then level off after construction is complete.

The majority of construction materials will come from the U.S. mainland (Berthoud 2009), with significant portions also originating in Asian countries (PB International 2008), mainly in China and Japan (Berthoud 2009). Wood has also been imported from Palau in the past (GovGuam 1995), and some materials are being imported from the Philippines and Indonesia (Jimenez et al. 2009). Blocks of cement and concrete currently come from FSM (Berthoud 2009). We do not know whether materials will be imported from any additional countries during the military relocation.

Timber pests. A large variety of plant pests are associated with timber. From 2003 to 2009, 106 different species were found in 194 interceptions on wood entering the United States from Asia, including 41families of insects (including wood-boring beetles and ants), 6 families of weeds, 4 families of mites, and 3 families of mollusks (USDA-APHIS-PPQ 2010a). Timber from U.S. locations has been found to harbor pests as well, including the little fire ant, *Wasmannia auropunctata* (Hymenoptera: Formicidae) (Hawley et al. 2006, Berthoud 2009). The little fire ant is currently found on Hawai'i and in other parts of the United States, from where it may be introduced on timber (Hawley et al. 2006). It has demonstrated an ability to establish on Pacific Islands, and is known to occur in New Caledonia, Vanuatu, Tuvalu, and the Cook Islands (Wetterer 2009). Like other fire ants, the little fire ant causes painful stings and harms native biodiversity (ISSG 2010).

Certain safeguarding measures are in place to minimize the spread of pests on timber (Table A3-4). Unpeeled saw logs are prohibited from entering Guam, and peeled saw logs and lumber must be inspected and found to be free of termites and wood-boring insects (GDOA 1997). Foreign timber is required to have an import permit detailing the required treatment, which is fumigation (USDA-APHIS 2007c). As with any commodity, GDOA has the authority to quarantine, inspect, fumigate, disinfect, destroy, or exclude timber infested with pests (GDOA 1997).

Table A3-4: Regulations Pertaining to Construction Materials and Equipment Entering Guam

Material	Treatment Requirements
Timber	Peeled saw logs (no bark material) and lumber from domestic locations are permitted to enter Guam after inspection and verification of freedom from termites and wood-boring insects (GDOA 1997); unpeeled saw logs from domestic locations are prohibited from entering Guam. Timber from foreign locations requires fumigation and an import permit, or must be debarked, heat treated or kiln-dried, permanently marked, and kept separate from other shipments (USDA APHIS 2007c). May be refused entry or subject to order to undergo phytosanitary treatment if found to be contaminated upon port-of-entry inspection (7 CFR § 330).
Tile/granite	May be refused entry or subject to order to undergo phytosanitary treatment if found to be contaminated upon port-of-entry inspection (7 CFR § 330).
Cement/concrete	May be refused entry or subject to order to undergo phytosanitary treatment if found to be contaminated upon port-of-entry inspection (7 CFR § 330).
Sand/gravel	GovGuam requires sand and gravel to be sterilized by approved methods (GEPA 1991, 2009); successful sterilization is verified through testing by the Guam Environmental Protection Agency prior to entry (GEPA 2009). May be refused entry or subject to order to undergo phytosanitary treatment if found to be contaminated upon port-of-entry inspection (7 CFR § 330).
Steel	May be refused entry or subject to order to undergo phytosanitary treatment if found to be contaminated upon port-of-entry inspection (7 CFR § 330).
Construction equipment	The DoD has specific guidelines for the inspection and washing of military equipment and removal of soil and hitchhiker pests (AFPMB 2008). Non-military construction equipment is not generally subject to any cleaning requirements; however, washing or other phytosanitary measures may be required or entry may be refused if construction material is found to be contaminated upon port-of-entry inspection (7 CFR § 330).

However, these measures may not be sufficient to mitigate the pest risk posed by timber imports. A risk assessment determined that similar mitigation measures in New Zealand were not sufficient to prevent pest introduction (Ormsby 2003). Inspection of wood is often complicated by the size of timber products and by the fact that wood-boring pests are usually hidden inside the wood. Prescribed quarantine treatments are not completely effective against all pests, and timber may be recolonized after effective treatment. For these reasons, and because of the large diversity of pests that may be associated with timber, there is a significant risk of pest introduction to Guam through this pathway.

A3.3.4.1 *Contaminating Pests*

Contaminating pests are those that do not have a biological association with the material they are transported on. For example, a snail does not feed or otherwise depend on steel tubes, but may still be transported on them. Most construction materials have the potential to transport pests as contaminants. For example, a recent shipment of insulation and housing beams entering Guam from South Korea was found to be infested with thousands of spiders belonging to at least two different species (University of Guam ANRP 2010). From 2003 to 2009, U.S. port-of-entry inspectors intercepted 355 species on some 1,300 shipments of tile and granite from Asia. These interceptions comprised 96 families of insects, 25 families of weeds, 8 families of mollusks, 7 families of mites, and 1 family of plant pathogens (USDA-APHIS-PPQ 2010a). Among the interceptions was the highly invasive cogongrass, *Imperata cylindrica*, (USDA-APHIS-PPQ 2010a), which has become widespread on Guam, and is under eradication in Palau and Yap (LaRosa 2010). While we have no interception records for cement or concrete blocks, they presumably have the same types of contaminating pests associated with them as tiles or granite.

Sand and gravel are also known to harbor pests. For example, seeds of the Siam weed, *Chromolaena odorata* (*Asteraceae*), which is currently found in CNMI, Guam, Palau, and Yap, have been detected in sand and gravel used in road construction, and can survive for long periods in this medium (Hawley et al. 2006). Over 130 different plant pest species were found in 394 interceptions on quarry products from Asia at U.S. ports from 2003 to 2009 (USDA-APHIS-PPQ 2010a). Similarly, 55 different species were found in 79 interceptions on steel and steel bars at U.S. ports of entry from 2003 to 2009, including 19 families of insects, 6 families of weeds, 2 families of mollusks, and 1 plant pathogen family (USDA-APHIS-PPQ 2010a).

Construction equipment and machinery are also well-known carriers of contaminating pests (AFPMB 2008); several exotic species in the Micronesia Region have been introduced as contaminants on construction equipment (Hawley et al. 2006). Of 271 interceptions from Asia on general equipment, machinery, and vehicles at U.S. ports of entry from 2003 to 2009, there were 49 families of insects, 13 families of weeds, 6 families of mollusks, 3 families of plant pathogens, and 1 family of nematodes (USDA-APHIS-PPQ 2010a). Weed contamination is of particular concern on construction equipment; a recent Australian study found that 25% of the machinery evaluated (including tractors, graders, and other equipment used for local land management) was contaminated with weed seeds (Moerkerk 2006).

No USDA regulations specifically address sand or gravel. GovGuam does have quarantine measures in place for timber, sand and gravel, and construction equipment (see Table A3-4); federal regulations give GCQA the authority to require phytosanitary treatment (including washing) of construction materials found to be contaminated with pests or soil through port-of-entry inspection. However, it is unclear how efficacious these measures are at preventing pest entry and how consistently they are applied.

A3.3.4.2 ***Expected Impact of Military Relocation***

The planned military relocation on Guam will lead to a significant increase in construction activity, and thus to an increase in construction material and equipment imports. These imports will increase dramatically during the relocation phase and then level off after most construction is complete. Imported materials will comprise a large diversity of items, many of which are likely to be contaminated with plant pests. Inspection of these items is difficult and existing safeguards are not sufficient to prevent pest introduction. There is little doubt that this pathway will present a significant plant pest risk for the duration of the relocation phase. After the relocation, the pest risk is expected to be slightly higher than its current level.

A3.3.5 Pathway: Plant propagative material

Propagative material used for landscaping on Guam is mainly imported from the United States (GovGuam 2002, McConnell 2010). Other countries of origin include Thailand, Taiwan, Philippines, Costa Rica, Ecuador, and Puerto Rico (Campbell 2010d). In addition to importing, Guam also exports plants to CNMI and FSM, providing a mechanism for pest spread from Guam to other parts of the Micronesia Region (GovGuam 2010).

A3.3.5.1 *Pathway for Plant Pests*

Movement of plant propagative material (whole plants, buds, bulbs, tubers, or seeds) is a primary means by which plant pests invade new areas (Palm and Rossman 2003, Brasier 2008). Propagative materials are usually planted in areas conducive to their growth, greatly facilitating their establishment and that of any associated pests. A large variety of pests are intercepted on propagative materials arriving at U.S. ports of entry (USDA-APHIS-PPQ 2010a). For example, from March 2009 to March 2010, over 16,000 pest specimens were found in some 5,600 interceptions, including insects (86 families), mollusks (16 families), mites (5 families), weeds (13 families), as well as viruses, fungi, bacteria, and nematodes. Mites, plant pathogens, and nematodes only accounted for 23% of interceptions. However, this is almost certainly not due to a low prevalence of these pests on propagative materials; rather, it is likely due to the difficulty of detecting these types of pests. This is supported by a study of Childers and Rodrigues (2005), who washed propagative plant materials in ethanol, and found 81 mites from 11 families on only 12 shipments of propagative materials arriving at Miami International Airport. By comparison, routine port-of-entry inspections at the same airport detected only one species of mite in over 40,000 propagative material shipments. Similarly, plant pathogens are often not detected, because the infected plant material may not express noticeable symptoms and appropriate diagnostic tools do not exist or are not feasible or affordable for plant quarantine purposes (Schaad et al. 2003).

Damaging arthropods have been or may be introduced into the Micronesia Region via the propagative materials pathway. The Asian cycad scale, *Aulacaspis yasumatsui* (Homoptera: Diaspididae), was first introduced into Florida through the importation of cycad plants by a botanical garden; from Florida it was introduced into Hawai'i and from there into Guam through the plant trade (Moore et al. 2005). The scale attacks *Cycas micronesica* (Cycadaceae), a plant endemic on Guam and the Micronesia Region. Since the scale's introduction, populations of *C. micronesic*a have declined to the point where the situation has been described as an environmental disaster akin to that caused by the brown treesnake (University of Guam 2007). Another exotic insect pest, the coconut rhinoceros beetle, *Oryctes rhinoceros* (Coleoptera: Scarabaeidae), is devastating betelnut, coconut, and ornamental palms on Guam (Smith and Moore 2008). While this pest was likely introduced on construction materials from Asia, movement of live host plants may further spread it throughout the Micronesia Region (Smith and Moore 2008); improper disposal of infested plants may also spread this pest to new locations on Guam. Movement of propagative material has contributed to the dramatic spread of the red palm mite, *Raoiella indica* (Acari: Tenuipalpidae), into and throughout the Caribbean region, where it attacks numerous palm species (Welbourn 2009). The red palm mite is not known to occur in the Micronesia Region and could have a significant impact if introduced.

Movement of propagative material is also linked to the spread of numerous plant pathogens, such as the banana bunchy top virus (Thomas et al. 1994) and the causal agent of the citrus disease Huanglongbing (Wang 2009). Finally, Cowie et al. (2008) identified the importance of the horticultural trade pathway in facilitating the spread of mollusks, listing 29 non-native species of terrestrial snails and slugs found during a survey of nurseries in Hawai'i. Terrestrial mollusks can damage nursery crops, displace native species, and vector human and animal diseases (Cowie 2001, Cowie et al. 2009). The polyphagous mollusk *Succinea tenella* (Succineidae), invasive in Hawai'i (Cowie et al. 2008), has been intercepted multiple times on orchid plants at Guam ports of entry (USDA-APHIS-PPQ 2010a).

A3.3.5.2 *Plant Propagative Material as Invasive Species*

Plant propagative material may become invasive when introduced into a new location. Certain characteristics that are desirable in landscape plants, such as rapid growth, high reproductive capacity, and the ability to withstand a range of environmental conditions (Peters et al. 2006), also predispose plants to being invasive (SPREP 2000; Richardson et al. 2004). Invasive plants can have devastating effects on ecosystems by displacing native species (ISSG 2010), altering the frequency and intensity of fires (Brooks et al. 2004), changing the erosion properties of soil (SPREP 2000), and clogging waterways (Opande et al. 2004; FLDEP 2009; ISSG 2010), among other impacts.

There are many examples of plants that have become invasive after being deliberately introduced into an area; in fact, most invasive exotic plant species were probably intentionally introduced. Waugh (2008) reports that of the 191 invasive plants examined in the insular Caribbean, 66% were introduced deliberately through the horticulture pathway; and Frank and McCoy (1995) state that approximately one quarter of Florida's flora comprises non-indigenous species, almost all of them introduced deliberately.

Lantana camara (Verbenaceae) was deliberately introduced into the Micronesia Region for use as an ornamental plant. However, it is poisonous to livestock (McGinty and Machen 1993) and is now considered a damaging invasive species (ISSG 2010). Similarly, *Miconia calvescens* (Melastomataceae) was introduced into Hawai'i as an ornamental tree; because of its aggressive growth and interference with watershed functions, this species is now listed as a noxious weed (Loope 1997).

A3.3.5.3 *Potting Media*

Demand for potting media, sometimes referred to as potting soil, is directly related to landscaping activity. Movement of potting media, whether intentional or unintentional, is a well-known pathway for a wide variety of potentially dangerous organisms.

In New Zealand, 25 species of exotic weeds were found in imports of coco peat, widely used as a growing medium in the nursery and horticulture industries (Biosecurity New Zealand 2009b). Live arthropods and weeds have been found in potting media sold at a Garden Center in Guam (Moore 2010) (Figure A3-8). Similarly, Cloyd and Zaborski (2004) found a total of 1,245 arthropods in 23 of 96 bags of potting media from wholesale distributors in the United States. Cartwright et al. (1995) reported that commercial potting media were the source of Pythium infecting tobacco seedlings. Commercially packaged potting media can also harbor organisms harmful to humans (Steele et al. 1990; Casati et al. 2009; Norcini et al. 2010).

Figure A3-8: Commercial Potting Soil Packaged In Plastic Bags (A) and Plants Growing Out Of a Closed Bag of Commercial Potting Soil in Guam (B)

Source: Aubrey Moore

A3.3.5.4 *Safeguards*

All plant propagative material imported into Guam, including transshipments to the CNMI, Palau, and FSM, is inspected at the Plant Inspection Station operated by GDOA (Campbell 2010d).

Plants imported for planting must be free of soil. In addition, plants entering Guam from Hawai'i must be treated with hot water drench or citric acid solution prior to shipment (mainly to prevent the introduction of coqui frogs), and must be inspected for pests of concern to Guam (GDOA 2004). While this regulation may help reduce the plant pest risk posed by propagative material from Hawai'i, the costs associated with the required treatment have caused a shift towards imports from Florida and the Caribbean (Campbell 2010d); no treatment requirements are currently in place for plants from these locations.

Both federal and GovGuam regulations prohibit the entry of certain types of plant propagative material from certain locations to prevent the introduction of specific pests of concern. For example, the importation of citrus, coconut, banana, taro, and sweet potato planting material is highly restricted; the same is true for certain plants from areas infested with the European corn borer, *Ostrinia nubilalis* (Lepidoptera: Pyralidae) (GDOA 1997). While these regulations provide some protection against the introduction of pests, the number of regulated pests pales in comparison to all pest species potentially associated with propagative materials entering Guam. The invasiveness potential of the propagative material itself is not considered in any of the existing regulations.

DoD drafted a landscape plan for Guam that includes a list of recommended plant species for military lands (NAVFAC 2010). It is not clear whether compliance with this plan is mandatory and, if so, how compliance will be enforced. The majority of species recommended in this landscape plan are native or non-invasive and commonly used in landscapes in Guam. However, the plan also contains some species that are invasive in parts of the Micronesia Region (Table A3-5). For example, *Pseuderanthemum reticulatum* (Acanthaceae) is invasive in Palau, and Space et al. (2003) discourage further planting. Another species, *Cynodon dactylon* (Poaceae), is considered one of the most aggressive grasses that has been introduced into the Micronesia Region (Space and Falanruw 1999). In addition, the landscape plan lists at least 11 species that are potentially invasive. For example, *Duranta repens* (Verbenaceae) is believed to have a high potential for invasiveness in the Micronesia Region because it has established beyond its natural range in other locations (PIER 2010).

Table A3-5: Plants Recommended in the DoD Landscape Plan That Are Invasive in the Micronesia Region or Information Is Insufficient to Determine Invasive Potential

Scientific name	Comments on invasiveness
Duranta repens (syn. *Duranta erecta*)	High risk of becoming invasive (PIER 2010)
Hedychium coronarium	High risk of becoming invasive (PIER 2010); Space et al. (1999) suggest monitoring *Hedychium* sp. for invasive behavior; invasive or potentially invasive in Palau (Space et al. 2009)
Heliconia psittacorum	High risk for becoming invasive (PIER 2010)
Paspalum vaginatum	High risk of becoming invasive (PIER 2010)
Pennisetum clandestinum	High risk of becoming invasive (PIER 2010)
Thevetia peruviana	High risk of becoming invasive (PIER 2010); species of concern in Palau (Space et al. 2009)
Alpinia purpurata	Evaluation of invasiveness recommended (PIER 2010)
Chrysalidocarpus lutescens (syn. *Dypsis lutescens*)	Evaluation of invasiveness recommended (PIER 2010)
Clusia rosea	Evaluation of invasiveness recommended (PIER 2010)
Cynodon dactylon	Weedy in Micronesia (Space and Falanruw 1999); Evaluation of invasiveness recommended (PIER 2010)
Livistona chinensis	Evaluation of invasiveness recommended (Space et al. 2009, PIER 2010)
Chlorophytum bichetti	Potential invasiveness unknown
Cordyline fruticosa	Potential invasiveness unknown
Philodendron selloum	Potential invasiveness unknown
Pseuderanthemum reticulatum (syn. *Pseuderanthemum carruthersii*)	Invasive in Palau; further planting is discouraged (Space et al. 2003)

In addition to regulated commerce, smuggled propagative material presents a potentially serious risk. Of particular concern are live plants sent through the mail or carried in passenger baggage. Various military guidelines for relocating personnel do not mention restrictions concerning plants and plant products. A DoD website for personnel assigned to foreign duty stations explicitly states that there are “No restrictions identified” for plant movement into Guam (DoD 2010d).

A3.3.5.5 *Expected Impact of Military Relocation*

The demand for plant propagative material, particularly plants for landscaping, will likely increase during the military relocation due to landscaping needs around newly constructed civilian and military housing, hotels, and commercial businesses. Apart from plantings on DoD lands, garden centers may increase their supply of ornamental plants to meet demands from a larger consumer base (including homeowners, hotels, and commercial businesses). Depending on consumer demand, garden centers may also increase their supply of novel ornamentals, including plants that have not been tested in Guam's landscapes and that could become invasive. Increased sales of commercial potting soil may also introduce and facilitate spread of pests from the U.S. mainland on Guam (Berringer 2010a). Increases in plant propagative imports will place additional strain on existing safeguarding staff and infrastructure, limiting their ability to prevent pests from entering the Micronesia Region.

A3.3.6 Pathway: Mail

Mail is a known pathway for the movement of exotic organisms. Almost two decades ago, a report of the U.S. Congress specifically identified mail as a source of invasive species (OTA 1993) and pointed out concerns about the potential spread of nematodes, mites, diseases, and parasites in shipments of bee and bumble bee colonies.

Larvae of the Mediterranean fruit fly, *Ceratitis capitata*, the melon fly, *Bactrocera cucurbitae*, the Oriental fruit fly, *B. dorsalis*, and the Malaysian fruit fly, B. *latifrons* (Diptera: Tephritidae), among other quarantine pests were found during an examination of first-class USPS and United Parcel Service packages arriving in California in 1990 to 1991 (McDowell and Krass 1992). Prohibited materials seized in public and private mail entering the United States include seeds, fresh fruits and vegetables, propagative plant parts, nuts, live insects, and soil (USDA-APHIS-SITC 2005; 2006; 2007; DHS CBP and USDA-APHIS-SITC 2008; USDA-APHIS-SITC 2009b; c). Indeed, the relatively low cost of mailing and lax enforcement of the regulations make the mail an attractive way of moving plant products, legally or otherwise.

Specific information about the significance of the mail pathway in Guam and the Micronesia Region is scarce, but interceptions from mail packages sent from the Micronesia Region to Hawai'i demonstrate the possibility of pests making their way from the Micronesia Region to Hawai'i via the mail pathway (Table A3-6). Pests of betelnut, *Areca catechu*, may be of special concern, because betelnuts seem to be sent frequently in the mail.

Table A3-6: Pest Insects Intercepted From Packages Mailed From the Micronesia Region Destined to Hawai'i between 2003 and 2008

Country of origin	Inspected host	Pest
Guam	*Mangifera indica* (fruit)	*Sternochetus* sp. (Curculionidae)
Guam	Unknown seeds	Curculionidae, species of
Guam	*Areca* sp. (fruit)	*Chrysomphalus aonidum* (Diaspididae)
RMI	*Areca catechu* (seeds)	Pseudococcidae, species of
FSM	*Psidium* sp. (fruit)	*Bactrocera* sp. (Tephritidae)
FSM	*Citrus* sp. (fruit)	*Lepidosaphes beckii* (Diaspididae)
FSM	*Citrus* sp. (fruit)	Tarsonemidae, species of
FSM	*Areca catechu* (fruit)	Pseudococcidae, species of
FSM	*Areca catechu* (fruit)	Diaspididae, species of
FSM	*Areca* sp. (fruit)	*Lepidosaphes similis* (Diaspididae)
Palau	*Areca* sp. (fruit)	*Pinnaspis* sp. (Diaspididae)

Source: USDA-APHIS-PPQ 2010a

A rise in e-commerce has caused an increase in the number of packages sent through the mail worldwide (Hafner 2006). While e-commerce is currently less utilized in the Micronesia Region than in other parts of the world, technological advancement and an influx of a large number of people from the United States, many of whom are accustomed to online shopping, may lead to increased e-commerce activity over time. Internet retailers and online auction sites are easily accessible sources of plants and other live organisms (Kay and Hoyle 2001; Derraik and Phillips 2010). Organisms sold online are often not identified to the species level or are misidentified (Walters et al. 2006; Keller and Lodge 2007), and consumers tend to be unaware of the phytosanitary risks and regulations associated with mail-order organisms.

In spite of steps taken by some Internet auction sites to curb the sale of invasive plants and plant pests (eBay 2009), such items, ordered online, are seized in the United States on a regular basis (Table A3-7) (USDA-APHIS-SITC 2009a, d). Seeds are the most common type of intercepted material, demonstrating the potential for exotic plant species to be mailed into the Micronesia Region from anywhere in the world; seeds and other types of mailed propagative material also pose the threat of introducing plant pests and diseases. It is worth noting that many of the plants listed in Table A3-7 are already established throughout much of Micronesia and the State of Hawai'i and most likely available from local sources (at least some varieties).

Table A3-7: Examples of Prohibited Items Purchased from Online Auction Sites Seized In International Mail Entering the United States in 2009

Country of origin	Organism intercepted	Organism type
Australia	*Zea mays*	seeds
China	bonsai tree	plant
Germany	bamboo	seeds
Malaysia	*Ipomoea aquatica*	seeds
Malaysia	*Zea mays*	seeds
Malaysia	Cucurbitaceae, species of	seeds
Malaysia	*Vigna sesquipedalis*	seeds
Malaysia	*Citrus* sp.	seeds
Singapore	*Ipomoea aquatica*	seeds
Singapore	*Citrus* sp.	seeds
Thailand	*Cycas* sp.	plant
Thailand	*Citrus hystrix*	seeds and plants
Thailand	*Oryza* sp.	seeds
Thailand	*Plumeria* sp.[b]	plant
Thailand	*Euphorbia* sp.[b]	plant
Thailand	dwarf bamboo	plant
Thailand	*Oryza* sp.	seeds
Thailand	*Ipomoea aquatica*	seeds
Thailand	*Citrus aurantifolia*	seeds
Thailand	*Fortunella* sp.	seeds
Thailand	*Tacca chantrieri*	tubers
Thailand	*Jatropha* sp.	seeds
Thailand	*Nephelium lappaceum*	seeds
Thailand	*Hylocereus* sp.	seeds

Country of origin	Organism intercepted	Organism type
Thailand	*Citrus* sp.	seeds
Thailand	Thai eggplant	seeds
Thailand	*Piper nigrum*	seeds
Thailand	*Capsicum annuum*	seeds
Thailand	*Ocimum tenuiflorum*	seeds
Thailand	*Cucumis sativus*	seeds
Thailand	*Coriandrum sativum*	seeds
Thailand	*Citrus amanuensis*	seeds
Thailand	*Ipomoea aquatica*	seeds
USA (GA/LA)	*Citrus* sp.	plants
USA (FL)	*Citrus aurantifolia*	plant
USA (FL)	*Citrus* sp.	seeds and plants
USA (FL)	*Fortunella* sp.	seeds
USA (FL)	*Marisa cornuarietis*	snails
Unknown	*Coco nucifera*	plant
Unknown	*Pomacea caniculata*	snail
Unknown	*Marisa cornuarietis*	snail
Unknown	*Annona squamosa*	seeds
Unknown	*Citrus* sp.	plants
Unknown	*Zea mays*	seeds
Unknown	*Acer buergerianum*	Bonsai plant
Unknown	orchids	plants

Source: USDA-APHIS SITC 2009a, d.

[a] Both plants were infected with *Ceratocystis* sp.

Mail service to Guam and the Micronesia Region is provided by the USPS and several private shipping companies. Military mail is handled by the Military Postal Service Agency. The Military Postal Service Agency is the single DoD point of contact with the USPS and is required to adhere to USPS rules, federal laws, and various international laws and agreements for movement of military mail. The Military Postal Service Agency uses USPS mail handling and distribution networks where they exist (MPSA 2010).

Guam's Main Post Office, located in Barrigada, is the Micronesian Region's mail service hub, serving as a processing facility and staging area for civilian and military mail entering the Region (Ericksen 2010). In addition to delivering mail to people on Guam, this facility processes domestic and international mail for CNMI, RMI, Palau, and FSM (Murphy 1983; Jimenez et al. 2009). Mail inspection also takes place at this facility. Thus, this facility's capacity directly affects the entire Region's biosecurity.

The Military Postal Service Agency educates military personnel about items that are prohibited in mailed packages, and the Guam Post Office displays educational posters describing prohibited mail items (Ericksen 2010).

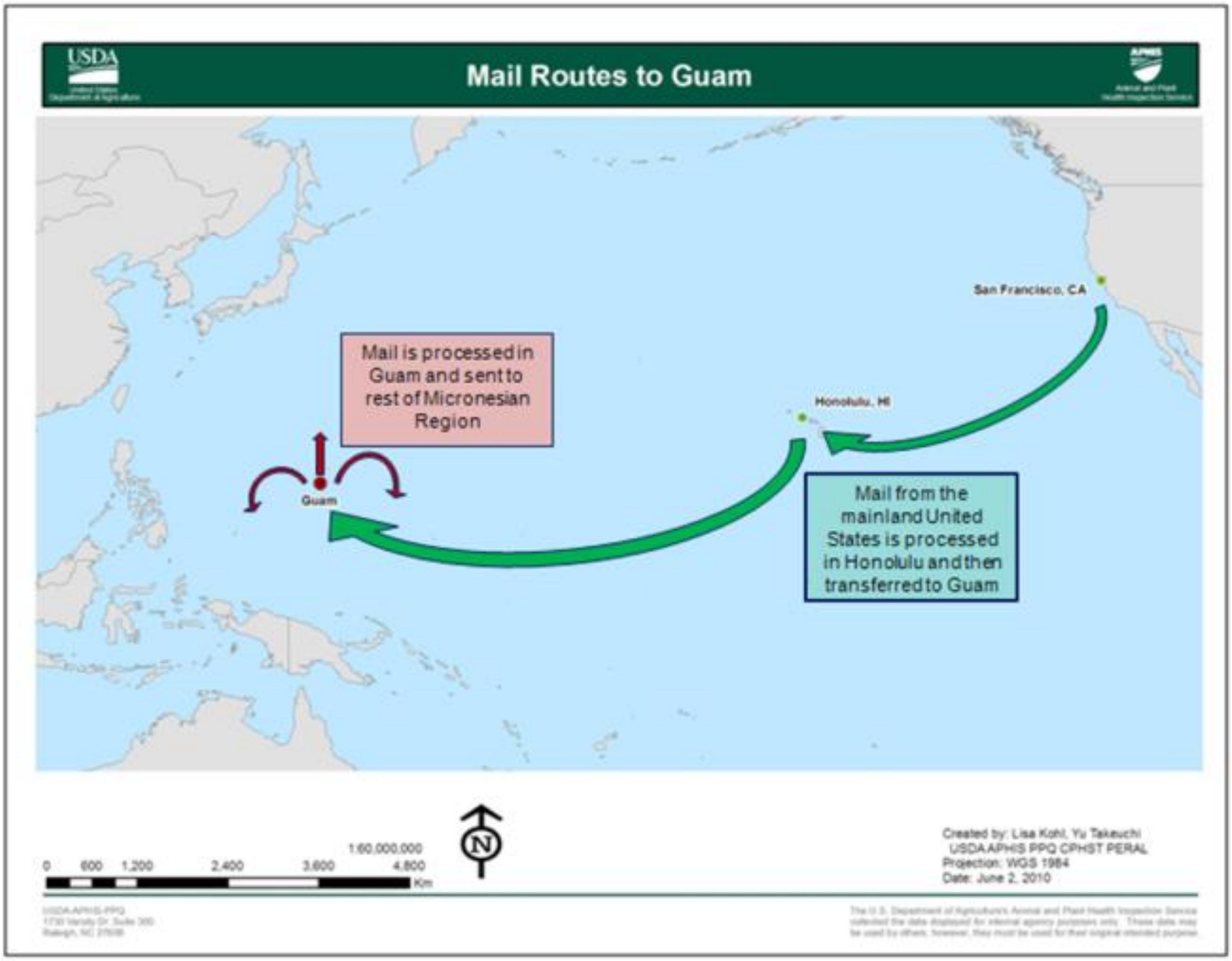
Mail sent between the United States, Guam, CNMI, RMI, Palau, and FSM through the USPS is considered U.S. domestic mail (USPS 2009), which means that standard domestic rates apply. This makes the USPS a relatively inexpensive shipping option (USPS 2010b) compared to private shipping companies, which charge international rates on packages sent between the United States and areas in the Micronesia Region (FedEx 2010; UPS 2010). Thus, most packages sent to the Micronesia Region from the United States are sent through the USPS rather than private companies (Ericksen 2010).

First-class mail sent via the USPS has legal protection under the Fourth Amendment to the Constitution of the United States, making it illegal to delay such mail or to open it without either a search warrant or permission from the addressee (DoD 2002; USPS 2007). These protections apply also in Guam, the CNMI, RMI, Palau, and FSM. However, of these locations, Guam is the only one where inspection of mail takes place. In order to obtain a search warrant for inspecting first-class mail, the Postal Inspector must establish probable cause. For this purpose, screening of the mail by detector dogs would be useful; however, detector dogs are not being used in the Guam postal facility (Meissner et al. 2010). The actual opening and inspection of the mail is carried out by GCQA officers, but a Postal Inspector must be present at the time of inspection. Because the postal facility cannot legally slow down the flow of domestic mail (39 CFR Title 39), the number of packages that can be inspected with the available workforce is very limited.

In contrast to USPS first-class mail, parcels shipped through private mail are considered cargo and are regulated and inspected as such. GCQA has the authority to inspect these packages, and no search warrant is needed. Privately shipped mail (with the exception of diplomatic parcels) may be x-rayed by GCQA (Shimizu 2010a).

All mail originating in the United States and most international packages destined for the Micronesia Region are processed in Honolulu, Hawai’i, before being sent to Guam (Figure A3-9). The postal facility of Honolulu has a compliance agreement in place that facilitates inspection of first-class USPS domestic packages. However, it is unclear to what degree mail destined for Guam is actually inspected in Honolulu. While Guam postal officials seem to rely on Hawai’i Department of Agriculture inspectors to inspect this mail (Ericksen 2010; Shimizu 2010a), postal officials in Hawai’i seem to believe that GCQA is carrying out these inspections (Gonzalez 2010). The Hawai’i Department of Agriculture recently experienced a drastic decrease in agricultural inspectors due to budget cuts (Advertiser Staff 2009), creating a general workforce shortage which also affects postal inspections.

Figure A3-9: Route for Packages Sent from the U.S. Mainland to the Micronesia Region



Source: Murphy 1983; Ericksen 2010

Approximately 1.5 million packages currently arrive in Guam; of these, some 100,000-150,000 packages arrive from international locations, mainly Japan and the Philippines (Ericksen 2010). The remainder arrives from domestic locations (Ericksen 2010). The USPS does not keep records of mail volumes for anywhere else in the Micronesia Region (USPS 2010a).

In addition to mail arriving from outside the Region, plant pests may also be mailed from Guam to areas within the Micronesia Region. Outgoing packages are not inspected on Guam, and other locations in the Region do not seem to inspect incoming mail (Ericksen 2010).

Expected impact of the military relocation. The military relocation is expected to increase mail volumes to Guam. An estimated additional 900,000 packages annually may be delivered to military personnel alone (Ericksen 2010). While we have no data to determine the percentage of packages entering Guam that contain plant quarantine materials, a value of 1% previously calculated based on randomly sampled international mail entering the United States (Meissner et al. 2009) serves as a reasonable estimate.

Based on this estimate, an additional 10,000 packages containing plant quarantine material may arrive annually in military mail. In addition, packages mailed to the large expected temporary workforce from Southeast Asia also present a risk.

A3.3.7 Pathway: Agricultural Commodity Imports

Most of the agricultural commodities consumed on Guam are imported, and most of these imports come from the United States. In 2002, the United States supplied 92% (based on weight) of Guam's agricultural imports, and 14 other trading partners provided the remaining 8% (Table A3-8). Some 160 types of agricultural commodities were imported from the United States, while Korea provided 90 types, and FSM provided 11 types.

Table A3-8: Percentage of Agricultural Commodity Imports to Guam by Country of Origin in 2002

Country of origin	Percentage of imports[a]
United States	92
Korea	3
FSM	2
New Zealand	1
All other countries[b]	<1

Source: GovGuam 1995; 1999; 2000; 2002.

[a] Fresh agricultural commodity imports exclude animal-based products.

[b] All other countries: Australia, China, CNMI, Japan, Malaysia, Netherlands, Philippines, Singapore, Taiwan, Thailand, and Palau.

USDA regulations regarding the importation of fresh fruits and vegetables into the United States (including Guam and CNMI) are detailed in 7 CFR (7 CFR § 319; 7 CFR § 318). For any fresh fruits and vegetables from foreign countries, USDA requires pest risk assessments detailing the likelihood and potential consequences of exotic plant pest introduction before permitting importation into the United States. Guam is almost never explicitly considered in these pest risk assessments; however, all fruits and vegetables approved for entry into any part of the United States are also permitted to enter Guam, unless they are specifically designated as not approved (which is rare). This leaves Guam vulnerable to pest introductions from foreign countries. In addition, commodities prohibited from entering Guam may be imported into the continental United States and sent from there to Guam as domestic shipments.

Domestic shipments from Hawai'i are governed by GovGuam regulations and 7 CFR § 318 federal regulations. GovGuam restricts the entry of certain agricultural commodities from domestic locations (GDOA 1997); e.g., hosts of the European corn borer from infested U.S. States and hosts of the oriental fruit fly, *Bactrocera dorsalis* (Diptera: Tephritidae), from infested areas in Hawai'i are prohibited. However, the majority of commodities from the United States are allowed to enter Guam without any phytosanitary restrictions, but subject to inspection.

In 2009, GDOA intercepted pests in agricultural shipments from the mainland United States (Campbell 2010c), including mites, aphids, thrips, beetles, flies, Hemiptera, Homoptera, Lepidoptera, fungi, and mollusks. Since most of the pests were not identified to the genus level, we were unable to determine their quarantine status. A wider variety of pests not known to occur or of limited distribution in the Micronesia Region have been found in agricultural shipments entering Hawai'i from the mainland United States, further demonstrating the potential of introducing pests from the mainland United States into the Micronesia Region (Table A3-9) (HDOA 2007).

Table A3-9: Pests Not Known To Occur or of Limited Distribution in the Micronesia Region that Were Intercepted in Hawai'i on Domestic Shipments of Agricultural Commodities From the Continental United States

Coleoptera: Chrysomelidae
Diabrotica balteata *Diabrotica undecimpunctata* *Microtheca ochroloma*
Hemiptera: Aphididae
Aphis coreopsidis *Aphis nasturtii* *Aphis menthaeradicis* *Aulacorthum magnolia* *Greenidea mangiferae* *Hyadaphis foeniculi* *Macrosiphum euphorbiae* *Macrosiphum rosae* *Melanaphis sorghi* *Myzus ascalonicus* *Rhopalosiphum padi*
Hemiptera: Diaspididae
Aonidiella aurantii *Chrysomphalus aonidum*
Hemiptera: Miridae
Lygus hesperus *Lygus lineolaris*
Hemiptera: Triozidae
Bactericera cockerelli
Hemiptera: Pseudococcidae
Dysmicoccus sp. nr. *bispinosus* *Dysmicoccus texensis* *Ferrisia malvastra* *Planococcus ficus* *Rhizoecus americanus* *Rhizoecus cacticans* *Rhizoecus falcifer*
Lepidoptera: Gracillariidae
Marmara gulosa
Lepidoptera: Noctuidae

Autographa californica
Mollusca: Agriolimacidae
Deroceras reticulatum
Mollusca: Succineidae
Succinea tenella

Source: HDOA 2007

Expected impact of the military relocation. The military relocation will lead to a considerable population increase on Guam. As a result, larger amounts of agricultural commodities will be imported. The increased workload for inspection personnel during and after the military relocation may place further strain on the safeguarding system. As a result, the frequency of pest introduction through the agricultural commodity pathway is likely to increase. However, we do not expect a fundamental change in the types of pests introduced; rather, we expect that the same types of pests will enter Guam more frequently and may thus establish sooner than they would have otherwise. In addition to legal imports, increased smuggling of agricultural commodities into Guam may occur, especially via mail or in passenger baggage.

A3.3.8 Pathway: Regulated Garbage

Garbage is defined as waste derived from fruits, vegetables, meats, or other plant or animal material. This may include unconsumed meals, food scraps, table refuse, galley refuse, food wrappers or packaging materials, and other waste material from stores, food preparation areas, passengers' or crews' quarters, or dining rooms in ships or airplanes. Garbage is regulated if it is on or removed from any conveyance that has been in any port outside the United States and Canada in the past 2 years (9 CFR § 94; 7 CFR § 330.400).

Regulated garbage may not be disposed of or removed from a conveyance except in accordance with federal Regulations. All regulated garbage must be contained in tight, covered, leak-proof receptacles during storage on board the conveyance while in the territorial waters, or while otherwise within the legal jurisdiction of the United States. If unloaded, regulated garbage must be moved under the direction of an inspector to an approved facility for incineration, sterilization, or grinding into an approved sewage system. Any person engaged in the handling or disposing of regulated garbage must first enter into a compliance agreement with APHIS (9 CFR § 94; 7 CFR § 330.400). The offloading of regulated garbage from all foreign countries except Canada into the United States is prohibited. Hawai'i, Puerto Rico, American Samoa, CNMI, FSM, Guam, the U.S. Virgin Islands, RMI, and Palau fall under the domestic quarantine notices restricting the offloading of regulated garbage into other States or territories.

Expected impact of the military relocation. If the above regulations are followed, regulated garbage poses little to no phytosanitary risk to Guam and the Micronesia Region; thus, changes in this pathway resulting from the military relocation are not likely to negatively affect the Micronesia Region.

A3.3.9 Overview of Pathways and Associated Safeguarding Challenges

Pathway	Significance of pathway	Safeguarding challenges
People	People may introduce plant pests intentionally or accidentally. Outdoor activities facilitate pest spread. More people will travel to and around the Region.	1. Lack of education about phytosanitary risks and prevention measures 2. Inadequate agricultural inspection staffing and equipment 3. Insufficient agricultural training and focus (inspectors) 4. Smuggling
Personal effects of military personnel	May be contaminated with pests, especially if it has been used or stored outdoors (bicycles, barbecue grills, outdoor furniture, etc.)	1. Lack of education about phytosanitary risks and prevention measures 2. Insufficient agricultural training and focus (military personnel conducting inspections) 3. Smuggling 4. Lack of compliance checks and quality assurance program
Shipping containers	External and internal contamination is common. Transported to multiple ports. Storage practices leading to recontamination. Loading practices may attract pests.	1. Insufficient equipment, space, and resources for agricultural inspection 2. Inspection of containers is rare 3. Cleaning is difficult and often not feasible
Wood packaging material	Wood-boring pests, contaminating pests, and soil contamination are common. Routinely reused and recycled. Inspection is difficult and rarely occurs.	1. Domestic WPM not subject to U.S. phytosanitary regulations 2. Inadequate agricultural inspection staffing and equipment 3. Recontamination due to outdoor storage
Construction materials: wood	Wood-boring pests and contaminating pests are common. Storage practices can lead to recontamination. Contact with disturbed sites facilitates pest establishment.	1. Phytosanitary treatment not required for some types of timber
Construction materials: concrete, sand, steel, etc.	Frequently contaminated with pests and soil. Storage practices can lead to recontamination. Inspection is difficult and rarely occurs. Movement to disturbed sites facilitates establishment.	1. Enforcement of existing regulations is lax 2. Insufficient inspection of incoming materials 3. Lack of phytosanitary procedures at construction sites

Pathway	Significance of pathway	Safeguarding challenges
Construction and other equipment	External and internal contamination with pests and soil very common. Contact with disturbed sites facilitates pest establishment.	1. Enforcement of existing regulations is lax 2. Insufficient inspection of incoming equipment 3. Lack of phytosanitary procedures at construction sites
Soil contamination	Soil that contains plant pests can adhere to containers, machinery, personal effects, agricultural commodities, shoes, and construction equipment. Numerous pests can be found and can survive for a long time in contaminating soil.	1. Insufficient resources for agricultural inspection staff 2. Lack of education about phytosanitary risks and prevention measures 3. Soil-cleaning procedures not in place for equipment moving from Guam to CNMI
Aircraft	Often visit multiple ports in short timeframe. Loading practices can attract pests.	1. Inadequate agricultural inspection staffing and equipment 2. Pest entry and contamination during loading/storage of aircraft 3. Inspection very difficult due to large size of aircraft
Maritime vessels	Often visit multiple ports in short timeframe. Loading practices can attract pests.	1. GCQA officers not allowed to board/inspect military vessels 2. Inadequate agricultural inspection staffing and equipment 3. Inspection is very difficult due to large size of ships
Propagative material	Plant material may become invasive itself or may be infested with pests. Increased landscaping needs of military and civilian population will likely increase imports of propagative materials. Landscaping activities may also facilitate further spread of already established exotic pests.	1. Inadequate agricultural inspection staffing and equipment 2. No weed risk assessment is required for plant importation 3. No code of conduct for nurseries, landscaping businesses, or other entities to promote responsible phytosanitary practices 4. Lack of education about phytosanitary risks and prevention measures 5. Smuggling 6. Very few phytosanitary requirements in place for domestic imports

Pathway	Significance of pathway	Safeguarding challenges
Mail	Plant pests are frequently transported through the mail, both intentionally and accidentally. Internet sales facilitate the movement of pests in the mail. Domestic mail volumes will increase as population of Guam increases.	1. Majority of domestic mail is not inspected 2. Lack of education about risks of sending agricultural materials in the mail 3. No existing mail inspection system in some parts of the Micronesia Region 4. Inadequate agricultural inspection staffing and equipment 5. Smuggling 6. Federal regulations hinder the inspection of domestic mail
Potting media	Direct contact with landscapes facilitates spread of pests.	1. Enforcement of existing regulations (sterilization)
Agricultural commodities	Most of the fruits and vegetable consumed on Guam are imported; most of these imports are domestic imports from the continental United States. May be contaminated with a multitude of pests. Agricultural commodity imports will increase as the population of Guam increases.	1. No phytosanitary requirements for most domestic imports.
Regulated garbage	Contamination with pests possible. Not a big phytosanitary concern if existing regulations are followed.	1. Enforcement of existing regulations

A3.3.10 Safeguarding Challenges–General Observations

Based on our risk assessment, we identified a number of overarching safeguarding challenges that pertain to all of the pathways discussed. Most of these challenges are not specific to Guam, but exist to some degree in any location where safeguarding activities take place.

A3.3.10.1 *Regulations, Guidelines, and Standard Operating Procedures*

Within the federal regulatory framework, Guam (and CNMI) are often considered part of the United States and fall under APHIS domestic quarantines (7 CFR § 318) as well as foreign quarantine regulations (7 CFR § 319). For example, commodity imports into Guam are subject to the federal risk assessment process; mail sent to Guam from the United States is considered domestic mail; and the movement of WPM between Guam and any part of the United States is considered domestic movement. This approach does not take into account Guam's special geographic, biological, and political reality and leaves Guam vulnerable to exotic pest introductions. While Guam has the authority to protect itself through its own regulations, this is neither economically nor political feasible.

In addition, regulations do not always sufficiently address existing pest threats, in part because the regulations are out of date, and in part because they are not based on an accurate assessment of pest risk. Moreover, regulations usually do not provide specific guidance on safeguarding actions. For example, regulations give GCQA and APHIS the authority to carry out inspections, but do not specify what exactly an inspection entails or how it should be conducted. Such details must be provided by separate guidelines or standard operating procedures (SOPs); however, guidelines or SOPs do not always exist where they are needed. In addition, the language of some guidelines or SOPs is vague enough to allow for a broad interpretation.

A3.3.10.2 *Phytosanitary Inspection*

Inspection presents an immense challenge in a number of different ways. First, the number of incoming items and the time required for their inspection do not permit thorough inspection of all incoming items. Second, inspection is hindered by logistical challenges, such as the necessity to unload cargo containers for thorough inspection and the lack of the necessary space and equipment for inspection. Third, the detection of plant pests is inherently difficult, as these pests tend to be minute, hidden, or both. Plant pathogens are practically impossible to detect if the infected plant material is asymptomatic, which is frequently the case. Also, inaccurate or imprecise information provided on import manifests sometimes makes it difficult for inspectors to identify shipments that contain materials of plant quarantine significance. Given these shortcomings, a majority of incoming plant pests routinely escape detection, and phytosanitary inspection tends to be overrated as a safeguarding tool.

A3.3.10.3 *Collaboration*

As in other locations, various entities work together to safeguard Guam against the introduction of exotic plant pests. GCQA and USDA-APHIS-PPQ collaborate not only with each other, but also with port management, the USPS, various other agencies, and industry on the island. Safeguarding success depends on productive and efficient collaboration, and there is considerable opportunity for improving existing working relationships. Especially regarding the mail pathway, an effort towards improved collaborations seems to be advisable.

A3.3.10.4 *Education*

Education on several levels is an important component of any safeguarding system: safeguarding personnel must receive the necessary training to be effective at their job (e.g., training in pest detection and pest identification); military personnel must receive adequate training on the potential impact of exotic plant pests and on ways to prevent their introduction and spread; similarly, the general public must be made aware of the exotic species problem and of opportunities to support safeguarding efforts.

A3.3.10.5 *Data*

Reliable data is necessary for assessing pest risk, evaluating the efficacy of safeguarding programs, weighing costs and benefits of safeguarding actions, and allocating resources. Lack of reliable data is a common problem in the United States; however, in Guam and the Micronesia Region this problem is much more pronounced. Pest interception data are not consistently recorded; especially on the side of the DoD, no pest interception records seem to exist. Import data often do not distinguish Guam from the mainland United States, and reliable import data don’t exist for the other Micronesian Region countries. There is little information on the number of conveyances and containers processed at the ports of entry, and data on mail volumes are lacking. The number and type of inspections performed is generally unknown.

A3.4 RECOMMENDATIONS

A3.4.1 Staffing and Infrastructure

- Ensure sufficient staffing (e.g., plant safeguarding specialists, identifiers, surveyors) to accomplish all necessary inspection and quarantine activities in the Micronesia Region. Already insufficient staffing levels will become further strained as a consequence of the military relocation as the workload at airports, maritime ports, the mail facility, and the Plant Inspection Station increases. Quarantine officers with plant health expertise should be on duty to clear cargo and conveyances whenever aircraft or maritime vessels arrive. Quarantine officers must be adequately trained in all aspects of their work and should receive periodic refresher training.
- Ensure availability of necessary equipment. Equipment necessary for effective safeguarding, such as hand lenses, microscopes, and computers, must be available to quarantine officers. X-ray machines or other appropriate scanning technology and cleaning equipment such as power washers must be provided where needed. A sufficient number of lifts must be available for sea cargo container inspections. All equipment must be maintained in working order over the long term. APHIS manuals provide detailed guidance on necessary equipment.
- Establish decontamination sites for cleaning military and other equipment. Such sites must be available at all locations where military training exercises will take place and at the ports of entry. Sites should contain a quarantine area for storing contaminated equipment prior to cleaning. Precautions must be taken to prevent contaminated water to run off into the soil. Ensure that wash systems used are effective (see Balbach et al. 2008, Flemming 2008).
- Deploy detector dogs and handlers a) to mail facility for efficient screening of mail for plant pests and to establish probable cause for inspection of domestic mail, and b) to airports for screening baggage for plant pests.

A3.4.2 Point-of-entry Activities (Cleaning, Inspection, Treatment)

- Conduct phytosanitary inspection of all arriving conveyances, military and non-military, for contaminating plant pests. Inspection must include a thorough search for contaminating pests on the exterior and the interior of the conveyance. In the case of military vessels, either PPQ safeguarding specialists must be made available to inspect military vessels, or GCQA officers must be allowed to inspect military vessels instead of PPQ safeguarding specialists.
- Conduct phytosanitary inspection of WPM. An adequate percentage of all domestic and foreign, military and non-military, WPM accompanying agricultural and non-agricultural cargo must be thoroughly inspected for pests. The help of a statistician should be enlisted to determine adequate sample size and inspection protocol. SOPs should be developed to

ensure consistent inspection methods. All inspections and pest interceptions should be carefully documented. Pest interceptions should also be recorded in the relevant APHIS database to be available for analysis that may contribute to safeguarding improvements and quality control.

- Conduct phytosanitary inspection of all incoming construction materials for contaminating pests, including materials that have been previously treated or cleaned (due to high chance of recontamination after treatment) and including construction material from the United States.
- Clean and disinfect containers and conveyances that arrive in the Micronesia Region contaminated with soil or exotic plant pests. Follow all current APHIS policies and guidelines. Evaluate the effectiveness of current cleaning methods and improve effectiveness as appropriate.
- Properly clean all equipment (construction and military) according to APHIS guidelines prior to entry into any part of the Micronesia Region to remove hitchhiker pests and soil contaminations. Equipment must also be cleaned before moving within the Micronesia Region (between countries, between islands of the same country, and, where appropriate, between areas of the same island).
- Establish an effective mail inspection system on Guam. Follow a similar model as Hawai'i to use detector dogs for establishing probable cause for inspection of first-class USPS packages. Use appropriate scanning technology for all other incoming mail. For mail arriving via Hawai'i, either ensure adequate level of inspection in Hawai'i or else carry out inspection in Guam. Establish effective working relationships to ensure that safeguarding personnel can carry out their responsibilities. Safeguarding personnel must have sufficient access to the postal facility.
- Treat storage areas with mollusicides or install mollusk barriers to prevent mollusks from infesting WPM and shipping containers. Remove weeds and other contaminants from container and WPM storage areas. Storage areas should be hard surface or gravel.

A3.4.3 Regulations, Guidelines, and Compliance

- Strengthen existing regulations and guidelines for all jurisdictions and consider options for improving pre-border activities that may assist in reducing risks.
- Require mandatory training of all construction and contracting companies used by both DoD and public sector developers hired by the Military.
- Systematically review all guidelines and SOPs of phytosanitary relevance. Ensure that they are clear, complete, and detailed. Develop guidelines or SOPs where they are lacking.
- Enforce full compliance with all applicable existing federal, GovGuam, and military regulations, guidelines, and SOPs. Issue adequate fines for violations.

- Require treatment of all WPM according to ISPM No. 15. All domestic and foreign, military and non-military, WPM entering the Micronesia Region should be required to be compliant with ISPM No. 15. Even though these treatments do not fully mitigate pest risk, they help reduce the presence of pests, especially wood-boring pests.
- Require phytosanitary treatment of all imported timber, including timber from domestic locations in order to mitigate the risk of pest entry on this pathway. Required treatments should have been scientifically shown to be effective in removing pests.
- Require weed risk assessment for the importation of exotic plant species. Prohibit the importation of all plant species exotic to and not yet naturalized on Guam unless they have been deemed unlikely to become invasive by a weed risk assessment. Exceptions may be made for plants that have been historically imported without becoming invasive.
- Develop best management practices for contractors and construction sites. Work with industry and gain their support in helping to prevent the introduction and spread of exotic plant pests. Implement "clean" practices at construction sites to minimize land disturbance and spread of plant pests.
- Adopt a voluntary code of conduct for nurseries, landscaping companies, hotels, and other businesses as appropriate to promote the sale and use of native and non-invasive plants. This code of conduct should stipulate that the businesses:
    - ensure that their staff is knowledgeable on the subject of invasive plants
    - help educate their customers about invasive plants
    - immediately report any potentially exotic pest organisms found on their premises
    - use native plants or non-invasive plants locally sourced
- Revise the DoD landscape plan by removing plant species that are or have the potential to be invasive in the Micronesia Region or Hawai'i. Request technical support from the University of Guam as appropriate.

A3.4.4 Education and Training

- Provide adequate education about the potential negative consequences of spreading plant pests and about ways to prevent pest spread. Provide a list of enterable and prohibited materials. Create awareness of the potential legal consequences of violating the law. Educate people on how they can actively contribute to exotic species prevention efforts. Educate military personnel and dependents; non-military workforce; tourists; the general public; and private industry.
- Provide training to increase inspection and identification expertise. Safeguarding inspectors (both non-military and military) should receive adequate training on a regular basis teaching them the proper techniques for detecting, extracting, recognizing, and identifying pests. A

communication network for continuously sharing relevant new information is also recommended.

- Provide specific and detailed guidance to military personnel on how to inspect clothing and personal effects for plant pests.

A3.4.5 Additional Safeguarding Practices

- Implement systematic surveillance for exotic pests, following the model of the Cooperative Agriculture Pest Survey. Surveillance should take place both on and outside of military lands. A transparent and well-documented process of pest prioritization, surveillance, data collection, and record keeping must be followed. Communication of survey results throughout the Micronesia Region would be an essential part of any survey program. Early detection of new pests increases the chances that these pests can be eradicated or controlled. Consider employing the help of qualified volunteers, such as amateur taxonomists or university students to reduce costs.
- Improve record keeping including recording types and quantities of inbound materials for all jurisdictions, such as agricultural products and origins of such products.
- Conduct periodic surveys of ethnic markets and grocery stores to intercept prohibited plant products, following the model of or cooperating with USDA-APHIS-PPQ Smuggling, Interdiction and Trade Compliance.
- Preferentially load conveyances in a way that minimizes pest entry. For example, avoid nighttime loading because lights attract insects.
- Minimize pest contamination of containers and WPM by:
    - minimizing storage outdoors
    - sealing surfaces of storage sites
    - keeping storage sites clean
    - controlling pests around storage sites
    - limiting the use of nighttime lighting around storage sites
- Re-export infested or non-compliant WPM (as opposed to chipping it). Chipped WPM may present a pest risk when the chips are re-used or improperly disposed of.
- Carefully inspect plant material recovered from construction sites for plant pests prior to replanting.

A.3.5 ACKNOWLEDGMENTS

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Reviewers from USDA-APHIS:

Leslie Newton, Rob McDowell, Mitch Nelson, Jim Warren, Maria Borja, and Gary Cave

We also thank the numerous people who met with us on our site visits to the Micronesia Region to share their expertise and answer our questions.

A4 TERRESTRIAL VERTEBRATES

This section of Micronesian Biosecurity Plan—*Methods and Strategies to Manage Invasive Species Impacts to Agriculture, Natural Resources, and Human Health and Safety Project*—was prepared by APHIS-WS, National Wildlife Research Center, Hawai'i Field Station.[6] The suggested citation for this section is: Wildlife Services, National Wildlife Research Center, Hawai'i Field Station, Methods and Strategies to Manage Invasive Species Impacts to Agriculture, Natural Resources, and Human Health and Safety Project. 2010. Terrestrial vertebrates. *In* Terrestrial plant and animal health risks associated with the U.S. military relocation in the Micronesia Region. United States Department of Agriculture, Animal and Plant Health Inspection Service. Washington, D.C.

A4.1 UNINTENTIONAL PATHWAYS

A4.1.1 Summary

The movement of the 3rd Marine Expeditionary Unit from Okinawa to Guam and associated actions will greatly increase maritime and air traffic, cargo movement, and military training exercises. As a result, the potential for the unintentional (Section A4.1) and intentional (Section A4.2) transport and introduction of terrestrial vertebrate species will also increase. A high management priority is preventing movement of the brown treesnake (*Boiga irregularis*) (hereafter, BTS) from Guam and Saipan; hence air and seaport biosecurity measures include screening of departing aircraft and cargo exports. The transport and introduction of terrestrial vertebrate species within the Micronesia Region has the potential to negatively impact the region's human health and safety, economy, and ecology.

In this section, we conducted a pathway-based risk assessment to determine the means by which terrestrial vertebrate species are unintentionally transported from one location to another in association with the military relocation. We used methods developed by the National Invasive Species Council and the Aquatic Nuisance Species Task Force to identify routes of transport that were related to, and affected by, the military mission; these routes were organized as pathways involving air transportation (the aircraft itself), water transportation (the vessel itself), cargo and cargo conveyance transportation, and transportation of people and baggage. We quantitatively ranked pathways based on the numbers and types of species they could transport, frequency of pathway use, species control measures currently used, characteristics of the pathway or species, and regulatory procedures currently in place governing the specific pathway. Each pathway was assigned to an impact category based on whether the species involved could harm human health and safety, the economy, or the ecology of the region.

Most pathways evaluated were rated as high risk because they all had the potential to transport species that could harm human health and safety. Species of particular concern are BTS and rodents because these species could be transported in the majority of the pathways. Pathways with the highest risks

[6] We gratefully acknowledge the following reviewers from USDA-APHIS for their assistance during this project: Leslie Newton, Rob McDowell, Mitch Nelson, Jim Warren, Maria Borja, and Gary Cave. We also thank the numerous people who met with us on our site visits to the Micronesian Region to share their expertise and answer our questions.

were related to the transport of military cargo that is associated with the relocation and for use in training exercises and deployment missions; military field missions and training exercises have the most potential to place gear and personnel in areas where the BTS occurs or could likely establish if introduced. Additionally, there are insufficient resources to meet current inspection requirements and demand, and military activities are expected to exacerbate the problems of an already burdened biosecurity system. For example, even if communications occur, either formal or informal, between the military, customs officials, and agricultural officials on Tinian when an inspection is required, the response capabilities do not exist, thereby preventing adequate inspections from occurring. Inspections of aircraft and vessels are focused on preventing the movement of agricultural pests and vectors of disease; therefore the likelihood of detecting terrestrial vertebrate species is decreased. Short transportation durations such as on aircraft and military high-speed vessels increase the probability of species survival during transport. Currently, GCQA can inspect military vessels and aircraft, unless the craft is carrying classified cargo, is actively engaged in warfare, or has already been pre-cleared. The least amount of risk was associated with fruits and vegetables as these are inspected closely, although only a portion of each shipment gets inspected.

Preventing the transport and introduction of terrestrial vertebrate species in the Micronesia Region will require a high degree of cooperation among agencies and increased awareness of the risks associated with invasive species. Additional resources like funding and enforcement are necessary to improve inspection procedures, maintain efficiency in current control measures, and allow for a higher level of biosecurity for the region. It is far more cost-effective to prevent the movement of species in the first place, than to implement management for the control and eradication of species that become established.

A4.1.2 Introduction

A4.1.2.1 *Methods*

The risk analysis process we used was developed jointly by the NISC Prevention Committee and the Aquatic Nuisance Species Task Force (ANSTF) collaborating as the Pathways Work Team in support of the NISC Management Plan (ANSTF and NISC 2007). Although some details of this risk analysis method did not always fit well with data on terrestrial vertebrate invasive species, the stepwise analysis allowed us to elucidate all of the potential risks. Thus, the absolute value of the risk score was not as important as the relative evaluation compared to other pathways and the identification of risk factors. Our risk analysis is pathway-based, meaning it focused primarily on the means by which species are transported and introduced, as well the species being moved. We identified the mission-related pathways in the Micronesia Region (associated with the military relocation), and then assessed those pathways based on the species likely to be transported in each.

The risk of transporting and introducing terrestrial vertebrate species for each pathway is evaluated based on a three-step nested process that assigns a risk factor based on aspects like the type of pathway, the species that may be transported, and current biosecurity measures in place in the region. First, mission-related pathways are identified, and each is then assessed based on a list of potentially invasive species that have been, or are likely to be, transported through each pathway. Impact category rating for a pathway depends upon the species that may be transported in that pathway; impacts, in descending order, are to human health and safety (Impact Category A), the economy (Impact Category B), and the ecology (Impact Category C). Thus, a species that poses a human health risk is assigned the highest category even though the number of people that are affected by the health risk is small compared to those affected economically (ANSTF and NISC 2007). Second, pathway scope level is evaluated based on the geographic area potentially affected by species transport and introduction. This ranking uses the number of incidents that may occur and how large an area may be affected. A pathway that provides for multiple invasive species across international boundaries is ranked the highest, whereas a pathway limited to a single potential event in a localized area is ranked the lowest. For example, risk could be intra-island (Pathway Scope I), inter-island (Scope II), between island groups (Scope III), between regions (Scope IV), and international (Pathway Scope V).

Third, the pathways are then evaluated according to a fixed set of criteria (16 questions) that capture the capacity of the pathway to transport invasive species and the likelihood that the invasive species will move through the pathway undetected in sufficient numbers to establish an incipient population. The 16 questions addressed issues pertaining to a) probability of species transport, b) invasiveness of species, c) the attributes of the pathway related to species movement, and d) control-interdiction-eradication methods. Each question was rated on a whole number scale of 0-10 (0 = No Risk) (Table A4-1). Risk ratings were science based and supported by quantitative datasets, peer-reviewed scientific literature, and expert opinion and expertise (NISC 2005; ANSTF and NISC 2007). Information content was evaluated in risk assessments by criteria such as if it was out of date, scant in detail, or not available, and/or if information was lacking for a pathway, or for a species not typically targeted for detection, able to escape detection and/or interdiction methods in use, or detected incidentally and never reported. Where species- and pathway-specific information was lacking, indirect information was used to supplement assessments. Such information included temperature-monitored shipments of laboratory mice in experimental studies on survival rates during air transport, as an indication of thermal conditions experienced by a hitchhiker (Syversen et al. 2008), or experiments determining ship stowaway rates of rodents within a specific commodity (Baker 1994).

Table A4-1: Whole Number Risk Level Determination Used For Assessing Each of the 16 Evaluation Criteria

Whole number level determination	Level descriptor
Level 0	No Risk
Level 1-2	Extremely Low Level of Risk
Level 3-4	Moderately Low Level of Risk
Level 5-6	Medium Level of Risk
Level 7-8	Moderately High Level of Risk
Level 9-10	Extremely High Level of Risk

Critical to the evaluation process was rating uncertainty, which exists to varying degrees in any risk assessment and thus was included in the analyses (Caley et al. 2006; ANSTF and NISC 2007). If there were unknowns, we could not be 100% certain of the risks involved; therefore, ratings represented how certain we were in our assessment of risks. Uncertainty was rated on a whole number scale of 1-5 (1 =

slightly uncertain) (Table A4-2). A general rationale for the uncertainty rating, such as flaws in methodology (Table A4-3), was coupled with specific details to provide justification. For example, the increased use of technologically advanced military vessels and aircraft in the region is a political impediment because biosecurity resources are already taxed, and a reason for biological unknowns because pathways are new, hence they lack information such as species-interception data.

Table A4-2: Whole Number Ratings of Uncertainty in Risk Assessments

Whole Number Uncertainty Level	Uncertainty Descriptor
Level 1	≥ 95 percent confident of assessment (slightly uncertain)
Level 2	80 percent – 94 percent confident of assessment
Level 3	65 percent – 79 percent confident of assessment
Level 4	50 percent – 64 percent confident of assessment
Level 5	≤ 49 percent confident of assessment (highly uncertain)

Table A4-3: General Basis for Uncertainty in Risk Assessment Ratings

Basis of Uncertainty
Flaws in methodology
Lack of expertise
Lack of issue coherence
Biological unknowns
Insufficient information
Political impediments
Other–Define

Numerical scores for the 16 questions were averaged for pathway risk rank; uncertainty ratings were also averaged and factored into risk ratings. Each pathway receives a risk score based on the combination of these three steps: a risk impact category (to human health, economy, ecology), a pathway scope level (local to international), and pathway risk ranking, which were used to determine the scale of invasiveness from a tabulated scoring ranging from 1 to 200; scores below 50 were assumed to have no harmful impact, from 51 to 100 were considered to be ecologically significant, from 101 to 150 economically significant, and from 151 to 200 significant to human health and safety (ANSTF and NISC 2007). The final numerical score provides a rough index to prioritize the pathways for significance. Rationale for each final risk rating was given in brief narrative format, followed by a list of specific risks identified for that pathway.

The Pathways Work Team grouped pathways under three umbrella categories of Transportation (T), Living Industry (L), and Miscellaneous (M). Pathways were assessed for the potential to unintentionally transport terrestrial vertebrate hitchhikers, defined as terrestrial vertebrate species unintentionally moved to a different location in cargo, packing material, or a shipping container used for transport, or on/in the conveyance of transport (Meissner et al. 2009). These pathways have been linked to the rapid, worldwide movement and spread of invasive species (Burgiel et al. 2006; Meyerson and Mooney 2007; Westphal et al. 2008; Hulme 2009; Osborn 2010). We defined an invasive species as a nonnative species whose establishment causes or is likely to cause harm to human health and safety, the economy including agriculture, or the ecology of places where they have been introduced (NISC 2005). Expected increased activities in these pathways during and following the proposed military relocation further increases the probability of unintentionally transporting invasive terrestrial vertebrate species throughout the Micronesia Region (Westphal et al. 2008).

Unintentional transport of hitchhiking terrestrial vertebrate species occurs in a number of ways. Hitchhiking species may initially become attracted to certain physical or chemical conditions. Examples include rats (*Rattus spp*.) nesting in aircraft wheel wells (Vice 2010c), BTS sheltering inside shipping containers (Fritts et al. 1999), amphibians such as coqui frog (*Eleutherodactylus coqui*) laying eggs among nursery plants and associated materials (Christy et al. 2007c), and mice (*Mus spp*.) feeding on grain and garbage shipments transported overseas (Baker 1994). Hitchhiking might also result when intentionally transported species escape en route from cargo holds (Graglia 2003; TMG 2009). The swimming ability of some hitchhiking species, like rats and lizards, enables them to jump ship in favorable scenarios, such as when the vessels are close to shore (Perry et al. 2006; Russell et al. 2007; Peacock 2010).

Species lists were generated using those species known to be successful invaders. Only those species present at the origin site but not present at the destination site were used except for rodents, which can be exposed to a disease present at the origin site that is absent at the destination site, and therefore have the potential to spread disease if they reach the destination site. Species presenting a human health impact are considered high priority. Species of snakes, particularly BTS, and rodents like rats were included due to their impacts on human health, economic interests, and the ecology (Brennan 1980; Baker 1994; Stenseth et al. 2003; Kurle et al. 2008; Vidal 2008; CDC 2010e).

A primary management objective in the Micronesia Region is to prevent the spread of BTS from Guam (Vice et al. 2009). The risk assessment accounted for the potential to transport and spread BTS within the Micronesia Region (Engeman et al. 1998b; Fritts et al. 1999; Wiles et al. 2003; Rödder and Lötters 2010; Shwiff et al. 2010). BTS presents a unique circumstance in terms of biosecurity; whereas most customs and quarantine inspections occur upon arrival and importation of goods into a country, BTS inspections take place upon departure and export of goods (Vice et al. 2009). Many of the small amphibians and lizards that could also be potentially transported can also become a prey base for BTS (Pitt et al. 2005, Christy et al. 2007a, Christy et al. 2007c).

Information is gravely lacking on the science of species survival, or the physical environment experienced by species during varying transport situations, primarily because the science of biological invasions is relatively new (Wonham 2006), the research of species survival is complex in considering myriad factors and their combinations (Meyerson and Mooney 2007), and because the global movement of species is increasing faster than our ability to understand the consequences (Hulme 2009). Assessment of species movement was associated with pathway and species aspects such as the conduciveness of a pathway to transport species, the probability of species survival during transport, probability of survival in the introduced ecosystem, and the biosecurity measures in place. For example, species survival during transport depends upon several factors, including the type of species, an individual’s fitness, the duration of transport, and the thermal environment experienced by the hitchhiker (Syversen et al. 2008; Vice and Pitzler 2008). The type of species and its fitness will determine the animal's ability to deal with stressors like temperature extremes, starvation, and dehydration, as observed in a cat (*Felis catus*) that survived 17 days in a goods container shipped overseas from Israel to Britain (Associated Press 2006). Reptiles can endure long durations without food and water, as evidenced by a BTS that survived 7 months in a crate of household goods on a cargo ship from Guam to Texas (USGS 2005a).

Temperature variations and extremes during transport influence species survival. For ocean transport, thermal fluctuations and extremes are more likely in surface-shipped freight than for freight transported below decks out of the elements, the latter being more conducive to species survival (Vice and Pitzler 2008). Monitored air shipments of laboratory mice indicated that temperature variations and extremes were more common during international versus domestic flights, when freight handlers used commercial over private aircraft, and on transport routes with stopovers (Syversen et al. 2008). Survival also depends upon the availability of food and shelter during transport. For example, feral mice can stow away in garbage, hay, grain, household goods, dog food, mattresses, and tires (Baker 1994). A combination of these factors likely influences the probability of species survival (Vice and Pitzler 2008).

Several of the species listed in this risk assessment have characteristics that would allow them to survive during transport, e.g., the ability to survive periods without food or water, or endure varying thermal environments during transport, such as the cold temperatures of aircraft cargo holds. House mice can survive short durations without food, and can adapt to gradual, rather than sudden, decreases of water intake (Haines et al. 1973; Newsome et al. 1976). In laboratory experiments, musk shrews (*Suncus murinus*) survived 32 hours of fasting and lived up to 25 days on 25% of their normal daily food consumption (Wayne et al. 1991; Yasuhara et al. 1991).

For the frog species *Hyla cinerea* (American green tree frog), the presence of a cutaneous barrier prevents excessive water loss (Wygoda and Williams 1991; Wygoda and Garman 1993); in laboratory experiments, this species endured a week of starvation and a 37% loss of body water (Layne Jr. et al. 1989). Arboreal frogs of the genus Litoria have lower rates of evaporative water loss than arboreal frogs in North America, also due to a cutaneous lipid barrier (Main and Bentley 1964; Buttemer 1990; Christian and Parry 1997). For *Rana sylvatica* (wood frog), a terrestrial hibernator, the ability to survive temperatures ranging from 1.5°C to 15°C and withstand long periods submerged in ice water (Light 1991; Muir et al. 2007) demonstrates the variable thermal environments tolerated by this species during transport.

The green anole (*Anolis carolinensis*) can also endure periods of starvation. In one laboratory experiment, the species was able to withstand up to 12 days of starvation (Windell and Sarokon 1976; Brown and Griffin 2005), and in another, they survived a very restrictive food intake regime for 4 weeks (Speedy and Mumme 1994). Other laboratory studies indicate green anoles are able to acclimate to and withstand temperatures ranging from 10°C to 35°C (Ragland et al. 1981; Art and Claussen 1982). In response to conditions of low humidity, the green anole can decrease the rate of cutaneous evaporative water loss, possibly through the deposition of lipids in the skin (Kobayashi et al. 1983; Kattan and Lillywhite 1989). In laboratory experiments, BTS were able to survive temperatures as low as -5°C for 1 hour, with half of those surviving temperatures up to 39°C (Christy et al. 2007b). Boa constrictors (*Boa* *constrictor*) were able to survive up to 168 days without food in the laboratory (McCue 2008). Southern ringneck snakes (*Diadophis punctatus*) withstood temperatures ranging from 3°C to 36°C, but could not survive for extended periods of time at 36°C (Henderson 1970). Burmese pythons (*Python molurus bivittatus*) can go up to a year without eating (Starck and Beese 2001, 2002). Red-sided garter snakes (*Thamnophis sirtalis parietalis*) survived for a month without food at 25°C in the laboratory (Starck and Beese 2002). Two species of habu (*Trimeresurus elegans and Trimeresurus flavoviridis*) have been reported to go for 2 to 3 years without food (Kamura and Nishimura 1992).

We factored in the likelihood of species establishing populations at arriving destinations, or the opportunity for species to establish extralimital populations in assigning risk ratings (Livo et al. 1998; Christy et al. 2007c). The likelihood of species establishing populations focused on either species-related or pathway-related aspects. Species-related aspects included assessments of the numbers, types, and frequency rates of species being moved, the viability of transported individuals, if species are difficult to detect within introduced ecosystems, if species are habitat generalists, and if species are further spread by human activity. Pathway-related factors included whether introductions are possible at multiple points of entry, frequency of pathway use, the types of screening procedures in practice at an entry or departure point, and also whether the pathway itself was conducive to moving the species.

Risk assessments accounted for cumulative effects of species transport and introduction. Alhough the cumulative effects of species introductions remain largely unknown (Baker 1994; Wonham 2006; Ricciardi 2007; Caut et al. 2008; Vidal 2008), repeated releases over an extended time period will increase the chance of successful invasion simply because the release “experiment” is repeated many times under different biotic and abiotic conditions, including different climates and seasons, fitness condition of released animals, and numbers of natural enemies present (Bomford 2008). Cumulative effects include invasive genes that spread among native populations rapidly and insidiously; invasive species hybridizing with native species can have biological, aesthetic, and legal implications. For example, populations of threatened California tiger salamanders (*Ambystoma californiense*) are at risk of losing federal protection as a listed species and becoming genetically extinct because of the rapid spread and introgression of introduced alleles from barred tiger salamanders (A*. tigrinum mavortium*) (Fitzpatrick et al. 2010). Further, it is expected that global climate change will exacerbate the worldwide problem of species invasions (Zhang et al. 2006b; Ward and Masters 2007; Sommer et al. 2010), resulting in uncertain long-term impacts. Such influence is evident in cane toads (*Rhinella marina*) introduced into Australia; the species is rapidly expanding its range in part because of changing environmental and habitat conditions (Christy et al. 2007c). Range expansion by introduced species allows them the ability to exert greater predation and competition pressures on natural ecosystems (White et al. 2008; Greenlees et al. 2010; Martin and Pfennig 2010).

Because preventive measures are touted as best management practices, the risk assessment took into account operational biosecurity measures in place for preventing the introduction of terrestrial vertebrate species (CDF and WWF 2002; MAF 2003; VPC 2007; Bomford 2008; Australian Government 2009;, Biosecurity New Zealand 2009a; CDF 2009; Galapagos Conservancy 2010). Risks were highest where efforts to prevent the transport of species were lowest. Risks were associated with gaps in biosecurity measures resulting from factors such as insufficient port screening capabilities (staff, equipment, etc.) (Wonham 2006, pg. 298), and regulatory provisions made for the military. For example, although military aircraft departing Guam undergo APHIS canine inspection for BTS, for urgent or medical missions aircraft may depart immediately without BTS inspection, thereby increasing the risk of species transport. The risk assessment also included aspects such as whether control measures are known, available, and effective, and whether control and eradication costs are feasible.

There were varying degrees of overlap among pathways. Overlap between military and civilian pathways resulted from the common use of facilities, such as military aircraft using commercial airport facilities (DeGuzman 2009). Overlap can occur when a species is able to access another pathway from the one it is in currently. For example, species may escape from cargo into a craft's recesses, or vice versa, as for escapees from a military aircraft carrier (vessel) to a staged aircraft (cargo). Overlap could also occur if animals are being intentionally transported, such as for research or for the pet trade, or as personal pets, and escape during transport (unintentionally) into a pathway.

Limited time and resources dictated the exclusion of some pathway assessment. We chose to focus on pathways associated with the relocation that seemed most likely to unintentionally transport terrestrial vertebrate invasive species. Cargo was not addressed as a single pathway because cargo and cargo conveyance transportation is complex; rather, cargo and conveyances, and their transport means, were addressed as they pertain to military activities in the region. Because of time constraints, not all sources of cargo were considered in each pathway; e.g., for plants transported in food-related pathways, the only source considered was the continental United States. Further, mail was not addressed as an unintentional pathway because it was presumed species moving in mail were most likely being intentionally transported, either legally or illegally; however, mail cargo and conveyance pathways are considered because they are capable of transporting species that escape from other pathways.

A4.1.3 Risk Assessment

A4.1.3.1 *Air Transportation*

The air transportation pathways focus on the aircraft itself as the mode of species transport. The term 'aircraft' includes both fixed and rotary-wing aircraft in military, commercial, and private sectors. Different types of military, commercial, and privately owned aircraft currently visit, are home-based, or routinely operate on Guam, with air transportation traffic in all three sectors expected to increase from military activities during and after relocation. Plans for the relocation include training and field exercises conducted on the islands of Tinian, Rota, and Saipan, which involve aircraft operations from Guam and from aircraft carriers.

Air transportation pathways are capable of unintentionally transporting mammals, reptiles, amphibians, and birds (Table A4-4). The Department of Transportation estimates that more than 2 million live animals are transported each year in passenger cabins and cargo holds (DOT 2005) as pets, laboratory, or medical research animals, or as a commodity in the wildlife trade, demonstrating the conduciveness of air transportation pathways in moving species and supporting species survival during transport (IATA 2010). Military forces may be required to deploy virtually anywhere in the world, with great potential for inadvertently spreading or introducing terrestrial vertebrate species (Dalsimer 2002).

Table A4-4: Invasive Species Transported in the Air Transportation Pathway

Class	Scientific name	Common name	Risk type[a]
Amphibians	*Eleutherodactylus coqui*	Coqui frog	ECN, ECL
	Kaloula pulchra	Asian painted frog	ECL
	Polypedates leucomystax	Common tree frog	ECL
Birds	*Padda oryzivora*	Java finch	ECN
Mammals	*Mus musculus*	Common mouse	H, ECN, ECL
Reptiles	*Boiga irregularis*	Brown treesnake	H, ECN, ECL

[a] H = health, ECN = economic, ECL = ecological.

Terrestrial vertebrate hitchhikers have been found aboard military and commercial aircraft (Brink 1968, U.S. Navy 2001). Incidents with military aircraft include BTS, and illustrate the ability of BTS to be transported over a large geographical region on aircraft (Table A4-5) (Claiborne 1997; USGS 2005a). Hitchhikers aboard civilian aircraft include rodent pups discovered by APHIS-WS inspectors in the rear wheel well of an aircraft that had landed on Guam in March 2010 (Vice 2010c). Both live and dead mice have been found within aircraft cabins (Michaels 2005; Bodry 2008; Moriarty 2010). Java finches (*Padda oryzivora*) were found within an aircraft cargo hold (Vice 2009). Four, 6-inch-long pythons escaped from an “appropriate” shipping container during a domestic Qantas flight over Australia and were never found upon arrival by luggage handlers or afterwards by fumigators (TMG 2009). Birds common around airport facilities such as house sparrows (*Passer domesticus*), starlings (*Sturnus vulgaris*), pigeons (*Columba spp*.), and mynahs (*Acridotheres spp*.) attract predatory reptiles and rodents that may then enter aircraft (Brink 1968; Christy et al. 2007c; Gandhi 2009; Cohen 2010).

Table A4-5: Examples of BTS Transport in Military Aircraft

Location	Year	Number of snakes found	Aircraft type
Kwajalein Atoll	1979	1	Cargo plane
Darwin, Australia	1984	1	B-52 bomber
Kadena AFB, Okinawa	1992	1	unknown
Hickham AFB, Hawai’i	1997	1	Cargo plane

Source: Claiborne 1997; Rodda et al. 1999b; USGS 2005a

Guam’s population is expected to increase due to the military relocation in both military and commercial sectors, thereby increasing air transportation activity throughout the region. Such activity includes military travel for training and services deployment. An increase is expected in military and civilian inter-island travel for recreation and tourism in the region, the latter necessary for regional economic growth. Travel may also increase for family visits to and from abroad. On Saipan, tourism is an economic driver alongside manufacturing. Rota boasts increasing economic development and legalized gambling, and has an emerging tourism industry that targets service members. Tinian’s primary community, San Jose, is agricultural. From 2000 to 2005, 90% of tourists visiting CNMI came from East and Southeast Asia (NOAA 2005). The expected increase in commercial air transportation traffic is evident in the scope of improvements underway at airports on Saipan, Tinian, Rota, and Guam (CPA 2007a, b; Todeno 2009; Deposa 2010; Guam ABWPIA 2010; Saipan Tribune 2010). Increased air traffic will increase the risk of vertebrate invasive species being transported on aircraft.

A4.1.3.1.1 *Commercial Air Traffic*

Commercial aircraft arrive and depart Guam at A.B. Won Pat International Airport, hereafter Guam International Airport, which serves "over 300 flights per week" (Guam ABWPIA 2010). These flights consist of daily international cargo and passenger transport. Traffic consists mainly of local aviators and inter-island taxi traffic, combined and referred to herein as commuter traffic (Table A4-6). Seven international airlines and six air freight couriers operate out of the Guam International Airport (WPIAA 2010b, a). Guam's commuter airlines include Freedom Air, Cape Air, and Pacific Island Aviation. Private jet planes traveling through the area are provided with full executive jet service and maintenance through Aviation Concepts, Airport Group International, and Guam flight services. The airport has 21 aircraft parking positions with 18 common use terminal gates (GEDA 2010). GCQA is available during scheduled aircraft operations and upon prior arrangement with field supervisors.

Table A4-6: Airport Operational Statistics for Guam and CNMI International Airports

	Guam[a]	Tinian[b]	Saipan[c]	Rota[d]
Aircraft based on the field	83	6	22	-[e]
Single engine airplanes	20	4	14	-
Multi-engine airplanes	10	2	8	-
Jet airplanes	52	-	-	-
Helicopters	1	-	-	-
Average aircraft operations/day	108	36	108	127
Percent commercial flights	55	<1	18	27
Percent air taxi flights	24	98	61	69
Percent local general aviation flights	21	1	2	3
Percent transient general aviation flights	<1	<1	16	<1
Percent military flights	<1	<1	1	<1

[a] For the 12-month period ending 04 May 2007 (AirNav 2010b).
[b] For the 12-month period ending 04 May 2009 (AirNav 2010d).
[c] For the 12-month period ending 31 December 2007 (AirNav 2010a).
[d] For the 12-month period ending 08 May 2008 (AirNav 2010c).
[e] Data unavailable.

The Francisco C. Ada Saipan International Airport houses several major airlines and a commuter terminal. Commuter traffic makes up the majority of the flights to and from Saipan (see Table A4-6). The major airlines are Asiana, Delta, United Airlines, Northwest Airlines, China Southern, Air China, Shanghai Airlines, China Eastern, and All Nippon Airways. They provide direct flights from Guam, Japan, Korea, Hong Kong, Manila, and China. Cape Air, Star Marianas, and Freedom Air provide commuter services to Tinian, Rota, and Guam (CPA 2007b; Deposa 2010;FlightStats 2010; POI 2010). The airport operates 24 hours, 7 days a week and has 24-hour availability of operating aircraft rescue personnel and equipment (CPA 2007b). Ground-handling services are provided by POI Aviation Services which is affiliated with Tan Holdings Company (POI 2010). Immigration and customs officials are available during scheduled operations, or by prior arrangements with the chief of Immigration Saipan (AirNav 2010a).

The majority of flights to and from Tinian are commuter flights (see Table A4-6). Tinian is serviced by Freedom Air, operating daily flights, and the privately chartered Star Marianas Air that provides services for the Tinian Dynasty Hotel & Casino customers (CPA 2005). Construction of a high-speed taxiway is currently being advertised for bid and is expected to increase traffic (AirNav 2010d). Ongoing construction of a new departure terminal is slated to be finished in September 2010 (Saipan Tribune 2010). The airport is equipped for night operation, with night flights from Saipan and Guam for the hotel and casino (CPA 2005). Immigration and customs officials are available during scheduled operations, or by prior arrangements with the chief of Immigration Saipan. The airport is also closed to unscheduled flights of carriers with more than 10 passenger seats without 24 hours' written notice to the airport manager (AirNav 2010d).

Traffic at the Rota International Airport also consists mainly of commuter flights, primarily from Saipan and Guam (see Table A4-6). Commuter airlines include Freedom Air and Cape Air, the latter a United Airlines Connection partner. Cape Air is suspending flights to Rota as of 5 October 2010 due to required scheduled maintenance on the ATR aircraft currently in service (PNC 2010). The airport is equipped for nighttime operations (CPA 2007a). Immigration, customs, and quarantine officials are available during scheduled aircraft operations and upon prior arrangements with field supervisors (AirNav 2010c).

United Airlines and its affiliates were selected as representative of these pathways, although other carriers provide similar services (Table A4-7) (United Airlines 2010). The flights listed in Table A4-7 are the flights that were evaluated and are by no means the only flights to and from Guam. Additionally, there are other carriers in the region other than United Airlines; however, many of their flights are similar to United's and are not listed here. From the continental United States, all other major carriers route through either Hawai'i or Japan.

Table A4-7: Representative Flights to and From Guam on United Airlines and Its Affiliates

Flight origin	Flight destination	Number of flights/day
Guam	Tokyo, Japan	3
Honolulu, Hawai'i	Guam	2[a]
Guam	FSM and RMI	1[b]
Guam	Palau	1
Guam	Saipan	6

[a] One flight is nonstop. The other flight makes five stops in Majuro (RMI), Kwajalein (RMI), Kosrae (FSM), Pohnpei (FSM), and Chuuk (FSM).

[b] Stops in Chuuk (FSM), Pohnpei (FSM), Kosrae (FSM), Kwajalein (RMI), and Majuro (RMI).

A4.1.3.1.2 *Military Air Traffic*

Military air traffic is expected to increase during and after the relocation as personnel are moved and training exercises increase. Military activities using air transportation pathways include those by the U.S. Transportation Command which oversees the movement of military personnel and equipment via aircraft, the U.S. Air Force Air Mobility Command that provides strategic and tactical airlift support for military operations by moving personnel and cargo, and the movement of military cargo not consigned to commercial carriers that would be transported by Air Mobility Command aircraft. Aircraft arrivals at Andersen AFB on Guam include both military and civilian flights resulting from training exercises, transporting military dependents, and moving cargo. Military aircraft are used in medical or other types of emergency missions, and these aircraft can depart Guam with little or no advance notice or BTS inspection. Aircraft operations for military training purposes are conducted by the Army, Marine Corps, Air Force, and Navy (U.S. Navy 2009j). Additional aircraft will be housed on Andersen AFB by the Marine Corps associated with the relocation, and additional training activities will occur (U.S. Navy 2009a).

On Tinian, the Marianas Island Range Complex draft EIS/Overseas EIS (U.S. Navy 2009j) identifies three range activities (strike warfare and two amphibious warfare activities) that presently include aircraft training (Table A4-8). Aircraft for these activities may come from the airfield or be staged on an aircraft carrier. The North Field on Tinian is an abandoned and unmaintained World War II era airfield with four runways. Two are abandoned and overgrown, one is used for military fixed-wing and helicopter activities, and the other is used for parachute drops and helicopter activities.

Table A4-8: Range Activities on Tinian Utilizing Aircraft

Training exercise	Type of aircraft utilized	Number of sorties/year[a]
Strike warfare (combat search and rescue)	SH-60, MH-60, HH-60, CH-53, C-17, C-130, V-22	≤ 75
Amphibious assault warfare	H-53, H-46, MV-22, UH-1, AH-1, AV-8	≤ 5
Amphibious raid warfare	H-53, H-46, MV-22, UH-1, AH-1, AV-8	≤ 2

[a] A sortie is defined as an operational flight by a single aircraft, as in a military operation.

Training missions associated with various aircraft staged on a carrier are identified in the Marianas Island Range Complex draft EIS/Overseas EIS, but actual numbers are difficult to come by (U.S. Navy 2009j). Should the carrier transit from Guam to CNMI, aircraft can redeploy rapidly with little time for an invasive species to leave the aircraft, particularly if this transfer occurs during daylight. Aircraft that are unloaded from the carrier while in port are considered cargo (U.S. Navy 2009b).

A4.1.3.1.3 *Aircraft Inspection*

Currently, biosecurity inspection procedures differ for military and commercial aircraft, between arriving and departing crafts, among the region’s airport security systems, and according to species of concern. Because inspections of any aircraft departing Guam, commercial or military, are primarily designed to detect BTS (BTS CEC 1996; USAF 2007), other species not specifically targeted have the potential to be missed or overlooked. Arriving military and commercial aircraft are not usually inspected for terrestrial vertebrate species by APHIS-WS unless an incident has been reported aboard (Vice 2010a).

Inspections for BTS

A Brown Treesnake Control and Interdiction Plan was developed by the Navy to prevent the movement of BTS off of Guam in response to Executive Order 13112, Invasive Species (The White House 1999; U.S. Navy 2005b). Executive Order 13112 made it the responsibility of all federal agencies to prevent the introduction and spread of invasive species in the United States and elsewhere. The BTS plan requires the military to cooperate fully with federal authorities during observations and inspections of cargo destined to be shipped from Guam. It also requires a close working relationship with APHIS-WS to effectively implement the plan. The plan directs the Department of the Interior and USDA to go through a rulemaking process on BTS inspections.

In general, all aircraft undergo similar inspection processes for BTS, regardless of the aircraft type and use. Planes that are not "quick turns" (on the ground for 3 hours or less) are inspected exteriorly using both detector dog and visual inspection. Very rarely are internal inspections of planes undertaken. It is highly unusual for a plane door to be left open if there is not someone immediately around the aircraft. If a plane is down for extended service, it is more likely to have hatches, doors, or exterior compartments open for extended periods. Depending upon circumstances, an internal inspection on such a plane may be done, but is not the norm (Vice 2010d). Additionally, if cargo is loaded onto a plane without prior inspection, an internal inspection of the craft may be conducted. In 2008 APHIS-WS inspected 88.6% of all departing commercial aircraft, and more than 98% of all departing military aircraft (USDA-APHIS WS 2008a).

All aircraft departing Guam are required to be inspected by APHIS-WS (U.S. Navy 2005b). APHIS-WS maintains dogs and equipment necessary to implement BTS control plans. During major exercises, commanders are to work with both Andersen AFB and APHIS-WS personnel to develop an aircraft parking plan to minimize BTS entry into aircraft. If APHIS-WS inspects an aircraft which subsequently is delayed in scheduled departure (after hours of darkness), WS may require another inspection prior to departure. Authority is given to APHIS-WS to stop the departure of aircraft from Guam, with some exceptions, if it is suspected to be harboring BTS; e.g., BTS inspections cannot delay medical emergency departures.

Military flight crews are instructed to keep doors of aircraft closed when the aircraft is idling to prevent entry of BTS, and to be aware of the potential for BTS presence during pre-flight inspections (U.S. Navy 2005a). All vehicles being shipped are required to be cleaned prior to departure from Guam. High-risk aircraft, such as those used in field exercises, may require additional measures. Such measures may include high-pressure washing, steam-cleaning, fumigation, or other methods required by DoD policy.

Military Aircraft Inspections

The Quarantine Regulations of the Armed Forces were written to allow the military to comply with the regulations of the U.S. Departments of Health and Human Services, Agriculture, Treasury, Homeland Security, Interior, and Commerce (DoD 1992). This was superseded by OPNAVINST 6210.2. The regulations are designed to prevent the introduction and spread of disease agents (human, animal, and plant), arthropod vectors, and pests of health or agricultural importance. The documents state that the military is to cooperate with the agencies listed above to comply with regulations. Inspectors from these agencies are authorized to board and inspect aircraft. However, inspectors from foreign countries are not allowed aboard aircraft, even to observe an inspection. In these cases, commanding officers certify compliance with the quarantine regulations of the foreign country to foreign officials. Certification may include a general description of the measures taken to be in compliance.

Section II, Subsection B of the Quarantine Regulations of the Armed Forces and Section 9b of OPNAVINST 6210.2 specifically govern aircraft (DoD 1992). Measures are to be taken prior to departure to minimize movement of human disease vectors and arthropod vectors of medical importance. Aircraft commanders are to comply with the medical and agricultural quarantine regulations of the destination country that are published in the U.S. Air Force Foreign Clearance Guide (AFR 8-5 and OPNAVINST

3710.2E). Aerosol disinfectants are required when leaving areas known to harbor yellow fever, malaria, or plague, unless a World Health Organization (WHO)- or DoD-approved disinfectant has been used and the aircraft contains certification to that effect. Commanding officers at the point of departure (embarkation) are required to determine whether mosquitoes or other vectors and pests of medical importance are near the airport. In addition, officers are required to undertake pest control measures to eliminate such pests, and minimize their access to aircraft. Commanding officers at the point of entry (debarkation) are required to eliminate breeding places that could be readily accessible to vectors or pests of medical importance, and to conduct routine surveillance for such pests.

Section II, Subsection C of the Quarantine Regulations of the Armed Forces and Section 10 of OPNAVINST 6210.2 cover the USDA requirements. These sections govern the movement of animal and plant diseases and pests. Aircraft moving between Hawai'i, Guam, Puerto Rico, the U.S. Virgin Islands, and the continental United States are required to undergo USDA inspection by a USDA inspector or representative. GCQA officers collaborate with USDA-APHIS to enforce federal regulations and have the authority to board military aircraft, provided cargo is not classified and the aircraft are not actively engaged in warfare (Taijeron 2010c), despite recent military questioning of the authority of GCQA to conduct inspections of military aircraft and ships (Delgado 2009, U.S. Navy 2009k). The disinfection measures currently available target primarily disease organisms and insects and may not be effective on many of the invasive species transported in aircraft. Subsection C requires surveillance aboard aircraft that includes spot checking and routine collection and identification of pest organisms.

The Defense Transportation Regulations, Part V establishes the requirements for agricultural cleaning and inspection, and the assignment of DoD personnel as agricultural and customs inspectors for pre-clearance programs. USDA-APHIS is responsible for providing DoD with guidance, information, and training to perform pre-clearance inspections (DoD 2009a). APHIS remains the final authority on the pest risk status of material or equipment. Stores and in-flight meals may not enter the United States and garbage must be placed in tight, leak-proof, covered containers and disposed of according to port procedures (DoD 2009a).

To facilitate redeployment operations, DoD can request pre-clearance inspections by CBP and USDA for cargo and equipment returning to the Customs territories of the United States (CTUS) (DoD 2009c). Pre-clearance inspections may be requested for redeployment from major exercises or contingencies, and are performed at the point of origin. Requests for pre-clearance inspections must be submitted no later than 75 days prior to when the inspection is needed. Requests must contain the following information: dates, times, and place of departure from a foreign country; date, time, and place of arrival in the CTUS; number and type of aircraft; identification of all stops between the point of departure and arrival; and whether the border clearance integrity of the aircraft will be maintained during en route stops. Examples of clearance integrity being breached are the addition or removal of cargo or passengers at any stop, crew member changes, off-loading of crew and passengers, or the aircraft remaining in a location overnight. Such breaches of integrity will void the pre-clearance authority.

Both CBP and USDA provide and approve training of Customs Border Clearance Agents for the military (DoD 2009c). When the planned destination is in the CTUS, Customs Border Clearance Agents inspect aircraft to ensure it is free of plants, animals, or plant and animal products. Equipment must be stored in a way that prevents re-infestation by pests. In addition, CBP can establish a Military Customs Inspectors–Excepted program at a DoD installation (DoD 2009d). Such a program allows DoD personnel to perform the same functions as CBP agents in connection with arriving military or military-chartered aircraft from overseas areas. Inspection duties of the DoD personnel under this program include customs, immigration, and agricultural inspections or functions.

The Armed Forces Pest Management Board published Technical Guide Number 31 to cover the cleaning and inspection procedures used in conjunction with retrograde washdowns (AFPMB 2008). Large aircraft that remain on the flightline are to have protected areas, such as wheel wells and around cargo and passenger doors, cleaned. A visual inspection of cargo and the flight deck is performed to determine whether further cleaning is needed. For fixed and rotary wing aircraft, the following areas are cleaned: cabin area, cockpit, wheels, wheel wells, skid/runner bars, under deck plates, panels, in flap wells, and all other areas where debris may lodge. Cleaning may consist of a water wash or steam as determined by the inspector on site. Washing and inspection of aircraft may only occur during daylight hours. We had hoped to see the cleaning of aircraft performed while we were on Guam, and specifically requested this, but were unable to schedule a demonstration.

Commercial Aircraft Inspections

The CFR provides some guidance on aircraft inspection and disinfection as it pertains to movement of regulated articles from Hawai'i and the territories, and movement of animals or animal parts. The pertinent portions are Title 7 (regulated articles from Hawai'i and the territories), Title 9 (movement of animals and animal parts), and Title 42 (public health). Title 7 (Subtitle B, Volume 5, Chapter 3, Part 3A.13-9 and Part 330.111) requires inspectors be notified prior to departure or arrival of aircraft on Guam, giving ample opportunity for the inspection process to occur. Title 9 (Volume 1, Chapter 1, Subchapter D, Part 93) allows the inspection of any aircraft from foreign locations without a warrant to determine whether the aircraft is carrying any animal or animal part subject to disposal to prevent the spread of disease. If the aircraft is found to be contaminated, the operator of the aircraft is responsible for disinfection. Title 9 (Volume 1, Chapter 1, Subchapter D, Part 95) also requires the disinfection of an aircraft if it has transported restricted items that were not contained in leak-proof containers. The method of cleaning prescribed in Title 9 (Part 95) includes the collection of litter and refuse, and disposal of that refuse by incineration or other approved method. This is to be followed by cleaning of the areas of the aircraft that were exposed to the contaminant and saturation of the contaminated surface with an approved disinfectant. The approved disinfectants are sodium carbonate solutions, sodium hydroxide solutions, or liquefied phenol. These disinfectants are specifically designed to target foot-and-mouth disease, rinderpest, and ticks. Title 42 (Part 71, Subpart E, Section 71.41) of the CFR states that carriers arriving at U.S. ports are subject to sanitary inspections to look for rodent, insect, or vermin infestation that may spread disease.

The APHIS-PPQ Manual for Agricultural Clearance contains information on the inspection of aircraft (USDA-APHIS-PPQ 2013). The manual instructs inspectors to look for "hitchhiking pests" on the aircraft, but does not specify whether this only refers to insects or also includes vertebrates. Inspectors are to board the aircraft after passengers have deplaned but prior to airline personnel, such as caterers and cleaners, to conduct their inspections. The areas to be inspected are the galley area and areas where stores are kept, passenger and crew areas, and cargo holds for cargo and military flights. The manual specifically instructs inspectors to look for hitchhiking insects in cargo holds, but does not mention vertebrate invasive species. Cargo holds are also to be inspected for plant and animal contamination and soil. If contamination or live pests are found, the aircraft must be disinfected. Disinfection procedures for animal contamination include treatment with Virkon®S or sodium carbonate with sodium silicate. Disinfection procedures for live pests are to be determined by a CBP Agricultural Specialist according to the APHIS-PPQ Treatment Manual. The treatment manual only contains guidance for treatment when khapra beetles, fruit flies, and soft bodied insects are found (USDA-APHIS-PPQ 2008). State aircraft are exempt from inspection unless there is a specific agreement in place that allows inspection. State aircraft are aircraft that have been given Diplomatic Overflight and Landing Clearance by the Department of State, Bureau of Political-Military Affairs, and Office of International Security Operations.

On July 18, 2007, the United States became a party to the International Health Regulations adopted by the WHO to mitigate public health risks associated with international travel (WHO 2005b). In 2009, the WHO published an updated guideline for hygiene and sanitation practices in aviation to protect passengers from serious illnesses (WHO 2009b). These regulations prescribe measures for routine cleaning of aircraft and procedures to be used when specific disinfection is required due to a known or suspected infected person traveling aboard the aircraft. All procedures in this guideline are focused on the spread of human disease primarily by humans or contaminated food and water.

Guam

GCQA officers clear aircraft, passengers, and cargo at the airport (Taijeron 2010a). There are seven officers at the airport to inspect air freight and 16 officers to process passengers (Taijeron 2010a). In addition to enforcing local regulations, GCQA officers collaborate with USDA-APHIS to enforce federal regulations (Taijeron 2010c). Inspections by the seven GCQA officers are focused on the interior of the plane and its compartments specifically to search for smuggled contraband, live animals, cargo with a manifest, agriculture violations, and abandoned agricultural items (Taijeron 2010b). In addition, GCQA ensures that garbage aboard aircraft meet local and federal requirements. If pests are found aboard the aircraft, the aircraft doors are shut, and appropriate measures are taken to handle the infestation (Reyes 2010).

Commonwealth of the Northern Mariana Islands

Aircraft from foreign countries arriving in Saipan are cleared by two separate agencies, Saipan Customs and Saipan Quarantine. In CNMI, the Customs Service is under the jurisdiction of the Department of Finance, whereas the Quarantine Service is under the Department of Lands and Natural Resources. All commercial aircraft arriving at the airport in Saipan from Guam are inspected by a BTS detector dog team (Pangolinean 2010). No other inspections are made. There are 14 quarantine officers assigned to operate 24 hours a day, 7 days a week. If a BTS is detected in an aircraft or cargo, Saipan Division of Fish and Wildlife is notified. In addition, if any animals or insects are found, the container is closed and APHIS-PPQ is notified. The Department of Land and Natural Resources, Division of Fish and Wildlife is in charge of training BTS detector dogs (Onni 2010). It takes 1 to 2 months to train a dog training 1 day per week. To be a certified BTS detector dog, dogs must be able to find 80% of the BTS present. Currently, there are four BTS detector dogs on Saipan, and one on Tinian. Funding has been obtained to place a BTS detector dog on Rota. There are 50 BTS traps at the airport, operated by the Division of Fish and Wildlife which currently must breed their own mice for the traps, that are serviced twice a week.

Currently, the BTS handler on Tinian only has a snake skin to train the single detector dog. Therefore, the dog is accustomed to finding a dead BTS as opposed to a live BTS. Additionally, because there is only one skin, the dog is used to finding only a single snake (Castro 2010). Additional training is provided off island, but it has been difficult to obtain matching funds from CNMI agencies to send personnel to the training. Personnel must breed their own mice for BTS traps, and recently some traps have been removed due to a lack of mice. The mouse colony on Tinian collapsed due to disease, and personnel did not have the resources to purchase new mice. On Tinian there are two issues; first, customs officials there are not always notified when aircraft bound for Tinian depart Guam without a BTS inspection, and second, even when notified, there is little or no response capability. Customs officials need approximately 12 hours prior notice to enable them to conduct the necessary inspections (Ferrell 2010).

Federated States of Micronesia

According to FSMC Title 18, Chapter 2 § 206, any aircraft entering FSM is subject to inspections by customs, immigration, agriculture, and administrative personnel. We were unable to find any information regarding exactly what these inspections entail. The immigration regulations of FSM state that all aircraft will be inspected for stowaways, presumably human (FSM ORC 2005). FSM developed a National Biosecurity Strategy and Action Plan in 2002 (FSM 2002), and each of the four FSM states (Kosrae, Pohnpei, Chuuk, and Yap) provided input for the plan. Overall coordination and support is provided through the Environmental Management and Sustainable Development Council and the Department of Economic Affairs.

Republic of the Marshall Islands

Aircraft entering or leaving RMI are subject to inspections by immigration, customs, agriculture, public health, or administrative personnel as stated in Title 43, Chapter 2, Section 205 of the Marshall Islands Revised Code (PacLII 2003). According to Title 8, Chapter 1, Section 110 of the Marshall Islands Revised Code, aircraft known or suspected to be harboring insects or agricultural pests are to be sprayed with an insecticide (PacLII 2004a). Any employee of the RMI Ports Authority may enter an aircraft for the purpose of inspection according to Title 22, Chapter 1, Section 153 of the Marshall Islands Revised Code (PacLII 2004c).

Palau

No information could be accessed regarding inspections of aircraft in Palau.

Japan

No information could be accessed regarding inspections of aircraft in Japan.

Hawai'i

Aircraft inspections follow the procedures outlined above for commercial aircraft inspections. There is a toll-free pest hotline to call if a BTS or other suspected alien pest is sighted, and various agencies and offices throughout Hawai'i have trained responders available.

Summary of Findings

All aircraft pathways were considered high risk because they can transport BTS and other IAS. In addition, rodent damage, such as gnawing aircraft electrical wiring, can have dangerous consequences (WHO 1995, pg. 7; Song et al. 2003; Moriarty 2010). Risk increased as the probability of species survival during transport increased. Higher risk was associated with planes on routes with few or no stops that travel over relatively short distances and/or durations, due to the increased probability of survival.

Risk also increased based on several factors related to the process of inspection. For military aircraft, risks were higher for conveyances not inspected, such as those departing on urgent missions, which are not delayed for BTS (or other terrestrial vertebrate) inspections. The risk of inspectors missing an invasive species increased as time constraints and equipment unavailability (broken or nonexistent equipment) increased, or the number of inspectors decreased. Risk rankings also reflected increased commercial air traffic without adequate increases in biosecurity needs, such as additional staffing for inspections and enforcement, updated equipment and facilities, continued training, and easier reporting capabilities.

A4.1.3.1.4 ***Specific Risk Factors***

The specific risk factors we found to be associated with the air transportation pathways are as follows:

Common Risk Factors

- BTS inspections may not address the movement of other potentially invasive species.
- No rapid response program or formal reporting network exists for introductory detections of vertebrate species other than alien snakes, albeit, the region does utilize informal networking to report potential alien species encounters and to ilicite support from a variety of internal and external resources. Formal reporting mechanisms with jurisdictional and regional coordinating offices established and utlitized would be preferable.
-
- Agricultural inspections at the port of entry may not adequately detect a vertebrate invasive species moving in aircraft.
- There are limited control measures for frogs and snakes that could be moved in aircraft pathways.
- There are no rapid lethal control methods for use to control reptile or amphibian infestations on aircraft.

Risk Factors Associated With Commercial Aircraft

- Inadequate financial resources exist in the CNMI, FSM, RMI, and Palau to maintain expensive control programs.
- Staffing is inadequate to meet current quarantine demands. Guam needs a total of 100 staff to meet anticipated demands of the relocation (Campbell 2010c). Saipan presently has 14 inspectors, and needs a total of 28 to meet demands (Pangolinean 2010). Tinian presently has 4 inspectors, and needs a total of 12 to meet demands (Berringer 2010c).
- Airports lack adequate screening equipment and facilities for effective and comprehensive inspections.

Risk Factors Associated With the Military

- The retrograde washdown and inspection process (AFPMB 2008) is focused on preventing the transport of agriculturally significant pests on vehicles and may not be effective for preventing the transport of vertebrate invasive species.
- Aircraft used in urgent missions such as search and rescue and medical evacuations are not delayed for BTS (or other terrestrial vertebrate) inspections.
- Communication is inadequate between the military and officials on Tinian to allow for proper inspections of aircraft associated with military training to occur, and even when notified, there is little or no response capability.

A4.1.3.2 *Water Transportation*

The water transportation pathways focus on the vessel itself as the mode of species transport, and include military, commercial, and private sector vessels. Types of vessels are numerous, including but not limited to rigid inflatable boats, long-line fishing boats, sailboats, amphibious landing craft, high-speed catamarans, cruise ships, container ships, cargo ships (bulk, break-bulk, roll-on/roll-off), aircraft carriers, landing craft utility vessels, barges, inter-island ferries, cruise ships and shuttles, platforms, and hovercraft. Different types of military, commercial, and privately owned vessels currently visit, are home-based, or routinely operate on Guam with water transportation traffic in all three sectors expected to increase from military activities during and after relocation. Plans for the relocation include the construction and use of training ranges for field exercises and activities on the islands of Tinian, Rota, and Saipan, which involves water transport of materials, equipment, and vehicles for range construction, operation, and field exercises. Assessment of these pathways excludes evaluating items carried on a ship such as cargo.

Water transportation vessels pose several risks in transporting terrestrial vertebrate species. The wide diversity of vessels operating in the Micronesia Region, along with the current and expected increase in vessel traffic due to military relocation, offer a variety of transport opportunities to hitchhiking terrestrial vertebrate pests. For example, on high-speed catamarans with long-distance capabilities in use by the military (Tack 2010), the probability of species survival during rapid transit times is increased, along with the chance for far-ranging spread and dispersal, whereas the same hitchhiker in the hold of a commercial cargo ship would typically experience longer transit durations that decrease survival probability en route; however, the global trade via the water transportation industry still facilitates the widespread movement and dispersal of pest species (Burgiel et al. 2006; Meyerson and Mooney 2007; Westphal et al. 2008; Hulme 2009; Osborn 2010). Vessels that are in direct contact with the ground, such as vessels in dry storage; are within shipyard facilities; or have technological advances such as military amphibious vessels, are vulnerable to species access. Vessels vary in their capacity for harboring species, depending upon the vessel's physical size and configuration. For example, a bulk cargo ship typically has fewer areas for harboring terrestrial vertebrate species than a break-bulk cargo ship, but both will have more discrete hiding places than a barge. All of these aspects increase the probability of successful species transport, including their myriad possible combinations.

Rodents have a history of hitchhiking in water transportation pathways (AQIS 2010), and are therefore considered a concern. Rats are a particular concern because rat species have reached about 80% of the world's islands and are among the most successful invasive mammals (Caut et al. 2008; Peacock 2010). Marine port facilities with rodent infestations have a higher likelihood of introducing them into the water transportation pathways (2005). As much as one-quarter of Chinese seaports have rodent infestations (Song et al. 2003). Rodent infestations around port facilities can occur from improper garbage handling and waste disposal and employees feeding the wildlife, combined with inadequate resources to control or eradicate detected populations or educate port staff (WHO 2007b, 2010h). Detection systems for rat introductions are lacking overall (Jarrad et al. 2010). Rodents, such as rats, are capable of swimming to and from shore in favorable scenarios (Peacock 2010). Other species are also capable of being transported in water transportation pathways (Table A4-9). Because rodents are well-known vectors of disease and are often well established at ports, this makes their presence on ships a special concern (WHO 2007b; Meerburg et al. 2009; WHO 2010h). Due to their confined nature, ships are conducive to spreading disease among passengers and crew (WHO 2007b, 2010h). This, combined with global travel, presents a risk of spreading infectious diseases to other ports.

Table A4-9: Invasive Species Transported in the Water Transportation Pathway

Class	Scientific name	Common name	Risk type[a]
Amphibians	*Bufo gargarizans*	Asiatic toad	ECL
	Kaloula picta	Slender-digit chorus frog	None foundb
	Rana catesbeiana	American bullfrog	ECN, ECL
	Rhinella marina	Cane toad	H, ECN, ECL
Birds	*Columba livia*	Rock dove	H, ECN, ECL
	Dicrurus macrocercus	Drongo	ECL
	Padda oryzivora	Java sparrow	ECN
	Passer domesticus	House sparrow	H, ECN, ECL
	Passer montanus	Tree sparrow	ECN
	Pycnonotus jocosus	Red-whiskered bulbul	ECN, ECL
	Streptopelia bitorquata dusimieri	Philippine turtle dove	ECL
Mammals	*Herpestes javanicus*	Small mongoose	H, ECN, ECL
	Mus musculus	Common mouse	H, ECN, ECL
	Rattus exulans	Pacific rat	H, ECN, ECL
	Rattus norvegicus	Norway rat	H, ECN, ECL

Class	Scientific name	Common name	Risk type[a]
	Rattus rattus	Black rat	H, ECN, ECL
	Rattus tanezumi	Asian house rat	H, ECN
	Suncus murinus	Musk shrew	H, ECN, ECL
Reptiles	*Anolis carolinensis*	Green anole	ECL
	Boiga irregularis	Brown treesnake	H, ECN, ECL
	Dinodon rufozonatum	Red banded snake	None found
	Elaphe carinata	Taiwan stink snake	None found
	Elaphe taeniura friesi	Taiwan beauty snake	None found
	Gehyra mutilata	Mutilating gecko	None found
	Gekko gecko	Tokay gecko	ECL
	Hemidactylus frenatus	Common house gecko	ECL
	Lepidodactylus lugubris	Mourning gecko	None found
	Naja kaouthia	Monocled cobra	H
	Trimeresurus elegans	Sakashima habu	H
	Trimeresurus flavoviridis	Habu	H
	Trimeresurus mucrosquamatu	Taiwan habu	H
	Xenochrophis piscator	Asiatic water snake	None found

a H = health, ECN = economic, ECL = ecological.
b No impacts found in the literature, but undocumented impacts may exist.

Both commercial and military maritime traffic are expected to increase due to the relocation, thereby increasing the risk of moving invasive species. Commercial maritime traffic plays a significant role in transporting a majority of commodities moved throughout the Micronesia Region, and maritime traffic in general will transport a majority of the cargo associated with the relocation on Guam (U.S. Navy 2009j, pages 97-112). Military maritime traffic will significantly impact the potential to transport vertebrate invasive species to Guam and CNMI. The complex set of training activities following the relocation on Guam and Tinian combined with the technically advanced types of military vessels used in the region pose significant opportunities for the movement of vertebrate invasive species (U.S. Navy 2009a, j). Vessels calling on the Port of Guam do so at Apra Harbor, which comprises both an outer harbor area (Outer Apra Harbor) and an inner harbor area (Inner Apra Harbor). Most of Outer Apra Harbor and the entire Inner Apra Harbor are under the jurisdiction of the Navy.

Species may stow away in a vessel’s hold or on the superstructure of the ship. Five classes of vessels were evaluated: commercial container ships, commercial barges, commercial fishing vessels, cruise ships, military vessels, and privately owned and operated vessels.

A4.1.3.2.1 *Commercial Maritime Traffic*

The Jose D. Leon Guerrero Commercial Port of Guam is located at the northern end of Apra Harbor, with commercial and recreational facilities located in the outer harbor. The commercial port has six berths associated with the main cargo terminal that provide port access to vessels with different draft and cargo container handling requirements. The berths are characterized in the Port of Guam Master Plan (PB International 2008). Commercial shipping activity and annual container traffic, as well as estimated increases due to the military relocation, are also included for both shipping activities and container traffic elsewhere in this document.

Guam also has two marinas, Hagatna Marina (Gregorio D. Perez Marina) and Agat Marina, that are administered by the Port Authority of Guam (PB International 2008). Both marinas have chainlink fences on their perimeter, but the fences are in generally poor condition, thereby allowing terrestrial vertebrate species access to port areas and vessels. Private vessels used for recreation, such as fishing, utilize these marinas. There are at least three major recreational fishing events associated with these marinas. These include the Guam Marianas International Fishing Derby, the Fisherman's Festival, and the Annual Marianas Underwater Fishing Federation Competition (Allen and Bartram 2008). The fishing derby averages around 70 boats and 300 fishermen (Allen and Bartram 2008). A total of 75 teams participated in the derby departing from both the Agat Marina and the Hagatna Marina in 2009. The underwater fishing competition had 13 teams from Guam and two from Saipan in 2005 (Allen and Bartram 2008).

The majority of cargo vessels in the region are operated by Matson Navigation Company and Horizon Lines (Horizon Lines 2010b, c, d, a; Matson 2010a, b). The Kyowa Shipping Company also operates in the area, shipping from the ports in Busan, South Korea and Yokohama, Japan into the port on Saipan (Kyowa Shipping Company 2010a, b). Kyowa Shipping is the transshipment service provider for Horizon in the region (PB International 2008). Shipping routes are shown in Figure A2-2 (Section A2). Regional shipping from the ports on Guam and Saipan throughout the region are handled by feeder services provided by Kyowa, Seabridge Marine, and Micronesia Express Service (PB International 2008). Major islands serviced by these providers in the region include Guam; Saipan and Tinian (CNMI); Majuro (RMI); Pohnpei, Chuuk, Kosrae, and Yap (FSM); and Palau. Regional shipping via Seabridge or Matson has a transit time between Guam and Saipan of approximately 12 hours according the Port Authority of Guam Master Plan Update (PB International 2008). We did not attempt to capture every possible shipping route in our analysis, but focused instead on the major routes. Therefore, routes from charter vessels, fuel vessels, and smaller shipping companies are not captured in the analysis.

The shipping companies contract with each other and other regional carriers to provide transshipment services throughout the region (PB International 2008). The interconnections between the different international and regional transshipment services make determining actual transit time for a given container difficult to predict. For example, it is possible for a container to be loaded in a port in Asia, be unloaded in Busan, reloaded on a regional ship and shipped to Saipan or transshipped further, on the same vessel to a port "downstream" of Saipan. A more complex route would have a container loaded on a ship in a port on the west coast of the United States, transshipped via Hawai'i to Guam, loaded on a Kyowa vessel and transshipped out of Guam to another port in the region. However, some estimates of shipping times are shown in Table A4-10 (PB International 2008; Horizon Lines 2010b, c, d, a; Kyowa Shipping Company 2010a, b; Matson 2010a, b).

Table A4-10: Estimates of Time in Transit for Various Shipping Companies and Routes

Carrier	Origination site	Destination site	Estimated transit time (days)

Horizon, Matson	U.S. west coast	Hawai'i	4
Horizon, Matson	Hawai'i	Guam	8
Horizon	China	Oakland, California	21
Matson	China	Los Angeles, California	18
Kyowa, Seabridge, Micronesia Express	Busan, Korea	Saipan, CNMI	10
Kyowa, Seabridge, Micronesia Express	Saipan, CNMI	Guam	<1
Kyowa, Seabridge, Micronesia Express	Guam	Chuuk, FSM	3
Kyowa, Seabridge, Micronesia Express	Chuuk, FSM	Pohnpei, FSM	2
Kyowa, Seabridge, Micronesia Express	Pohnpei, FSM	Kosrae, FSM	3
Kyowa, Seabridge, Micronesia Express	Pohnpei, FSM	Yap, FSM	4
Kyowa, Seabridge, Micronesia Express	Yap, FSM	Koror, Palau	2

A4.1.3.2.2 *Military Maritime Traffic*

The Marianas Island Range Complex is a major naval training area and includes Guam, as well as the islands of Saipan, Tinian, Rota, Farallon de Medinilla, and the training area W-517 (U.S. Navy 2009j). It includes 501,872 square nautical miles of sea space for naval training, as well as 10,074 hectares (24,894 acres) of land range. Navy ships that may operate in the area during any major training exercise include nuclear aircraft carriers, cruisers, frigates, landing craft utility vessels, high-speed transport vessels, and amphibious support and assault vessels (U.S. Navy 2009j). Exercises involve 3 to 30 ships and last 5 to 21 days. Training events may occur 1 to 5 times per year. The types of ships currently operating in the area attached to the U.S. Navy Military Sealift Command include tanker ships and ships carrying break bulk and containers (U.S. Navy MSC). The southern end of Apra Harbor on Guam has four major wharves available for docking ships: Victor Wharf, Sierra Wharf, Polaris Point, and Kilo Wharf. Navy waterfront facilities are located in both the outer harbor and the inner harbor. Waterfront facilities for the U.S. Coast Guard are located in the inner harbor.

A4.1.3.2.3 *Ship Inspection Procedures*

World Health Organization Regulations

On July 18, 2007, the United States became a party to the International Health Regulations adopted by the WHO to mitigate public health risks associated with international travel (WHO 2005b). Article 27 of these regulations states that if a source of contamination or infection is found or suspected on board a ship, authorities are allowed to decontaminate the ship which may include deratting. Article 28 states that, if an infected ship wishes to enter a port that is not equipped to deal with the infection, the port authorities may order the ship to proceed to the nearest suitable port for inspection. Port authorities are required to notify the next known port of entry of the infection.

Article 39 of the International Health Regulations governs Ship Sanitation Control Certificates and Ship Sanitation Control Exemption Certificates. Formerly, these certificates were referred to collectively as a

Deratting/Deratting Exemption Certificate. With the publication of the 2005 International Health Regulations, these certificates were changed to include all public health risks, not just those pertaining to rodents (WHO 2007a). Certificates are only valid for 6 months, after which inspection is required for renewal. If a port is unable to perform an adequate inspection at the time of renewal, the certificate may be renewed for up to 1 month to allow the necessary inspection to be performed. Inspections for certification are to be conducted when the ship and holds are empty. Ship Sanitation Control Exemption Certificates are issued when an inspection reveals no evidence of a public health risk, and authorities are satisfied the ship is free of contamination or disease vectors (WHO 2007a). A Ship Sanitation Control Certificate is issued when an inspection reveals evidence of a public health risk or sources of contamination and appropriate control measures have been undertaken. If appropriate control measures cannot be performed at the port of inspection, this is to be noted on the Ship Sanitation Control Certificate and the next port of call notified; this does not guarantee response by officials receiving notification.

The third edition of the International Health Regulations Guide to Ship Sanitation was published in October 2007. The guide contains both general and specific recommendations to be considered in the construction of ship facilities, as well as measures that can be undertaken to minimize problems in ships that have already been constructed (WHO 2007b, 2010c). Section 10.7 of the ship sanitation guide contains specific recommendations for controlling insect and rodent disease vectors. Essentially, any openings larger than 1.25 centimeters (cm) (0.5 inches [in]) should be obstructed with rat-proof materials. Insulation that is thicker than 1.25 cm (0.5 in) must also be protected against gnawing by rats. The rat-proof materials mentioned in the guide include steel plates, sheet iron or steel, sheet aluminum or metal alloy, perforated sheet metal, expanded metal, flattened expanded metal, wire mesh, or hardware cloth. These materials must not contain openings greater than 1.25 cm (0.5 in). Non-rat-proof materials may be used in rat-proof areas as long as boundaries and gnawing edges are protected. Rat-proof material is defined as a material having surfaces and edges that are resistant to gnawing by rats. A rat-proof area is defined as an area that is completely isolated from other areas by means of rat-proof material. Examples of rat-proof areas include galleys, pantries, cargo holds, storage spaces, and shaftways. A rat-tight area is an area bounded by material that contains no hole large enough for the passage of rats, and is sufficient only in more frequented areas where rats cannot gnaw undisturbed. Examples of rat-tight areas include quarters, dining rooms and mess rooms, and public spaces such as lounges, radio rooms, and wheelhouses.

The ship sanitation guide also recommends delegating at least one person on board a ship to be responsible for a rodent trapping program. Traps are to be set after leaving a port where rats could possibly have come on board directly or with cargo. If, after 2 days, no rats are caught, the traps can be removed. Otherwise, traps are to be left in place until no more rats are caught. Records of when and where traps were set along with catch records should be recorded in the ship’s log to be available for port health inspectors. In addition to trapping, regular inspections should be performed to look for evidence of rats, such as droppings. In particular, these inspections should focus on areas where food is prepared and garbage is stored, as well as any place rats might potentially hide. Port authority officials conduct inspections of the ship to ensure the ship has adequately assessed and addressed potential health risks. For larger ships that have monitoring and management programs in place, inspection at the port may consist only of auditing records to ensure compliance. Ships that have had an outbreak of disease or pests will be inspected by authorities to determine the cause.

The U.S. government does not require ships to hold a Ship Sanitation Control Certificate or Ship Sanitation Control Exemption Certificate (CDC 2009). The authority for compliance with the International Health Regulations in the United States is the U.S. Department of Health and Human Services. Most of the responsibilities associated with the International Health Regulations are assigned to the Centers for Disease Control and Prevention. The United States currently does not provide ship sanitation inspections of commercial cargo carriers, and is awaiting further guidance from the WHO regarding these inspections (CDC 2009; WHO 2010e).

Federal Regulations

The CFR provides some guidance on ship inspection and disinfection. The pertinent portions are Title 7 (regulated articles from Hawai'i and the territories), Title 9 (movement of animals and animal parts), and Title 42 (public health). Title 7 (Subtitle B, Volume 5, Chapter 3, Part 3A.13-9 and Part 330.111) specifically requires notification of inspectors prior to departure or arrival of ships on Guam, giving the inspector the opportunity to conduct an inspection. Title 9 (Volume 1, Chapter 1, Subchapter D, Part 93) allows the inspection of any ship from foreign locations without a warrant to determine whether the ship is carrying any animal or animal part subject to disposal to prevent the spread of disease. If the ship is found to be contaminated, the operator of the ship is responsible for disinfection. Title 9 (Volume 1, Chapter 1, Subchapter D, Part 95) also requires the disinfection of a ship if it has transported restricted items that were not contained in leak-proof containers. The method of cleaning prescribed in Title 9 (Part 95) includes the collection of litter and refuse, and disposal of that refuse by incineration or other approved method. This is to be followed by cleaning of the areas of the ship that were exposed to the contaminant and saturation of the contaminated surface with an approved disinfectant. The approved disinfectants are sodium carbonate solutions, sodium hydroxide solutions, or liquefied phenol. These disinfectants are specifically designed to target foot and mouth disease, rinderpest, and ticks. Title 42 (Part 71, Subpart E, Section 71.41) of the CFR states that carriers arriving at U.S. ports are subject to sanitary inspections to look for rodent, insect, or vermin infestation that may spread disease.

The APHIS-PPQ Manual for Agricultural Clearance contains information on the inspection of ships (USDA-APHIS-PPQ 2013). The manual provides a table for determining whether a ship needs to be boarded on arrival, boarding can be deferred, or the ship only needs to be monitored. Ships that need to be boarded on arrival are generally from known infected areas, have a history of violations, or are foreign ships. Ships in the deferred boarding category are usually U.S. Armed Forces vessels not boarded on arrival, U.S. flag ships, private ships, or ships that frequent the port and have a low pest risk. Ships are monitored on an unannounced, spot-check basis for compliance with garbage regulations and adequate safeguarding of stores. Ships that were not previously boarded are monitored when feasible, and at least 50% of ships that were previously boarded will also be monitored.

There are three factors that determine the focus and extent of ship inspections (USDA-APHIS-PPQ 2013), the location of the port, where the ship has traveled and taken on cargo, and whether the ship is on a watch list for previous violations or known pest outbreaks. The areas to be inspected include the galley and stores, quarters, and deck. These areas are inspected for fresh fruits and vegetables, evidence of pests, and compliance with garbage regulations. The manual specifically instructs inspectors to focus their inspections of barges on the deck areas. If live or dead animals, contamination, or leaking garbage is found, the area is to be cleaned and disinfected. Disinfection procedures for animal contamination include treatment with Virkon®S or sodium carbonate with sodium silicate. Disinfection procedures for live pests are to be determined by a CBP Agricultural Specialist according to the APHIS-PPQ Treatment Manual. The treatment manual only contains guidance for treatment when khapra beetles, fruit flies, and soft bodied insects are found (USDA-APHIS-PPQ 2008).

CBP published a Vessel Inspection Guide in 2009. However, this guide does not contain information on inspection of ships per se. The guide contains instructions for checking the paperwork of crew members and passengers, signs of human trafficking, and how to handle human stowaways (CBP 2009).

Commercial Vessel Inspections

The Centers for Disease Control and Prevention published a Vessel Sanitation Program Operations Manual in 2005. This manual also provides guidance to the cruise ship industry on methods to minimize public health risks (CDC NCEH 2005). Compliance with the program is voluntary. However, the U.S. Public Health Service has the authority under the Public Health Service Act (Title 42, Part G) to make regulations and take actions to prevent the spread of communicable diseases (FDA 1999a, b). Title 42 of the CFR also gives the Public Health Service the authority to conduct sanitary inspections. The National Center for Environmental Health at the Centers for Disease Control and Prevention became responsible for administering the program in 1986. A fee is charged for the service depending on the size of the ship. The manual contains guidance on keeping food areas free of rodents and other pests, such as using tight-fitting lids on garbage containers. Incoming food supplies are to be inspected for signs of insect, rodent, or other pest infestation. Areas of the ship that are inspected include medical facilities, potable water systems, swimming pools, whirlpools, galleys, dining rooms, child activity centers, hotel accommodations, ventilation systems, and common areas. The manual recommends that any vessel with a foreign itinerary carrying more than 13 passengers be inspected twice yearly for food safety and environmental sanitation. However, inspections do not occur every 6 months (WHO 2010e). These are to be unannounced inspections if the vessel is available. Inspection reports or summary reports are published on the Vessel Sanitation Program website.

Military Vessel Inspections

The Quarantine Regulations of the Armed Forces were written to allow the military to comply with the regulations of the U.S. Departments of Health and Human Services, Agriculture, Treasury, Homeland Security, Interior, and Commerce (DoD 1992). This was superseded by OPNAVINST 6210.2. The regulations are designed to prevent the introduction and spread of disease agents (human, animal, and plant), arthropod vectors, and pests of health or agricultural importance. The documents state that the military is to cooperate with the agencies listed above to comply with regulations. Military vessels are exempt from inspections by foreign officials, although they must meet the quarantine requirements of each entry port that are published in the U.S. Air Force Foreign Clearance Guide (AFR 8-5 and

OPNAVINST 3710.2E). Commanding officers may certify compliance to foreign health officials, which may include a general description of the measures taken to be in compliance. Foreign officials are not allowed to board a U.S. Armed Forces ship, even to observe inspections.

Section II, Subsection A of the Quarantine Regulations of the Armed Forces and Section 9a of OPNAVINST 6210.2 specifically govern vessels (DoD 1992). Measures are to be taken prior to departure to minimize movement of human disease vectors, including insects and rats. As soon as a vessel is berthed at a pier, and for the remainder of its stay at the pier, certain preventive measures must be taken to minimize the likelihood of rats gaining access to the ship. Ships must be moored at least 6 feet from the pier. Gangways and other access points to the ship are to either be well lit and guarded, or separated from the shore. Cargo nets or similar devices extending between the ship and the shore will be raised or removed unless actually in use. All connecting lines are to be fitted with rat guards. The International Health Regulations no longer require the use of rat guards on mooring lines unless the ship is berthed in a port where plague is endemic. However, commanding officers or medical department representatives can still require their use in ports with a large rodent population. Cargo is only to be loaded after it has either been found to be free of rodents or has been treated to remove all rodents. Before the ship departs the port, it must be inspected for fleas and rodents and treated to remove these pests if found.

All naval ships are required to have current Ship Sanitation Control or Ship Sanitation Control Exemption certificates because they can be deployed anywhere in the world on short notice (U.S. Navy 2001). These may be issued either by the U.S. Public Health Service or by a Public Health Service designated military quarantine representative (DoD 1992; OPNAVINST 6210.2). According to BUMED 6210, the primary medical personnel that are authorized to issue ship sanitation certificates are Navy preventive medicine technicians (U.S. Navy 2010b), and inspectors are not allowed to inspect or issue a ship sanitation certificate for a vessel where they are part of the ship's company (U.S. Navy 2001, 2010b). Navy medical personnel are authorized to issue ship sanitation certificates for Navy, Army, Military Sealift Command, Coast Guard, and National Oceanic and Atmospheric Administration vessels. Qualified inspectors are issued an official seal from the U.S. Public Health Service to be used in the issuance of ship sanitation certificates (U.S. Navy 2010b). According to BUMED 6250.14A, rodent inspections for ship sanitation certificates are to be conducted during daylight hours with an empty hold or a hold containing only material unattractive to rodents (U.S. Navy 2010b). If rodents are found, BUMED 6250.14A instructs personnel to continue to conduct control operations for 3 to 5 days after signs of an active infestation have ceased before requesting a re-inspection. Deratting should be conducted when holds are empty if possible. Ship sanitation certificates are to be issued in duplicate, with one copy going to the ship and the medical department retaining the other. Specifications and directions for rat guards are also given in BUMED 6250.14A.

Section II, Subsection C of the Quarantine Regulations of the Armed Forces and Section 10 of OPNAVINST 6210.2 cover the USDA requirements. These sections govern the movement of animal and plant diseases and pests. Ships moving between Hawai'i, Guam, Puerto Rico, the U.S. Virgin Islands, and the continental United States are required to undergo USDA inspection by a USDA inspector or representative. GCQA officers collaborate with USDA-APHIS to enforce federal regulations (Taijeron

2010c). The disinfection measures currently available target primarily disease organisms and insects and may not be effective on many of the invasive species transported in ships. Subsection C requires surveillance aboard ships that includes spot checking and routine collection and identification of pest organisms.

The Defense Transportation Regulations, Part V establishes the requirements for agricultural cleaning and inspection, and the assignment of DoD personnel as agricultural and customs inspectors for pre-clearance programs. USDA-APHIS is responsible for providing DoD with guidance, information, and training to perform pre-clearance inspections (DoD 2009a).

To facilitate redeployment operations, DoD can request pre-clearance inspections by CBP and USDA for vessels returning to the CTUS (DoD 2009c). Pre-clearance inspections may be requested for redeployment from major exercises or contingencies, and are performed at the point of origin. Requests for pre-clearance inspections must be submitted no later than 75 days prior to when the inspection is needed. Requests must contain the following information: dates, times, and place of departure from a foreign country; date, time, and place of arrival in the CTUS; number and type of ships; identification of all stops between the point of departure and arrival; and whether the border clearance integrity of the ship will be maintained during en route stops. Examples of clearance integrity being breached are the addition or removal of cargo or passengers at any stop, crew member changes, or off-loading of crew and passengers. Such breaches of integrity will void the pre-clearance authority. Both CBP and USDA provide and approve training of Customs Border Clearance Agents for the military (DoD 2009c). When the planned destination is in the CTUS, Customs Border Clearance Agents inspect ships to ensure they are free of plants, animals, or plant and animal products. Equipment must be stored in a way that prevents re-infestation by pests.

The Armed Forces Pest Management Board published Technical Guide Number 31 to cover the cleaning and inspection procedures used in conjunction with retrograde washdowns (AFPMB 2008). Decks of ships that held vehicles or equipment are required to be thoroughly cleaned. In particular, recessed areas, underneath shelving, corners, and hard to reach places should be cleaned to remove soil. Causeways on naval vessels are to be washed with either fresh or salt water during back loading. Vessels, such as the Captain’s launch or a liberty launch, are not required to be cleaned unless they are contaminated. Although the guide recommends that operators of these vessels conduct a thorough inspection, it does not require it.

NAVMED P-5010-8 is the Naval Manual of Preventative Medicine, Chapter 8, Navy Entomology and Pest Control Technology (U.S. Navy BMS 2004). This manual covers the use of preventive measures and oral bait stations and anticoagulants for rodent control. The species of concern that are listed in the manual are the Norway rat (*Rattus norvegicus*), roof rat (*Rattus rattus*), and house mouse (*Mus musculus*). Some general characteristics of each are described to aid in identification. Measures that are mentioned to control and prevent rodent infestations include the elimination of food and shelter, rodent proofing when feasible, rodenticides, snap traps, and glue boards. The manual contains a specific section on controlling and preventing rodents aboard ships which include proper sanitation, pierside inspections, rat guards, illumination and movement restrictions, glue boards, and snap traps. Pierside inspections for signs of rodents (droppings, hair, gnawing) should be conducted on all subsistence items and cargo. Rat guards are required to be a minimum of 91 cm (36 in) in diameter and be mounted at least 1.8 m (6 feet) from shore or 0.6 m (2 feet) from the ship. Access points to the vessel, such as gangways, are to be separated from the shore by at least 1.8 m (6 feet), and cargo nets or similar devices extending between ship and shore are to be raised or removed when not in use. Vessels departing from ports where certain diseases such as yellow fever, malaria, and plague are endemic or epidemic in the port area must be disinfected.

The U.S. Navy Shipboard Pest Control Manual, NAVMED P-5052-26, provides guidance on inspection and deratting procedures to be carried out on ships (U.S. Navy 2008). This manual also lists the Norway rat, roof rat, and house mouse as the most common rodents of concern. The commanding officer of a ship is to ensure that medical department personnel are trained and certified in shipboard pest control. The medical department representative ensures that there is an ongoing pest control program on board the ship. This includes maintaining current ship sanitation certificates, conducting inspections, and keeping records of pest control activities. Records of activities include pierside and onboard inspection records, ship sanitation certificates, and pesticide use records.

According to the U.S. Navy Shipboard Pest Control Manual, inspections occur pierside for incoming food, and surveillance on a ship is to occur at least every 2 weeks (U.S. Navy 2008). If control measures are implemented, they should be followed up with surveillance to determine efficacy. Rodent signs to look for during inspections include runways and rub marks, tracks, gnawing, droppings, urine, and hairs. Prevention measures listed are similar to those provided in NAVMED P-5010-8. In addition to the rat guard requirements listed in NAVMED P-5010-8, the pest control manual requires rat guards to have a cone angle of 30 degrees and be made of 18 gauge steel or aluminum. Gaps are to be plugged with rags that are tightly secured to prevent rodents from pulling them apart. Stray lines are to be kept out of the water, and if two lines are close to each other, they are either to be installed through the same rat guard or have rat guards installed side by side to prevent rats from jumping from line to line. The U.S. Navy Shipboard Pest Control Manual also reiterates the guidelines in the CFR listed above.

In addition to the U.S. Navy Shipboard Pest Control Manual, MIL-STD-904B provides guidance on the detection, identification, and prevention of pest infestations. This standard is provided in full in Appendix G of the U.S. Navy Shipboard Pest Control Manual (U.S. Navy 2008). The standard applies not only to insects and rodents, but to birds and other animals as well. For preventing cross-contamination of pathways (cargo to vessel), the standard requires samples be taken of subsistence items that have a history of contamination or infestation or items that have been stored near contaminated or infested items. Samples should be taken from the area most likely to be infested, such as the outermost containers of a stack, or the area closest to the contaminated or infested items. Closed packages are to be inspected for holes made by insects, and rodent, bird, or other animal contamination or damage. If signs of contamination or damage are found, the package is to be opened. Opened packages weighing less than 4.5 kg (10 pounds) are to be inspected in their entirety. If the opened package weighs more than 4.5 kg (10 pounds), a 1.4 kg (3 pounds) sample is to be taken from the top and bottom of the unit and adjacent to tears or holes. Subsistence items shipped from tropical environments are to be paid special attention and inspected thoroughly. Stored subsistence items are to be inspected at least once monthly, as are storage areas. Items are to be stored off the floor on pallets or shelves and be at least 0.5 m (18 in) from the wall to minimize hiding areas available to rodents, birds, and other animals.

Guam

Commercial ships providing a ship sanitation certificate that arrive in the Port of Guam will have acquired it from a previous port of call on the identified list of ports identified by the WHO (Ames 2010). Guam is listed in the WHO International Health Regulations Authorized Ports List as being able to issue ship sanitation certificates (WHO 2010e). All vessels tying up at the dock must place rodent barriers on mooring lines (Merfalen 2010). All commercial cargo is subject to inspection and is selected based on the manifest associated with the shipment (Merfalen 2010). The process for inspecting the vessel will follow the guidelines established in the International Health Guidelines interim technical advice, but will vary procedurally by the country of issuance (WHO 2007a). Title 10 Chapter 37 of the Guam Code requires docks and wharves to be constructed so as to prevent rodents from gaining access to them during low and high tides. Food stored at docks and wharves must be stored in such a manner to prevent access by rodents. The Director of Public Health and Social Services is to enforce international quarantine regulations for controlling rodents for all vessels and watercraft arriving on Guam (GCA). Perimeter fencing supports traps for BTS (PB International 2008).

Commonwealth of the Northern Mariana Islands

Privately owned vessels returning to Saipan are inspected by CNMI Customs and Quarantine officers for rodents and BTS by the detector dog teams. The BTS detector dog teams are part of the CNMI Division of Fish and Wildlife, which is a separate agency from the CNMI Customs and CNMI Quarantine agencies. Customs personnel accompany the dog detector team aboard the vessel (Guerrero 2010). Saipan is listed in the WHO International Health Regulations Authorized Ports List as being able to issue ship sanitation certificates (WHO 2010e). We observed perimeter fencing supporting traps for BTS during our site visit to the Port of Saipan in January 2010. The Port of Tinian receives cargo ships routed from Saipan or Guam and inter-island ferry traffic. We observed perimeter fencing supporting traps for BTS during our site visit to the Port of Tinian in January 2010. During the site visit on Tinian there were no mice available to use in BTS traps due to collapse in the species' population on the island, and insufficient funding to purchase new mice (Castro 2010).

Federated States of Micronesia

According to FSMC Title 18, Chapter 2 § 206, any ship entering FSM is subject to inspections by customs, immigration, agriculture, and administrative personnel. We were unable to find any information regarding exactly what these inspections entail. The immigration regulations of FSM state that all ships will be inspected for stowaways, presumably human (FSM ORC 2005). FSM is a party to the WHO, and therefore is bound by the International Health Regulations.

Republic of the Marshall Islands

Vessels entering or leaving RMI are subject to inspections by immigration, customs, agriculture, public health, or administrative personnel as stated in Title 43, Chapter 2, Section 205 of the Marshall Islands Revised Code (PacLII 2003). According to Title 8, Chapter 1, Section 110 of the Marshall Islands Revised

Code, vessels known or suspected to be harboring insects or agricultural pests are to be sprayed with an insecticide (PacLII 2004a). Any employee of the RMI Ports Authority may enter a vessel for the purpose of inspection according to Title 22, Chapter 1, Section 153 of the Marshall Islands Revised Code (PacLII 2004c). RMI is a party to the WHO, and therefore is bound by the International Health Regulations.

Palau

No information could be accessed regarding ship inspections in Palau. However, Palau is a party to the WHO, and therefore is bound by the International Health Regulations.

China

China is a member state of the WHO, and therefore is bound by the International Health Regulations, and according to the WHO International Health Regulations Authorized Ports List, can issue ship sanitation certificates (WHO 2010e). Chapter 4 of the Rules for the Implementation of Frontier Health and Quarantine Law of the People's Republic of China covers seaport quarantine (Chinese Ministry of Public Health 1989). Both entry and exit quarantine inspections are conducted, although what these inspections actually entail is not explained. Article 29 states that inspections will occur between sunrise and sunset only, unless the port is equipped for night navigation. Inspections will not occur at night if the ship is from an area with a known infestation. Ship Sanitation Control Certificates are required for entry to ports in China according to Article 30.

Korea

Korea is not listed as a member state of the WHO, and therefore may not follow the International Health Regulations. However, the Republic of Korea is listed in the WHO International Health Regulations Authorized Ports List as being able to issue ship sanitation certificates (WHO 2010e). No information could be accessed regarding ship inspections in Korea.

A4.1.3.2.4 *Summary of Findings*

All water transportation pathways were considered high risk due to their ability to transport species, such as BTS and rodents, with potential impacts to human health. Risk increased as the probability of species survival during transport increased, such as for high-speed vessels and vessels transiting short distances. Risk also increased based on several factors related to the process of inspection. Risk increased in ports where the International Health Regulations are not enforced. The risk of inspectors missing an invasive species increased as time constraints and equipment unavailability (broken or nonexistent equipment) increased, or the number of personnel decreased. Risks basically reflected an increase in commercial ship traffic without adequate increases in biosecurity needs, such as additional staffing for inspections and enforcement, updated equipment and facilities, continued training, and easier reporting capabilities.

A4.1.3.2.5 *Specific Risk Factors*

The specific risk factors we found to be associated with the water transportation pathways are as follows:

Common Risk Factors

- Rat guards may not be required or used for prevention in all ports of call on vessels transiting to Guam or the Micronesia Region.
- Rat guards may not prevent BTS from accessing the ship by crawling up a mooring line.
- The ability of the canine inspection to locate BTS in a complex environment may be compromised.
- An inspection/management program focused on preventing introduction of an agricultural pest may not detect or prevent the movement of a vertebrate invasive species to another pathway.
- Regulations pertaining to ships are primarily focused on insects, rodents, and the prevention of spreading human disease. Invasive species that do not fall under one of these categories, such as amphibians, may be missed during inspections.
- Inadequate financial resources exist in CNMI, FSM, RMI, and Palau to maintain expensive control programs.

Risk Factors Associated With Commercial Maritime Traffic

- Commercial carrier vessels from the major shipping lines are cleared rapidly (approximately 30 minutes) by customs and quarantine officers (Merfalen 2010). Emphasis is on regulated waste inspections and reviewing cargo manifests.
- Cruise ships are not required to comply with the Vessel Sanitation Program and only need to supply ship sanitation certificates if it is required for a port at which the vessel is docking.
- Staffing on Guam and CNMI is inadequate to meet current quarantine demands.

Risk Factors Associated With Military Maritime Traffic

- Retrograde washdown procedures primarily target soil and may not remove invasive species hidden in areas not targeted for washing.
- Captain's launches and liberty launches are not required to be inspected or cleaned upon return to a ship unless they are contaminated, increasing the likelihood of moving invasive species undetected.

A4.1.3.3 *Military Cargo and Vehicles Used In Training Exercises*

The pathways we evaluated in this analysis are focused on the risk of moving invasive species on cargo associated with military training. Cargo includes equipment, gear, vehicles, vessels, aircraft, and supplies used in training exercises. Current training activities are presented in the Marianas Island Range Complex draft EIS/Overseas EIS (U.S. Navy 2009j). Future training activities following the relocation of the 3rd Marine Expeditionary Unit from Okinawa to Guam are presented in the second and third chapters of Volume 2 of the draft EIS/Overseas EIS (U.S. Navy 2009f, Vol 2, Chap 2, 2009g, Vol 2, Chap 3).

Various species can be moved in cargo (Table A4-11). The Marianas Island Range Complex EIS specifically lists tent and camp setup as activities that will occur during field training and force protection exercises at Northwest Field and Andersen South (U.S. Navy 2009j). There have been documented reports of the transport of invasive species of concern in cases of munitions (Vice et al. In preparation). Therefore, we evaluated munitions being brought to Guam and spent munitions being shipped from Guam as a result of training. Vehicles, such as trucks and tanks, amphibious assault and support vessels, and high-speed vessels will be used in training exercises to transport troops and supplies (U.S. Navy 2009j, f).

Table A4-11: Invasive Species Transported In Military Cargo and Equipment

Class	Scientific name	Common name	Risk type[a]
Amphibians	*Bufo gargarizans*	Asiatic toad	ECL
	Eleutherodactylus coqui	Coqui frog	ECN, ECL
	Eleutherodactylus planirostris	Greenhouse frog	ECL
	Fejervarya cancrivora	Crab-eating frog	ECL
	Fejervarya limnocharis	Asian cricket frog	ECL
	Kaloula pulchra	Asian painted frog	ECL
	Litoria fallax	Dwarf tree frog	ECL
	Microhyla pulchra	Marbled pygmy frog	ECL
	Polypedates leucomystax	Common tree frog	ECL
	Polypedates megacephalus	Spot-legged tree frog	ECL
	Rana catesbeiana	American bullfrog	ECN, ECL
	Rana guentheri	Guenther's frog	H, ECL
	Rhinella marina	Cane toad	H, ECN, ECL
Birds	None likely	None likely	
Mammals	*Mus musculus*	Common mouse	H, ECN, ECL
	Rattus exulans	Pacific rat	H, ECN, ECL
	Rattus norvegicus	Norway rat	H, ECN, ECL
	Rattus rattus	Black rat	H, ECN, ECL
	Suncus murinus	Musk shrew	H, ECN, ECL
Reptiles	*Anolis carolinensis*	Green anole	ECL
	Boiga irregularis	Brown treesnake	H, ECN, ECL
	Dinodon rufozonatum	Red banded snake	None found[b]
	Elaphe carinata	Taiwan stink snake	None found
	Elaphe taeniura friesi	Taiwan beauty snake	None found
	Gehyra mutilata	Mutilating gecko	None found
	Gekko gecko	Tokay gecko	ECL
	Hemidactylus frenatus	House gecko	ECL
	Lepidodactylus lugubris	Mourning gecko	None found
	Naja kaouthia	Monocled cobra	H
	Trimeresurus elegans	Sakashima habu	H
	Trimeresurus mucrosquamatu	Taiwan habu	H
	Xenochrophis piscator	Asiatic water snake	None found

[a] H = health, ECN = economic, ECL = ecological.

[b] No impacts found in the literature, but undocumented impacts may exist.

A4.1.3.3.1 *Military Cargo and Vehicle Inspection*

A Brown Treesnake Control and Interdiction Plan was developed by the Navy to prevent the movement of the BTS off of Guam in response to Executive Order 13112, Invasive Species (The White House 1999; U.S. Navy 2005b). Executive Order 13112 made it the responsibility of all federal agencies to prevent the introduction and spread of invasive species in the United States and elsewhere. The BTS plan requires the military to cooperate fully with federal authorities during observations and inspections of cargo destined to be shipped from Guam. It also requires a close working relationship with APHIS-WS to effectively implement the plan. The plan directs the Department of the Interior and USDA to go through a rulemaking process on BTS inspections.

The plan requires that 100% of all outbound cargo is to be inspected for BTS using canine detection methods; however, the plan also states that military commanders and APHIS-WS personnel must jointly decide the extent of inspections based on the nature of the training exercise and the volume of cargo to be transported. On Guam, APHIS-WS maintains dogs and equipment necessary to implement BTS control plans. APHIS-WS may recommend holding a cargo carrier from departing Guam if it is suspected to harbor BTS, and allow commanders to make the decision whether to release the cargo (Vice 2010a).

Prior to establishing bivouac sites on Guam, APHIS-WS personnel are to be consulted so they can recommend areas that have a lower BTS risk. Cargo shipped to Tinian from Guam is tagged following inspection and clearance by APHIS-WS and this tag is subject to confirmation by CNMI Quarantine inspectors. Untagged cargo may be refused entry and reloaded aboard the conveyance for return to Guam. Vehicles are to be cleaned and inspected prior to being moved to an approved cargo staging area. Vehicles and equipment that are considered to be higher risk for BTS infestation may be required to undergo additional cleaning measures such as high pressure washing, steam-cleaning, or fumigation. Once cargo is cleaned and inspected, it is to be immediately loaded onto a vessel or aircraft. If a delay will occur between inspection and loading, cargo may be placed in a APHIS-WS approved staging area and re-inspection may be required. Cargo staging areas are to be chosen to minimize the likelihood that BTS can access cargo. APHIS-WS is to be given complete access to staged cargo and equipment for the purposes of BTS inspections. Prior to breaking camp, all personal belongings and tents used in a bivouac area are to be inspected by APHIS-WS for the presence of BTS.

Inspections of baggage and personnel are focused on preventing the movement of drugs, firearms, plant and animal products, and undeclared items (DoD CBCPP 2009c). All DoD cargo is to be made available for inspection by CBP upon entry to the United States. It is up to the discretion of CBP personnel to determine what level of inspection is required.

To facilitate redeployment operations, the DoD can request pre-clearance inspections by CBP and USDA for cargo and equipment returning to the CTUS (DoD 2009c). The Defense Transportation Regulations, Part V establishes the requirements for agricultural cleaning and inspection, and the assignment of DoD personnel as agricultural and customs inspectors for pre-clearance programs. USDA-APHIS is responsible for providing the DoD with guidance, information, and training to perform pre-clearance inspections (DoD 2009a). APHIS remains the final authority on the pest risk status of material or equipment.

Pre-clearance inspections may be requested for redeployment from major exercises or contingencies, and are performed at the point of origin. Requests for pre-clearance inspections must be submitted no later than 75 days prior to when the inspection is needed. Requests must contain the following information: dates, times, and place of departure from a foreign country; date, time, and place of arrival in the CTUS; amount and type of cargo; identification of all stops between the point of departure and arrival; and whether the border clearance integrity of the aircraft or ship will be maintained during en route stops. Examples of clearance integrity being breached are the addition or removal of cargo or passengers at any stop, crew member changes, off-loading of crew and passengers, or an aircraft remaining in a location overnight. Such breaches of integrity will void the pre-clearance authority.

Both CBP and USDA provide and approve training of Customs Border Clearance Agents for the military (DoD 2009c). When the planned destination is in the CTUS, CBP agents inspect cargo to ensure it is free of plants, animals, or plant and animal products. Equipment must be stored in a way that prevents re-infestation by pests. In addition, CBP can establish a Military Customs Inspectors–Excepted program at a DoD installation (DoD 2009d). Such a program allows DoD personnel to perform the same functions as CBP agents in connection with arriving military or military-chartered aircraft from overseas areas. Inspection duties of the DoD personnel under this program include customs, immigration, and agricultural inspections or functions. Inspectors under the Military Customs Inspection Excepted program may not conduct searches of personnel.

Chapter 511 of the Defense Transportation Regulations Part V states that all cargo entering Guam, regardless of origin, is subject to inspection by GCQA. GCQA requires a packing list for all containers, and will conduct inspections of containers. What these inspections entail is not described, other than to say that inspectors must make sure departing containers are free of BTS. Coordination of inspection activities between the military and foreign governments falls to the U.S. Transportation Command (DoD CBCPP 2009b). Part II of the Defense Transportation Regulations covers cargo, but contains little information regarding inspections (DoD 2008a).

OPNAVINST 6210.2 states that USDA-APHIS-PPQ personnel may inspect cargo to prevent the introduction of plant and animal pests or diseases. No cargo is to be loaded in foreign countries unless it is free of soil or pests. Cargo is to be cleaned to remove soil and pests, and packed in such a way as to prevent access of pests to cleaned cargo. The Quarantine Regulations of the Armed Forces states that cargo is subject to inspection by a representative of USDA to prevent the introduction or spread of animal and plant diseases or pests (DoD 1992). For the purposes of these regulations, Guam is considered part of the United States. The CFR provides some guidance on military cargo inspection and disinfection as it pertains to movement of regulated articles from Hawai'i and the territories, and movement of animals or animal parts. Title 7 (Subtitle B, Volume 5, Chapter 3, Parts 3A.13-8 and 3A.13-10) states that cargo moving between Guam, CNMI, Hawai'i, and the continental United States is subject to agricultural inspection.

The Armed Forces Pest Management Board published Technical Guide Number 31 to cover the cleaning and inspection procedures used in conjunction with retrograde washdowns (AFPMB 2008). Washing and inspection of vehicles and equipment shipped as cargo may only occur during daylight hours. Prior to arriving at a washdown area there are several preparations that must take place on vehicles. Vehicles are to be prepared by having the cab and all storage and tool compartments swept or vacuumed. The battery and battery box should be removed, cleaned, and reinstalled. Outside dual tires and spare tires should be removed and placed in the back of the vehicle. Payloads, seat cushions, detachable sideboards, canvas dies/tops, and person gear are to be removed and left at the mobile staging area for cleaning. Vegetation, insects, or other debris should be removed from the radiator. Trucks that are equipped with collapsible sides should have the sides disengaged, and all recessed areas and ledges cleaned. Engine packs should be removed from tanks and Bradley fighting vehicles prior to washing. Once at the washdown area, vehicles are exposed to either high pressure (minimum 90 psi) fresh water or steam.

After vehicles are washed, they are inspected to ensure all soil has been removed (AFPMB 2008). Common areas to be inspected include top and bottom access points, paying particular attention to crevices. Top access points are floor boards; battery boxes; storage and tool compartments; wheels and tires; windshield bases; front and rear bumper hollows and braces; radiator front; and truck beds. Bottom access points are fender wells; rocker panels; fore and aft frames; coil spring wells; transmission support beams; rear suspension A-frames; pivot points; and drain holes; trailer hitch bolt recesses; front, side, and rear body lips; drive shaft tunnels; power take-offs; axle brackets; fuels tanks; transaxle brackets; leaf springs; and air tank braces.

The troop compartment, crew area, and the crew's personal equipment on amphibious vehicles are required to be cleaned. All soil packed into the treads, around the rubber cleats, in the tread connectors, and between and behind tread guides and roller supports on tracked vehicles must be removed. The interior of tracked vehicles, including the battery box, must also be free of soil. Bilges can contain some sand as long as it is mixed with salt water and is not being transported on an aircraft. Tracked vehicles can only be cleaned on shore as long as they can be reloaded without recontamination of the treads, otherwise they must be cleaned on the ship's well deck. The problem areas of specific vehicles are shown in the Appendices of Technical Guide Number 31 (AFPMB 2008).

Hand brooms, rags, compressed air, and other non-water methods can be used to clean supplies and equipment such as mount-out boxes/Hardigg-like cases, field desks, and communications equipment (AFPMB 2008). In particular, attention should be paid to cracks, crevices, and recesses. Pallets are to be cleaned of soil and vegetation. Tents and canvas should be spread out on a pest free surface and swept down on both sides, paying particular attention to the seam and flaps. No water should be used to clean tents and canvas, but compressed air may be used to aid in the cleaning process.

A4.1.3.3.2 *Summary of Findings*

With the exception of transporting hazardous waste from the naval base on Guam to the continental United States, all pathways were considered to be high risk due to their potential to transport species that can harm human health and safety. The hazardous waste pathway was only likely to vertebrate species and species that could be transported in this pathway only had ecological effects. Inspections of cargo departing Guam are primarily focused on BTS and pests with agricultural risks; thus, inspections may miss some vertebrate invasive species. Detection of BTS relies on a large degree of cooperation among agencies, particularly APHIS-WS and the military. Resources are limited in CNMI to maintain expensive prevention and control programs for BTS, increasing the risk that the BTS could become established there.

A4.1.3.3.3 *Specific Risk Factors*

The specific risk factors we found to be associated with transport of military cargo used in training exercises are as follows:

- BTS inspections may not address the movement of other potentially invasive species.
- Tent cleaning and inspection processes emphasize agricultural pest risks and may not adequately address the risk of transporting an invasive vertebrate species.
- The emphasis on preventing the movement of invasive species associated with tent cities is on departure from Guam and BTS. No emphasis is placed on the risk of bringing new invasive species to Guam.
- No contact networks exist for species other than BTS. This network may be used when other invasive species are located or captured, but this is not always the case.
- Agricultural inspections of cargo at the port of entry may not adequately detect a vertebrate invasive species moving in vehicles, cargo or equipment.
- There are limited control measures for frogs, toads, lizards, and snakes that could be transported with military cargo.
- The retrograde washdown and inspection process is focused on preventing the transport of agriculturally significant pests on vehicles and may not be effective for preventing the transport of vertebrate invasive species.
- Inadequate financial resources exist in CNMI to maintain expensive prevention and control programs.
- Communication is inadequate between the military and officials on Tinian, and response capabilities are lacking on Tinian, to allow for proper inspections of cargo associated with military training to occur.

A4.1.3.4 *Cargo and Container Conveyances*

Movement of invasive vertebrate species in containerized cargo and on the container conveyance itself is a significant pathway, capable of moving many types and a large number of species (Table A4-12). There is an anticipated increase in the amount of containerized cargo that will be shipped to Guam to support the relocation and the provisioning of increased military personnel.

Table A4-12: Invasive Species Transported in the Cargo Container Pathway

Class	Scientific name	Common name	Risk type[a]
Amphibians	*Bufo melanostictus*	Asian common toad	None found[b]
	Eleutherodactylus coqui	Coqui frog	ECN, ECL

Class	Scientific name	Common name	Risk type[a]
	Eleutherodactylus planirostris	Greenhouse frog	ECL
	Hyla cinerea	American green tree frog	ECL
	Kaloula pulchra	Asian painted frog	ECL
	Limnodynastes tasmaniensis	Spotted grass frog	ECL
	Litoria aurea	Green and golden bell frog	H, ECL
	Litoria caerulea	Australian green tree frog	ECL
	Litoria chloris	Red-eyed tree frog	None found
	Litoria ewingii	Whistling tree frog	ECL
	Litoria fallax	Eastern dwarf tree frog	ECL
	Osteopilus septentrionalis	Cuban tree frog	H, ECN, ECL
	Polypedates leucomystax	Common tree frog	ECL
	Pseudacris regilla	Pacific tree frog	ECL
	Rana sylvatica	Wood frog	ECL
Birds	None likely	None likely	
Mammals	*Didelphis marsupialis*	American opossum	H, ECN, ECL
	Mus musculus	Common mouse	H, ECN, ECL
	Myotis lucifugus	Little brown bat	H, ECN
	Pipistrellus javanicus	Javan pipistrelle	H, ECN
	Rattus exulans	Pacific rat	H, ECN, ECL
	Rattus norvegicus	Norway rat	H, ECN, ECL
	Rattus rattus	Ship rat	H, ECN, ECL
	Rattus tanezumi	Asian house rat	H, ECN, ECL
	Suncus murinus	Musk shrew	H, ECN, ECL
Reptiles	*Agama agama*	Common agama	None found
	Anolis cristatellus	Common Puerto Rican anole	ECL
	Anolis distichus	Hispaniolan gracile anole	ECL
	Anolis extremus	Barbados anole	ECL
	Anolis porcatus	Cuban green anole	ECL
	Anolis sagrei	Cuban brown anole	ECL
	Boa constrictor	Boa constrictor	H, ECN, ECL
	Boiga irregularis	Brown treesnake	H, ECN, ECL
	Calotes versicolor	Eastern garden lizard	ECL
	Chondrodactylus bibronii	Bibron's thick-toed gecko	ECN
	Cnemidophorus lemniscatus	Rainbow lizard	ECL
	Cryptoblepharus carnabyi	Spiny-palmed snake-eyed skink	None found
	Cryptoblepharus peocilopleurus	Mottled snake-eyed skink	ECL
	Cryptoblepharus plagiocephalus	Péron's snake-eyed skink	None found
	Cryptoblepharus virgatus	Cream-striped shinning-skink	None found
	Cyrtopodion scabrum	Rough-tailed gecko	ECL
	Elaphe taeniura friesi	Taiwan beauty snake	None found
	Elgaria multicarinata	Southern alligator lizard	None found
	Emoia cyanura	Bluetail emo skink	ECL
	Eulamprus tenuis	Bar-sided forest skink	None found
	Gehyra mutilata	Mutilating gecko	None found

Class	Scientific name	Common name	Risk type[a]
	Gekko gecko	Tokay gecko	ECL
	Gonatodes albogularis	Yellow-headed gecko	None found
	Hemidactylus frenatus	Common house gecko	ECL
	Hemidactylus garnotii	Indo-Pacific gecko	None found
	Hemidactylus platyurus	Flat-tailed house gecko	None found
	Hemidactylus turcicus	Mediterranean house gecko	ECL
	Hemiphyllodactylus typus	Common dwarf gecko	None found
	Lampropholis delicata	Delicate skink	ECL
	Lepidodactylus aureolineatus	Golden scaly-toed gecko	None found
	Lepidodactylus lugubris	Mourning gecko	None found
	Lipinia noctua	Moth skink	None found
	Lycodon aulicus	Common wolf snake	ECL
	Mabuya multifasciata	Rough mabuya	None found
	Python molurus bivittatus	Burmese python	H, ECN, ECL
	Ramphotyphlops braminus	Blind snake	None found
	Sceloporous occidentalis	Western fence lizard	None found
	Sphaerodactylus argus	Ocellated gecko	None found
	Sphaerodactylus elegans	Ashy gecko	None found
	Tarentola mauritanica	Common wall gecko	None found
	Tiliqua scincoides	Common bluetongue	None found
	Trimeresurus flavoviridis	Habu	H
	Uta stansburiana	Northern side-blotched lizard	None found

[a] H = health, ECN = economic, ECL = ecological.
[b] No impacts found in the literature, but undocumented impacts may exist.

Cargo and its conveyances originate from numerous sources, and the actual points of origination for much of this traffic have not been identified. The major shipping companies for containerized cargo transport in the Micronesia Region are Horizon, Matson, Kyowa, and Marianas Express Lines (PB International 2008). Information from these companies was used to determine the routes by which cargo is likely to be shipped. The shipping pathways are taken from the current schedules posted on the websites for Horizon, Horizon Lines of Guam, Kyowa, Mariana Express Lines, and Matson (Horizon Lines 2010b, c, d, a; Kyowa Shipping Company 2010a, b; Mariana Express Lines 2010a, b; Matson 2010a, b).

Shipping routes were chosen to capture the risks associated with the movement of containerized cargo in the region with emphasis on the most likely sources for material associated with the relocation. We focused on containerized cargo coming from Asia, specifically that shipped through South Korea by Kyowa, and from the continental United States via the West Coast and Hawai'i to Guam by Matson and Horizon.

A4.1.3.4.1 *Cargo Container Inspections*

International and Federal Regulations

The International Health Regulations contain guidance regarding containers and cargo with respect to public health concerns (WHO 2005b). Chapter 4, Article 34, governs containers and loading areas. Container shippers are responsible for ensuring that containers are kept free of vectors and reservoirs of disease and contamination during the packing process. Loading areas are also to be kept free of disease vectors and reservoirs. If containers are used for multiple types of cargo, shippers must ensure that cross-contamination does not occur. Countries may determine, at their discretion, that a container is sufficiently large to require a sanitary inspection for disease vectors and reservoirs; no guidance is given on what "sufficiently large" means. Inspection facilities are to be available at container loading areas if practical. Chapter 5, Article 23, allows any country to require inspections of cargo and containers prior to departure and arrival if deemed necessary for public health reasons.

The CFR provides guidance on cargo and cargo container inspection and disinfection as it pertains to movement of regulated articles from Hawai'i and the territories, and movement of animals or animal parts. Title 7 (Subtitle B, Volume 5, Chapter 3, Parts 3A.13-8 and 3A.13-10) states that cargo moving between Guam, CNMI, Hawai'i, and the continental United States is subject to agricultural inspection. Title 9 (Volume 1, Chapter 1, Subchapter D, Part 93) allows the inspection of any shipping containers on aircraft or ships from foreign locations without a warrant to determine whether the aircraft or ship is carrying any animal or animal part subject to disposal to prevent the spread of disease. If the container is found to be contaminated, the operator of the aircraft or ship is responsible for disinfection. Title 9 (Volume 1, Chapter 1, Subchapter D, Part 95) also requires the disinfection of a container if it has transported restricted items that were not contained in leak-proof containers. The method of cleaning prescribed in Title 9 (Part 95) includes the collection of litter and refuse, and disposal of that refuse by incineration or other approved method. This is to be followed by cleaning the areas of the container that were exposed to the contaminant and saturation of the contaminated surface with an approved disinfectant. The approved disinfectants are sodium carbonate solutions, sodium hydroxide solutions, or liquefied phenol. These disinfectants are specifically designed to target foot and mouth disease, rinderpest, and ticks.

The APHIS-PPQ MAC instructs inspectors to inspect cargo if it is of agricultural interest (USDA-APHIS-PPQ 2013). Cargo of agricultural interest will contain either plant or animal material and is inspected primarily for agricultural pests or diseases. The APHIS-PPQ Treatment Manual contains procedures for treating cargo with fumigants, phosphine, methyl bromide, aerosols, or micronized dust (USDA-APHIS-PPQ 2008).

BTS Inspections

A Brown Treesnake Control and Interdiction Plan was developed by the Navy in response to Executive Order 13112, Invasive Species (The White House 1999, U.S. Navy 2005b), to prevent the movement of BTS off of Guam. Executive Order 13112 made it the responsibility of all federal agencies to prevent the introduction and spread of invasive species in the United States and elsewhere. The BTS plan requires the military to cooperate fully with federal authorities during observations and inspections of cargo destined to be shipped from Guam. It also requires a close working relationship with APHIS-WS to effectively implement the plan. APHIS-WS maintains dogs and equipment necessary to implement BTS control plans. The plan directs the Department of the Interior and USDA to go through a rulemaking process on BTS inspections.

The plan requires that 100% of all outbound cargo be inspected by BTS detector dog teams. However, the plan also states that military commanders and APHIS-WS personnel must jointly decide the extent of inspections based on the nature of the training exercise and the volume of cargo to be transported. Cargo shipped to Tinian is tagged following inspection and clearance by APHIS-WS, and this tag is subject to confirmation by CNMI Quarantine inspectors; however, the limited resources on Tinian hamper these confirmation inspections. Untagged cargo may be refused entry and reloaded aboard the conveyance for return to Guam. Once cargo is cleaned and inspected, it is to be immediately loaded onto a vessel or aircraft. If a delay will occur between inspection and loading, cargo may be placed in an APHIS-WS approved staging area and re-inspection may be required. Cargo staging areas are to be chosen to minimize the likelihood that BTS can access cargo. APHIS-WS is to be given complete access to staged cargo and equipment for the purposes of BTS inspections.

Military Regulations

All DoD containerized cargo is to be made available for inspection by CBP upon entry to a U.S. port of entry. It is up to the discretion of CBP personnel to determine what level of inspection is required. Inspections are focused on preventing the movement of drugs, firearms, plant and animal products, and undeclared items (DoD CBCPP 2009c). When the planned destination is in the CTUS, CBP agents inspect cargo to ensure it is free of plants, animals, or plant and animal products. Technically, Guam is not considered a CTUS.

To facilitate redeployment operations, DoD can request pre-clearance inspections by CBP and USDA for containerized cargo and equipment returning to the CTUS (DoD 2009c). The Defense Transportation Regulations, Part V, establish the requirements for agricultural cleaning and inspection and the assignment of DoD personnel as agricultural and customs inspectors for pre-clearance programs. USDA-APHIS is responsible for providing DoD with guidance, information, and training to perform pre-clearance inspections (DoD 2009a). Both CBP and USDA provide and approve training of Customs Border Clearance Agents for the military (DoD 2009c; DoD CBCPP 2009a, c). In addition, CBP can establish a Military Customs Inspectors–Excepted program at a DoD installation (DoD 2009d). Such a program allows DoD personnel to perform the same functions as CBP agents in connection with certain cargo as laid out in a memorandum of understanding between the installation commander and the local CBP port director. Inspection duties of the DoD personnel under this program include customs, immigration, and agricultural inspections or functions.

According to the requirements for agricultural cleaning and inspection (Part 5, Chapter 505), no cargo is to be loaded in a foreign country unless it is free from plant and animal contamination or pest infestations (DoD 2009a). Pre-clearance inspections may be requested for redeployment from major exercises or contingencies, and are performed at the point of origin (DoD 2009c). Requests for pre-clearance inspections must be submitted no later than 75 days prior to when the inspection is needed. Requests must contain the following information: dates, times, and place of departure from a foreign country; date, time, and place of arrival in the CTUS; amount and type of cargo; identification of all stops between the point of departure and arrival; and whether the border clearance integrity of the aircraft or ship will be maintained during en route stops. Examples of clearance integrity being breached are the addition or removal of cargo or passengers at any stop, crew member changes, off-loading of crew and passengers, or an aircraft remaining in a location overnight. Such breaches of integrity will void the pre-clearance authority. APHIS remains the final authority on the pest risk status of material or equipment.

Chapter 511 of the Defense Transportation Regulations Part V states that all containerized cargo entering Guam, regardless of origin, is subject to inspection by GCQA. GCQA requires a packing list for all containers, and will conduct inspections of containers. What these inspections entail is not described, other than to say that inspectors must make sure containers are free of BTS. Coordination of inspection activities between the military and foreign governments falls to the U.S. Transportation Command (DoD CBCPP 2009b). Part II of the Defense Transportation Regulations covers cargo, but contains little information regarding inspections (DoD 2008a).

OPNAVINST 6210.2 states that USDA-APHIS-PPQ personnel may inspect containerized cargo to prevent the introduction of plant and animal pests or diseases. For the purposes of these regulations, Guam is considered part of the United States. No military cargo is to be loaded in foreign countries unless it is free of soil or pests. Cargo is to be cleaned to remove soil and pests and packed in such a way as to prevent access of pests to cleaned cargo. The Quarantine Regulations of the Armed Forces states that cargo is subject to inspection by a representative of USDA to prevent the introduction or spread of animal and plant diseases or pests (DoD 1992).

Australia

The Australia Customs and Border Protection Service operates Container Examination Facilities at seaports, which were established to address border risks such as narcotics and terrorism (ACBPS 2009a, b). The Australia Customs and Border Protection Service conducts risk assessments for incoming cargo, and conducts inspections of all high risk cargo using x-ray machines in combination with physical examinations. Containers are x-rayed upon arrival at the port, and a determination is made whether the cargo requires an examination. Those requiring examination are physically inspected.

The Australian Quarantine and Inspection Service also conducts inspections of cargo containers. Inspections are designed to exclude exotic pests and diseases, and examine the external and internal cleanliness of containers. Containers from areas where the giant African snail (*Achatina fulica*) is found undergo a mandatory inspection. Containers are also examined for the presence of soil, plant material, and animal products.

China

China Customs and the Ministry of Agriculture are responsible for import and export inspections. The best information that we could obtain for cargo inspections by China Customs is related to inspection of goods. This information was used because goods may be packaged as cargo in containers. All inspections are conducted by two or more officers in a Customs control area. Goods are inspected to ensure that they match what is listed on the customs declaration. Customs officers have the discretion to determine what level of inspection is required. Inspections may be either thorough or selective, and may take place by either manual inspection, machine inspection, or both. Manual inspection may be of the exterior of packages, the interior of packages, or both (Xinsheng 2005; GAC 2007). Containers may also be inspected under the Import and Export Animal and Plant Quarantine Regulations by Ministry of Agriculture officials (People's Republic of China State Council 1982). No details could be found as to what quarantine inspections entail.

Commonwealth of the Northern Mariana Islands

The Saipan Customs Division looks for undeclared items, non-English labeled items, drugs, and weapons during its inspections of cargo (Sabian 2010). Saipan Customs has an x-ray machine for container inspections at the Port of Saipan. There is a BTS barrier at the Port of Saipan for containers, but Customs does not currently have a protocol for using it. Cargo that does not come from the continental United States is put in the barrier area for a minimum of 3 days. Personnel from the Department of Land and Natural Resources place traps around the barrier, and inspect the exterior of the containers with BTS detector dogs (Guerrero Jr. 2010). If a BTS detector dog alerts to a container, the container will stay within the barrier longer than 3 days for further inspection. Detector dog inspections are usually only conducted in the morning because the metal of the containers gets too hot during the middle of the day for the dogs. The BTS detector dog teams are part of the Division of Fish and Wildlife, which is a separate agency from the CNMI Customs and CNMI Quarantine agencies. Customs officials at the Saipan Airport receive training and certification for clearing exports (Pangolinean 2010). Staffing is currently inadequate at the airport, and Customs officials lack the necessary safety equipment to conduct inspections. The x-ray machine that was in use at the airport is nonfunctional because it is so old that replacement parts can no longer be obtained.

There is also a BTS barrier at the Port of Tinian (Ferrell 2010). Any containers that come from Guam get put into the barrier until the BTS detector dog can inspect it. Another BTS barrier is needed at the Tinian airport where the military C-130s unload their cargo. The military does not always inform Tinian Quarantine when they are coming with cargo; therefore, not all cargo gets inspected. Further, even when notification does occur, Tinian lacks the necessary response capabilities. Agricultural inspections in CNMI are overseen by APHIS-PPQ.

Federated States of Micronesia

FSMC Title 54, Chapter 2, Subchapter 3 gives Customs officials the right to examine goods. All cargo entering at an FSM port is required to be reported to FSM Customs within 1 day of arrival. No information could be found regarding Customs inspections of cargo. FSMC Title 22, Chapter 4, governs agricultural inspections of cargo, but no information is contained regarding what inspections entail.

Guam

Containerized cargo import inspections are to be conducted at designated ports unless otherwise authorized by the Director of GCQA (GCA 2010a). Seals on cargo and containers are not to be broken except by GCQA officials. There are 78 container freight stations on Guam (Merfalen 2010). Because of the volume of traffic, not all containers are selected for inspection. It is unknown how many arriving containers are opened and inspected for vertebrate invasive species. However, GCQA does not routinely open containers unless they lack proper documentation or are from a country Guam has deemed a country of concern (Merfalen 2010). Countries may be considered a concern for a variety of reasons, including whether they harbor an agricultural pest of concern, have had a disease outbreak, or have had previous customs violations.

The container freight station at the Guam International Airport currently only has one, two-man team. The freight station needs at least two teams to handle the relocation. GCQA has a new facility at the airport that will be able to handle the increased cargo flow from the relocation once it is fully operational. However, GCQA at the airport is currently understaffed and will need at least 31 additional personnel to handle the increased cargo flow due to the relocation (Shimizu 2010b). Guam Customs has two x-ray machines at the airport; they were inoperable at the time this was document was written and are awaiting replacement RapidScan machines (Berringer 2010b). GCQA relies on a paper trail to identify containers likely to require inspection. For example, in the Port of Guam, a container identified as requiring an inspection will be tagged by a Guam Customs and Quarantine Agent. This container may then be released to a consignee for movement from the port to a container freight station until inspection.

Hong Kong

Containerized cargo export examination is carried out by the Hong Kong Customs and Excise Department. Selection for examination is done in such a way as to minimize disruption of the shipping process. Hong Kong allows shippers to submit either a paper or an electronic cargo manifest. No specific information could be accessed regarding cargo examination procedures (Hong Kong CED 2010). We were unable to find any information regarding agricultural inspections of cargo.

Indonesia

No information could be found regarding inspections of cargo in Indonesia.

Japan

Exporters in Japan must obtain an export permit from Japan Customs, and goods are physically examined (Japan Customs and Tariff Bureau , MoF). Cargo is also subject to agricultural inspections by personnel from the Ministry of Agriculture, Forestry, and Fisheries. We could not obtain information regarding what inspections entail.

Korea

In order to promote foreign trade, the Korea Customs Service utilizes a paperless system for exporters to file paperwork. Technically, exported goods are exempt from inspection; however, Customs officials use risk selection criteria to select a certain percentage of exported containers to inspect. The risk selection criteria include shippers with past violations and forged goods or documents (MSF 2009). We were unable to find any information regarding agricultural inspections of cargo. The United States military has a manual specifically for customs inspections of military cargo in Korea (USFK CLE 2010). Military inspectors are to coordinate with the Korea Customs Service to conduct inspections and to ensure violations are reported and investigated. Military cargo imports are inspected on a case by case basis, with the emphasis placed on preventing military property from entering the black market. In light of this emphasis, cargo with a high black market value is considered high risk and is targeted for inspection.

Malaysia

No information could be found regarding inspections of cargo in Malaysia.

New Zealand

The Ministry of Agriculture and Forestry is responsible for agricultural inspections of cargo, and the New Zealand Customs Service is responsible for customs inspections. The only guidance concerning agricultural inspections of cargo and cargo containers we could find is related to import requirements for companies shipping to New Zealand. The interior of containers is to be inspected prior to being packed for animals, insects and other invertebrates, insect egg casings, animal materials, plant materials, water, and soil (MAF). During loading, containers are not to be contaminated with soil by forklifts or footwear, and are to be loaded on a hard, sealed surface. Containers are not to be left open for extended periods of time or overnight to prevent entry by pests. The exterior of containers are to be inspected for egg masses, grass, insects, pests, nests, seeds, snails, soil, and webs. Importers must file a Quarantine Declaration form that includes information about any treatments the container has received; otherwise it will be considered high risk. It is unknown if exported cargo must meet the same requirements.

The New Zealand Customs Service has an online declaration website that exporters can use to clear their exports with Customs. Shippers using this service must first be approved by customs officials as a registered user of the site. No information could be found regarding whether containers and cargo are inspected, how containers and cargo are selected for inspection, or what inspections entail.

Palau

The Bureau of Agriculture is the NPPO of Palau and maintains the legal authority from the Plant and Animal Quarantine Regulations (1999) as amended in 2008 to inspect containers and their contents for plant pests. The Palau NPPO is not responsible for the issuance of phytosanitary regulations or arranging for phytosanitary certification with the objective of ensuring that exported plants, plant produces, regulated articles, and consignments are in conformity with the certifying statement that the shipment is in compliant IPPC standards (Werner 2012).

Philippines

The Philippine Bureau of Customs regulates exports, but no information could be found regarding inspections for cargo other than paperwork requirements. Imported cargo agricultural products ae inspected by the Bureau of Customs (BOC) control. A cargo manifest for both incoming vessels and airways are shared with the Plant and Animal Quarantine to inform of incoming products. As per agreement in different ports of entry all attached government agencies involved in regulating the imported agricultural products provide clearance prior to BOC release. Upon arrival of agricultural products, BOC notifies plant and animal quarantine section to facilitate inspection and clearance. All documentation have to pass and satisfy both agencies prior to release. For export products, all agricultural products for export has to comply with the import requirement of the importing countries. Plant quarantine will issue a phytosanitary certificate for plants and plant products and international veterinary certificate for animals and animal products along with the inspection, treatment and compliance to any bilaterally agreed protocol required by the importing country. Documentation and treatment requirements of all cargoes with agricultural commodities for export are being done in the exporter's premises prior to transport to the port. For hand-carry baggage and small consignments, there are plant and animal quarantine inspection booths present in all ports of departure to inspect outgoing agricultural products and issue export certifications.

Republic of the Marshall Islands

The Marshall Islands Revised Code (Title 48, Chapter 2, Section 216) gives Customs officials the authority to examine goods carried on ships and aircraft (PacLII 2004b). No information is given regarding what examinations entail. The Marshall Islands Revised Code (Title 8, Chapter 1, Section 106) authorizes agricultural inspections of cargo to enforce plant and animal quarantine regulations (PacLII 2004a). No detail is given as to what agricultural inspections entail.

Singapore

Cargo that is to be exported requires a Customs permit and is cleared by Singapore Customs officials (Singapore Customs 2007a, b). No information was available as to what the clearance procedures entail. We were unable to find any information regarding agricultural inspections of cargo.

Taiwan

The Directorate General of Customs (DOGC) is the authority to regulate cargo container inspections for both imports and exports for non-agriculture items. Importers are required to provide documents that can prove the authenticity of country of origin, eg. certificate of origin, contract of conveyance, the information of manufacturing factory, export goods declaration form, etc. DOGC will check all the related documents for each cargo to ensure that they match with each other. However, physically examination on cargos are randomly sampled. The number of samples is determined based on entities, types, packages, and quantities of commodities. If dangerous cargo is suspected, then police agencies will jointly inspect the cargo with DOGC. Imported fresh fruit and vegetables, live animals, and plants may be exempted from inspection by DOGC. DOGC do not inspect these items for export. The Bureau of Animal and Plant Health Inspection and Quarantine (BAPHIQ), Council of Agriculture, is the authority responsible for both imports and exports of agricultural inspections of cargo. Food and Drug Administration, Department of Health and BAPHIQ are the authorities responsible for inspection of meat for human consumption.

United States

United States regulations are covered above under federal regulations.

Vietnam

Vietnam Customs is responsible for government inspections related to national security issues and inspects both imported and exported cargo (Vietnam Customs 2008a, b). Shippers who have been importing goods for 2 years without customs violations are exempt from inspection. It is unknown if this exemption also applies to exporters. In addition, there are certain types of goods that are exempt from inspection such as equipment and machinery. Ten percent of the cargo containers that do not meet one of these two requirements are inspected. Those shippers that have had three or more customs violations in the past 2 years will have the entire shipment of cargo inspected. We were unable to find any information regarding agricultural inspections of cargo.

A4.1.3.4.2 *Summary of Findings*

All pathways were considered high risk due to their ability to transport species that can harm human health and safety. The primary risk associated with this pathway is that current inspection procedures do not include inspection for vertebrate invasives because they have an agricultural pest or national security emphasis. In addition, containers are generally not opened unless they lack proper documentation or are from a country with a history of transporting invasive species or other violations. Such directed inspections, as opposed to true random inspections, make it more likely vertebrate invasive species could get missed. However, the optimal container selection strategy is a topic of current research (Eiswerth and Johnson 2002, Horan et al. 2002, Batabyal and Beladi 2006, Batabyal and Lee 2006, Surkov et al. 2009, Batabyal and Herath 2010).

A4.1.3.4.3 *Specific Risk Factors*

The specific risk factors we found to be associated with the cargo container pathways are as follows:

- Customs agencies are constrained by resources to only inspect a portion of containers. These inspections tend to be of material that has insufficient documentation or is from a country of concern.
- The paperwork associated with arriving containers is not automated which does not allow for more rapid selection of containers for screening.
- Documentation is lacking with regard to interception of vertebrates in or on cargo containers. Often a species is identified as moving in cargo but the specifics are not available.
- Container scanners are not available on Guam. They are available on Saipan but not used due to funding limitations.
- Not all cargo from Asia is required to be inspected prior to export.

A4.1.3.5 *Wood Packaging Material*

Wood packaging material can be a commodity shipped, used in the shipping process as packing material, and the conveyance used in packing, such as wooden crates. Wood packaging materials are used in almost all major shipments of cargo, and are known pathways for plant pest and pathogen introductions (USDA-APHIS 2003, FAO 2006e). Risk assessments to date have focused primarily on the movement of plant pests and pathogens; however, the WPM pathway can also move terrestrial vertebrates (Table A4-13).

Table A4-13: Invasive Species Transported in the Wood Packaging Material Pathway

Class	Scientific name	Common name	Risk type[a]
Amphibians	*Bufo melanostictus*	Asian common toad	None found[b]
	Eleutherodactylus coqui	Coqui frog	ECN, ECL
	Eleutherodactylus planirostris	Greenhouse frog	ECL
	Hyla cinerea	American green tree frog	ECL
	Kaloula pulchra	Asian painted frog	ECL
	Limnodynastes tasmaniensis	Spotted grass frog	ECL
	Litoria aurea	Green and golden bell frog	H, ECL
	Litoria caerulea	Australian green tree frog	ECL
	Litoria chloris	Red-eyed tree frog	None found
	Litoria ewingii	Whistling tree frog	ECL
	Litoria fallax	Eastern dwarf tree frog	ECL
	Osteopilus septentrionalis	Cuban tree frog	H, ECN, ECL
	Polypedates leucomystax	Common tree frog	ECL
	Pseudacris regilla	Pacific tree frog	ECL
	Rana sylvatica	Wood frog	ECL
	Rhinella marina	Cane toad	H, ECN, ECL
Birds	None likely	None likely	
Mammals	*Didelphis marsupialis*	American opossum	H, ECN, ECL
	Mus musculus	Common mouse	H, ECN, ECL
	Rattus exulans	Pacific rat	H, ECN, ECL
	Rattus norvegicus	Norway rat	H, ECN, ECL
	Rattus rattus	Ship rat	H, ECN, ECL
	Suncus murinus	Musk shrew	H, ECN, ECL
Reptiles	*Agama agama*	Common agama	None found
	Anolis cristatellus	Common Puerto Rican anole	ECL
	Anolis distichus	Hispaniolan gracile anole	ECL
	Anolis extremus	Barbados anole	ECL
	Anolis porcatus	Cuban green anole	ECL
	Anolis sagrei	Cuban brown anole	ECL
	Boa constrictor	Boa constrictor	H, ECN, ECL
	Boiga irregularis	Brown treesnake	H, ECN, ECL
	Calotes versicolor	Eastern garden lizard	ECL
	Chondrodactylus bibronii	Bibron's thick-toed gecko	ECN
	Cnemidophorus lemniscatus	Rainbow lizard	ECL
	Cryptoblepharus carnabyi	Spiny-palmed snake-eyed skink	None found
	Cryptoblepharus peocilopleurus	Mottled snake-eyed skink	ECL
	Cryptoblepharus plagiocephalus	Péron's snake-eyed skink	None found
	Cryptoblepharus virgatus	Cream-striped shinning-skink	None found
	Cyrtopodion scabrum	Rough-tailed gecko	ECL
	Elaphe taeniura friesi	Taiwan beauty snake	None found
	Elgaria multicarinata	Southern alligator lizard	None found
	Emoia cyanura	Bluetail emo skink	ECL
	Eulamprus tenuis	Bar-sided forest skink	None found
	Gehyra mutilata	Mutilating gecko	None found
	Gekko gecko	Tokay gecko	ECL
	Gonatodes albogularis	Yellow-headed gecko	None found

Class	Scientific name	Common name	Risk type[a]
	Hemidactylus frenatus	Common house gecko	ECL
	Hemidactylus garnotii	Indo-Pacific gecko	None found
	Hemidactylus platyurus	Flat-tailed house gecko	None found
	Hemidactylus turcicus	Mediterranean house gecko	ECL
	Hemiphyllodactylus typus	Common dwarf gecko	None found
	Lampropholis delicata	Delicate skink	ECL
	Lepidodactylus aureolineatus	Golden scaly-toed gecko	None found
	Lepidodactylus lugubris	Mourning gecko	None found
	Lipinia noctua	Moth skink	None found
	Lycodon aulicus	Common wolf snake	ECL
	Mabuya multifasciata	Rough mabuya	None found
	Python molurus bivittatus	Burmese python	H, ECN, ECL
	Ramphotyphlops braminus	Blind snake	None found
	Sceloporous occidentalis	Western fence lizard	None found
	Sphaerodactylus argus	Ocellated gecko	None found
	Sphaerodactylus elegans	Ashy gecko	None found
	Tarentola mauritanica	Common wall gecko	None found
	Tiliqua scincoides	Common bluetongue	None found
	Trimeresurus flavoviridis	Habu	H
	Uta stansburiana	Northern side-blotched lizard	None found

[a] H = health, ECN = economic, ECL = ecological.
[b] No impacts found in the literature, but undocumented impacts may exist.

WPM encompasses such things as crates, pallets, dunnage, packing blocks, drums, cases, load boards, pallet collars, skids, veneer peeler cores, sawdust, wood wool, wood shavings, raw wood cut into thin pieces, and cable spools. Because WPMs differ and are not likely to transport the same types of terrestrial vertebrates, they were grouped into three broad categories for the risk analysis depending on what they were likely to transport. Cable spools, cases, crates, drums, and pallets were grouped together as being likely to transport a variety of amphibians, mammals, and reptiles because of the availability of hiding places. Dunnage, load boards, packing blocks, pallet collars, raw wood cut into thin pieces, skids, and veneer peeler cores were grouped together because they most likely will only transport tree frogs, geckos, and skinks as these species are capable of clinging to various surfaces. Finally, sawdust, wood shavings, and wood wool were grouped together as being likely to only transport rodents that might be attracted to the material as bedding or nesting habitat.

Because of the paucity of documentation specifically relating to the movement of invasive species in WPM, species that were listed as having been moved in cargo were used to generate the species lists, and further, only those that were deemed likely to use a particular type of packing material based on biological information were used. Species selection was based on criteria such as body size, presence of toe pads on amphibians and lizards, ability to walk on vertical surfaces and upside down, whether a species tends to be arboreal or terrestrial, and the resting or nesting sites typically utilized. Many species are listed as having been moved in cargo, but no specific information is given as to where in the cargo they were found. They may have been clinging to the inside of the cargo container itself, clinging to WPM such as dunnage, or have found their way inside packing material such as sawdust. There is likely to be overlap between the species listed in these pathways and those listed in the cargo container pathway. Because no good data exist, there is some uncertainty inherent in the list of species for this pathway.

Information from the major shipping companies servicing the Micronesia Region was used to determine the routes by which cargo is likely to be shipped. This information was used because no information exists explicitly on the transport of WPM, and WPM is likely to be used with specific cargo. The major shipping companies used for cargo delivery in the Micronesia Region and their routes are covered elsewhere in this document.

A4.1.3.5.1 *Wood Packaging Material Inspections*

Wood packaging material can be shipped as cargo to companies that then use those materials in the packing and shipping of cargo goods. The United States began fully enforcing treatment of WPM being shipped as cargo according to the ISPM on July 5, 2006 (USDA-APHIS 2007b). Wood packaging materials themselves are subject to ISPM regulations listed in ISPM 15 that were developed by the IPPC (FAO 2006e). The IPPC is an international agreement regarding plant health and the prevention of the movement of plant pests. Currently, it has 173 signatories, making the majority of the countries involved in this pathway subject to ISPM 15 regulations (IPPC 2010). These regulations do not apply to WPM used in the packing and shipping of cargo goods.

The regulations allow manufacturers and shippers two options: heat treatment or treatment with methyl bromide. For materials to receive the ISPM 15 quality mark, materials being shipped as cargo must be inspected by an agency accredited by either the American Lumber Standard Committee for heat treatment (ALSC 2009), or the National Wood Pallet and Container Association for methyl bromide fumigation (NWPCA 2009). Inspection procedures by both agencies must follow ISPM 15 regulations. The regulations were developed to prevent the movement of plant pests such as insects, rather than vertebrate invasives. These regulations only apply to pallets, dunnage, crates, packing blocks, drums, cases, load boards, pallet collars, and skids that are transported as cargo and not as a conveyance (FAO 2006e). Materials such as veneer peeler cores, sawdust, wood wool, wood shavings, and raw wood cut into thin pieces are not considered pathways of introduction for quarantine pests and thus are not regulated (FAO 2006e). These regulations do not apply to movement within the United States or to export to U.S. Trust Territories (USDA-APHIS 2008a). Also exempt is WPM used in DoD cargo shipments of WPM that are imported for use by the DoD or its contractors, although some contractors may choose to implement ISPM procedures (CBP 2010c).

Although heat treatment and methyl bromide may eliminate many insect and plant pests, both treatments are utilized during the manufacturing stage only, and terrestrial vertebrate species may enter treated WPM during the packing process. Heat treatment consists of heating wood until the minimum wood core temperature is 56°C for at least 30 minutes (FAO 2006e). The methyl bromide fumigation procedure is temperature and dosage dependent, but the minimum temperature is not to be less than 10°C and the minimum exposure time is not to be less than 24 hours. Minimum monitoring of the methyl bromide concentration should be conducted at 2, 4, and 24 hours (FAO 2006e).

Customs agents clearing WPM imported as cargo rely on quality marks, the labeling required by ISPM 15 for WPM. Quality marks allow for clear and easy identification of material that has been properly treated and its country of origin. The country of origin is identified by a two letter ISO (International Organization for Standardization) country abbreviation (FAO 2006e). Quality marks include information such as a trademark, facility identification, and treatment used. The trademark identifies who made the inspection, and is an identifying symbol, logo, or name of the accredited agency that provided inspection services. The facility identification gives the product manufacturer name, brand, or assigned facility number. The treatment used is symbolized as HT for heat treatment and MB for methyl bromide. The quality mark contains an approved international symbol for compliant WPM, and an indication of whether the material is used as dunnage; dunnage can either be spelled out or abbreviated. Dunnage imported as cargo may be specifically singled out for marking because it can be made from wood that has or has had bark on it, or it may be recycled and used to build crates or pallets; therefore, it needs to be especially clear that it has been treated to avoid movement of insect pests (FAO 2006e). Wood packaging material cargo that is recycled must be re-certified and re-marked to ensure that no new pests, particularly insects, have entered the material prior to recycling (FAO 2006e).

Accredited inspection agencies periodically audit WPM manufacturer facilities and provide the quality mark to the manufacturer. Audits typically include an inspection of records to ensure compliance with ISPM 15, and may or may not include an inspection of the manufacturing floor or operational procedures. It is incumbent upon the individual manufacturer to maintain proper records and quality assurance procedures. Generally, only representative samples from random lots of material are inspected (ALSC 2009, NWPCA 2009). An obvious invasive species might get detected during this process, but most invasives listed in this pathway are small and may go undetected. In addition, most vertebrate invasives are most likely to enter this pathway when the materials are used post-manufacture to cushion other cargo during transport. This screening does nothing to prevent a species from entering the material while it is being used in the packing process, post-manufacturing.

CBP inspects WPM shipped as a commodity for compliance with ISPM 15 and the presence of quality marks indicating inspections were completed by an accredited agency (CBP 2010b). CBP does not validate quality marks which is the jurisdiction of USDA, but it does check to ensure marks are legible and permanent (SAL). Most of the countries involved in this pathway are parties to the IPPC, and require adherence to ISPM 15 regulations (USDA-APHIS 2009b).

Title 7 of the CFR governs the treatment and inspection of WPM being shipped as a cargo commodity. Part 305 of Title 7 covers phytosanitary treatments and states that treatments are to occur at APHIS certified facilities and are to be monitored by APHIS officials. Part 319 of Title 7 of the CFR defines regulated WPM as dunnage, crating, pallets, packing blocks, drums, cases, and skids. All regulated WPM are required to have the IPPC quality mark, unless they are a DoD shipment. Regulated WPM is to be inspected at the first port of entry. If pests are found, the shipment can either be cleaned and treated or refused entry. A minimum of 7 days' advance notice to the APHIS officer in charge is required for all regulated WPM coming into a port in the United States.

The APHIS-PPQ Manual for Agricultural Clearance directs inspectors to check whether regulated WPM is compliant or non-compliant, but gives no other information on inspections (USDA-APHIS-PPQ 2013). Dunnage on barges is a particular concern because it is more susceptible to becoming flotsam. The APHIS-PPQ Treatment Manual contains specific instructions for the treatment of regulated WPM with heat or methyl bromide (USDA-APHIS-PPQ 2008).

The APHIS Miscellaneous and Processed Products Manual contains inspection guidance that also applies to Guam and CNMI (USDA-APHIS-PPQ 2010d). Inspectors are instructed to look specifically for timber pests, other insects, and unspecified hitchhikers. If the WPM came from the United States, including U.S. territories, or from the DoD, it is to be released but may be inspected. Wood packaging material coming from foreign locations is inspected for the proper ISPM 15 quality mark and for timber pests, other insects, and hitchhikers. Inspection is defined in the manual as a review of documentation and articles to determine compliance with regulations. Logs, lumber, wood crating, and dunnage have special inspection instructions that are related to the safety of the inspector. When no special inspection instructions exist, 2% of the shipment is inspected. In addition, these articles are inspected for beetles, borers, nematodes, termites, and weevils. A list of 28 items that routinely use WPM that should be paid special attention to are given in this manual. These include such items as cast iron products, equipment, pottery, and stoneware.

It is unknown how many containers are opened and the WPM used in the packing and shipping process are inspected for terrestrial vertebrate invasive species, or the thoroughness of inspections. GCQA does not routinely open containers unless they lack proper documentation or are from a country Guam has deemed a concern (Shimizu 2010b). Countries of concern for Guam tend to be in Asia and on smaller Micronesian islands that have little or no resources for biosecurity, because these were identified as points of origin for cargo and related packing materials, or have had previous violations. Inspection protocols similar to Guam's are in place on Saipan and Tinian (Ferrell 2010; Sabian 2010). We were unable to find information specifically relating to the inspection of WPM by the other countries listed as moving cargo and WPM.

A4.1.3.5.2 *Summary of Findings*

All pathways were considered high risk because of their ability to transport species that could harm human health and safety. The primary risk associated with this pathway is that current inspection procedures do not include inspection for terrestrial vertebrate species, nor do they prevent the entry of these species into the material during the packing process. Inspections driven solely by proper documentation and country of origin, as opposed to true random inspections, make it more likely to miss terrestrial vertebrate species inadvertently being transported. Risk increased as the resources of customs agencies decreased. The required ISPM 15 quality marks have been counterfeited or fraudulently used (Brindley 2010; WPA 2010). More data are needed on the interception of vertebrates found specifically in WPM upon arrival with cargo.

A4.1.3.5.3 *Specific Risk Factors*

The specific risk factors we found to be associated with the WPM pathways are as follows:

- The inspection process for WPM applies to pre-packaged material manufactured at the plant of origin and does not apply to vertebrates that have entered the material while it is being used post-manufacturing as packing material for cargo shipments.
- Customs agencies are constrained by resources such as time and finances, to inspect only a portion of arriving containers, and may exclude any WPM within.
- It is unclear how thorough inspection of containers is with regard to WPM.
- ISPM 15 quality marks may be counterfeited or fraudulently used.
- Documentation is lacking with regard to interception of vertebrates found in WPM.

A4.1.3.6 *Relocation: Household Goods and Personal Vehicles Related to Relocation*

In general, household goods and vehicles are well-known pathways for the movement of invasive species (Long 2003, Vice and Pitzler 2008, Kraus 2009). This type of cargo is capable of transporting BTS and rodents among other species (Table A4-14). A large number of military personnel and their dependents will be relocating to Guam as a result of the military relocation (see Section 0). Personnel will be bringing household goods and personal vehicles, increasing the risk of moving vertebrate invasive species. Additionally, military and civilian household goods and vehicles are routinely shipped commercially throughout the Micronesia Region.

Military personal property is shipped by the U.S. Transportation Command, who can transport the cargo on a military conveyance or book a commercial contract carrier (DoD 2008b, 2010a). To the extent possible, personal property is shipped using the services of the Air Mobility Command or the Military Sealift Command. Property is commonly packed commercially and moved off base by commercial channels as freight (Vice and Pitzler 2008). Additionally, when service members are relocated they are entitled to have one vehicle transported to their new duty station at government expense (DoD 2009e). Other vehicles may be transported at the service member's expense.

Regionally, Guam is a commercial center for the Micronesia Region for commodities such as small appliances, furniture, and other household goods that are often shipped regionally from Guam throughout the region for both private and military purposes. This type of cargo may be containerized or palletized. Personally owned vehicles, particularly used vehicles, are also shipped from Guam, often as bulk cargo.

Three major routes for this type of cargo shipment were considered in the analyses: Okinawa to Guam, Guam to the continental United States, and Guam to other parts of the Micronesia Region via Saipan. Household goods and personally owned vehicles can be shipped commercially from Okinawa via Miike Harbor, Japan, once a week. The shipping company is Hueng-A Shipping Company, Limited, and their agents for the Okinawa to the Port of Miike route are either Kaniyaku Corporation or Minami Nihon Kisen (Port of Miike). Containerized cargo can then be transshipped via Busan by Kyowa to Guam or via a port in China to Guam by Matson or Horizon. Arrangements can be made through a freight forwarding company. Cargo shipped commercially off Guam by Matson or Horizon to the continental United States is transshipped through Asia prior to returning to the continental United States (Matson 2006; Horizon

Lines 2008). Regional shipping from the ports on Guam and Saipan throughout the Micronesia Region is handled by feeder services provided by Kyowa, Seabridge Marine, and Micronesia Express Service (PB International 2008).

Table A4-14: Invasive Species Transported in the Household Goods and Personal Vehicles Pathways

Class	Scientific name	Common name	Risk type[a]
Amphibians	*Eleutherodactylus planirostris*	Greenhouse frog	ECL
	Kaloula picta	Slender-digit chorus frog	None found[b]
	Kaloula pulchra	Asian painted frog	ECL
	Litoria fallax	Dwarf tree frog	ECL
	Polypedates leucomystax	Common tree frog	ECL
	Rhinella marina	Cane toad	H, ECN, ECL
Birds	None likely	None likely	
Mammals	*Mus musculus*	Common mouse	H, ECN, ECL
	Rattus exulans	Pacific rat	H, ECN, ECL
	Rattus norvegicus	Norway rat	H, ECN, ECL
	Rattus rattus	Black rat	H, ECN, ECL
	Rattus tanezumi	Asian house rat	H, ECN, ECL
	Suncus murinus	Musk shrew	H, ECN, ECL
Reptiles	*Anolis carolinensis*	Green anole	ECL
	Boiga irregularis	Brown treesnake	H, ECN, ECL
	Elaphe taeniura friesi	Taiwan beauty snake	None found
	Gehyra mutilata	Mutilating gecko	None found
	Gekko gecko	Tokay gecko	ECL
	Lepidodactylus lugubris	Mourning gecko	None found

[a] H = health, ECN = economic, ECL = ecological.
[b] No impacts found in the literature, but undocumented impacts may exist.

A4.1.3.6.1 *Inspection of Household Goods and Personal Vehicles*

Military Regulations

Shipping of military household goods and personally owned vehicles is covered in Part 4 of the Defense Transportation Regulations. Other regulations that pertain to these items are covered in Section 0. Personnel are counseled prior to a move as to what is required of them, and they are required to sign form DD 1797 stating they have been counseled as to moving requirements (DoD). Household goods that contain engine power driven equipment must be free of dirt and grease (DoD 2010b). Personal property items are also to be free of soil and pest infestations, such as gypsy moths or BTS (DoD 2010b, c). Any item that can be scratched, broken, or otherwise damaged during shipment is individually wrapped (DoD 2010e). Household goods packed on Guam are inspected by APHIS-WS detector dog teams for BTS during packing for households with more than an estimated 1,814 kg (4,000 pounds) of personal property (Vice and Pitzler 2008). During fiscal year 2008, approximately 70% of all packed household goods were inspected by APHIS-WS BTS detector dogs at Andersen AFB, 80% at the naval base, and 87% at the commercial ports (USDA-APHIS WS 2008a).

Shipment of personally owned vehicles is covered in Chapter 408 and Attachment K3. Personnel are responsible for ensuring that all exterior surfaces and the undercarriage of the vehicle are free of soil and foreign matter (DoD 2009e, f). The vehicle processing center at the naval base on Guam advises vehicle owners to make sure their vehicles are free of plants, leaves, seeds, soil, dirt, mud, food, beverages, insects, rodents, and animals (Pepka 2010). An inspection is performed of the vehicle by personnel at the vehicle processing center to note any damage prior to shipping and to ensure the cleanliness of the vehicle (DoD 2009e, f). On Guam, USDA personnel inspect the engine, engine compartment, radiator grill, hood, trunk, hatch, door compartments, wheels, wheel areas, and undercarriage areas (Pepka 2010), and APHIS-WS BTS detector dogs inspect the vehicles prior to shipping. If destined for the United States, vehicles are inspected again upon arrival. GCQA inspects vehicles coming from foreign locations, but does not inspect vehicles coming from the continental United States. During fiscal year 2008, 100% of all vehicles were inspected by APHIS-WS BTS detector dogs at Andersen AFB and the naval base, and 99% at the commercial ports (USDA-APHIS WS 2008a).

Japan

Exporters of military household goods and personal vehicles in Japan must obtain an export permit from Japan Customs, and goods are physically examined. Cargo is also subject to agricultural inspections by personnel from the Ministry of Agriculture, Forestry, and Fisheries. We could not obtain information regarding what inspections entail.

Guam

Cargo and vehicles arriving in Guam shipped as commercial freight would be subject to GCQA inspection (Merfalen 2010). Cargo inspections are to be conducted at designated ports unless otherwise authorized by the Director of GCQA (GCA 2010a). Seals on cargo are not to be broken except by GCQA officials. There are 78 container freight stations on Guam where selected containers are moved from the point of entry and staged for inspection (Merfalen 2010). Because of the volume of traffic, not all containers are selected for inspection. It is unknown how many arriving containers are opened and inspected for vertebrate invasive species. However, GCQA does not routinely open containers unless they lack proper documentation or are from a country Guam has deemed a country of concern (Merfalen 2010). Countries may be considered a concern for a variety of reasons, including whether they harbor an agricultural pest of concern, have had a disease outbreak, or have had previous customs violations.

The container freight station at the Guam International Airport currently only has one two-person team. The freight station needs at least two teams to handle the relocation. GCQA has a new facility at the airport, which will spatially be able to handle the increased cargo flow from the relocation once it is adequately staffed and equipped and fully operational. Currently, GCQA at the airport is currently understaffed, and will need at least 31 additional personnel to handle the increased cargo flow due to the relocation (Shimizu 2010b). Guam Customs has two x-ray machines at the airport; they were inoperable at the time this was document was written and are awaiting replacement RapidScan machines (Berringer 2010b). GCQA relies on a paper trail to identify containers likely to require inspection. For example, in the Port of Guam, a container identified as requiring an inspection will be tagged by a Customs and Quarantine Agent. This container may then be released to a consignee for movement from the port to a container freight station until inspection.

Commonwealth of the Northern Marianas Islands

The Saipan Customs Division looks for undeclared items, non-English labeled items, drugs, and weapons during its inspections of household imports (Sabian 2010). Saipan Customs has an x-ray machine for containerized cargo import inspections at the Port of Saipan. There is a BTS barrier at the Port of Saipan for containers, but Customs does not currently have a protocol for using it. Cargo that does not come from the continental United States is put in the barrier area for a minimum of 3 days. Personnel from the Department of Land and Natural Resources place traps around the barrier, and inspect the exterior of the containers with BTS detector dogs (Guerrero Jr. 2010). If a BTS detector dog alerts to a container, the container will stay within the barrier longer than 3 days for further inspection. Detector dog inspections are usually only conducted in the morning because the metal of the containers gets too hot during the middle of the day for the dogs. Customs officials at the Saipan Airport receive training and certification for clearing exports (Pangolinean 2010). Staffing is currently inadequate at the airport, and Customs officials lack the necessary safety equipment to conduct inspections. The x-ray machine that was in use at the airport is nonfunctional because it is so old that replacement parts can no longer be obtained.

There is also a BTS barrier at the Port of Tinian (Ferrell 2010). Any containers that come from Guam get put into the barrier until the BTS detector dog can inspect it. Another BTS barrier is needed at the Tinian airport where the military C-130s unload their cargo. The military does not always inform Tinian Quarantine when they are coming with cargo; therefore, not all cargo gets inspected; however, when information is relayed, there is typically little or no response capability to perform inspections. Agricultural inspections in CNMI are overseen by APHIS-PPQ.

A4.1.3.6.2 *Summary of Findings*

All pathways were considered high risk due to their ability to transport species that could harm human health and safety. Household goods that are individually wrapped and/or packed are associated with lower risk of transporting vertebrate invasive species because the packing process makes detection more likely (Vice and Pitzler 2008). However, the probability of detecting BTS by canine inspection teams is greatly decreased once household goods are sealed inside containers or wooden crates (Vice and Pitzler 2008). Short shipment times, particularly those within the Micronesia Region, increase the probability of species survival during transport (Vice and Pitzler 2008). Higher risk ratings also resulted because resources for implementing biosecurity measures were inadequate to meet even current demands.

A4.1.3.6.3 *Specific Risk Factors*

The specific risk factors we found to be associated with the household goods and personal vehicles pathways are as follows:

- BTS inspections may not address the movement of other potentially invasive species.

- No contact networks exist for species other than BTS for responding to detections and sightings of invasive species, or when species are captured; however, these networks are not always guaranteed to operate efficiently.
- Shipments of household goods and vehicles within the Micronesia Region have a greater risk of transporting terrestrial vertebrate species successfully due to the short transportation time.
- Agricultural inspections at the port of entry may not adequately detect a vertebrate invasive species moving in vehicles or household goods.
- There are limited control measures for frogs, toads, lizards, and snakes that could be moved in these pathways.
- Inadequate financial resources exist in CNMI to maintain inspections and expensive control programs.
- There are insufficient numbers of Customs and Quarantine staff to inspect the anticipated quantity of military household goods and vehicles to be shipped to Guam as part of the relocation on Guam (Taijeron 2010a).

A4.1.3.7 *Transportation of Construction Materials, Equipment, and Vehicles*

Construction for military facilities, housing, infrastructure, and improvements at the Port of Guam will be required for the relocation (U.S. Navy 2009a). Associated with this construction will be a variety of materials, equipment, and vehicles. Significant numbers and types of invasive vertebrate species are moved in cargo shipments, and break-bulk cargo like construction equipment and vehicles (Long 2003; Kraus 2009; ISSG 2010) (Table A4-15). There was a general lack of information regarding amounts, types, and origins of construction materials, equipment, and vehicles; therefore, this assessment should be re-evaluated once information becomes available.

Table A4-15: Invasive species transported in or on construction materials, equipment, or vehicles

Class	Scientific name	Common name	Risk type[a]
Amphibians	*Bufo melanostictus*	Asian common toad	None found[b]
	Eleutherodactylus coqui	Coqui frog	ECN, ECL
	Eleutherodactylus planirostris	Greenhouse frog	ECL
	Hyla cinerea	American green tree frog	ECL
	Kaloula pulchra	Asian painted frog	ECL
	Limnodynastes tasmaniensis	Spotted grass frog	ECL
	Litoria aurea	Green and golden bell frog	H, ECL
	Litoria caerulea	Australian green tree frog	ECL
	Litoria chloris	Red-eyed tree frog	None found
	Litoria ewingii	Whistling tree frog	ECL
	Litoria fallax	Eastern dwarf tree frog	ECL
	Osteopilus septentrionalis	Cuban tree frog	H, ECN, ECL
	Polypedates leucomystax	Common tree frog	ECL
	Pseudacris regilla	Pacific tree frog	ECL

Class	Scientific name	Common name	Risk type[a]
	Rana sylvatica	Wood frog	ECL
Birds	None likely	None likely	
Mammals	*Didelphis marsupialis*	American opossum	H, ECN, ECL
	Herpestes javanicus	Small Indian mongoose	H, ECN, ECL
	Mus musculus	Common mouse	H, ECN, ECL
	Rattus exulans	Pacific rat	H, ECN, ECL
	Rattus norvegicus	Norway rat	H, ECN, ECL
	Rattus rattus	Ship rat	H, ECN, ECL
	Rattus tanezumi	Asian house rat	H, ECN, ECL
	Suncus murinus	Musk shrew	H, ECN, ECL
Reptiles	*Agama agama*	Common agama	None found
	Anolis cristatellus	Common Puerto Rican anole	ECL
	Anolis distichus	Hispaniolan gracile anole	ECL
	Anolis extremus	Barbados anole	ECL
	Anolis porcatus	Cuban green anole	ECL
	Anolis sagrei	Cuban brown anole	ECL
	Boa constrictor	Boa constrictor	H, ECN, ECL
	Boiga irregularis	Brown treesnake	H, ECN, ECL
	Calotes versicolor	Eastern garden lizard	ECL
	Chondrodactylus bibronii	Bibron's thick-toed gecko	ECN
	Cnemidophorus lemniscatus	Rainbow lizard	ECL
	Cryptoblepharus carnabyi	Spiny-palmed snake-eyed skink	None found
	Cryptoblepharus peocilopleurus	Mottled snake-eyed skink	ECL
	Cryptoblepharus plagiocephalus	Péron's snake-eyed skink	None found
	Cryptoblepharus virgatus	Cream-striped shinning-skink	None found
	Cyrtopodion scabrum	Rough-tailed gecko	ECL
	Elaphe taeniura friesi	Taiwan beauty snake	None found
	Elgaria multicarinata	Southern alligator lizard	None found
	Emoia cyanura	Bluetail emo skink	ECL
	Eulamprus tenuis	Bar-sided forest skink	None found
	Gehyra mutilata	Mutilating gecko	None found
	Gekko gecko	Tokay gecko	ECL
	Gonatodes albogularis	Yellow-headed gecko	None found
	Hemidactylus frenatus	Common house gecko	ECL
	Hemidactylus garnotii	Indo-Pacific gecko	None found
	Hemidactylus platyurus	Flat-tailed house gecko	None found
	Hemidactylus turcicus	Mediterranean house gecko	ECL
	Hemiphyllodactylus typus	Common dwarf gecko	None found
	Lampropholis delicata	Delicate skink	ECL
	Lepidodactylus aureolineatus	Golden scaly-toed gecko	None found
	Lepidodactylus lugubris	Mourning gecko	None found
	Lipinia noctua	Moth skink	None found
	Lycodon aulicus	Common wolf snake	ECL
	Mabuya multifasciata	Rough mabuya	None found
	Python molurus bivittatus	Burmese python	H, ECN, ECL
	Ramphotyphlops braminus	Blind snake	None found
	Sceloporous occidentalis	Western fence lizard	None found
	Sphaerodactylus argus	Ocellated gecko	None found
	Sphaerodactylus elegans	Ashy gecko	None found

Class	Scientific name	Common name	Risk type[a]
	Tarentola mauritanica	Common wall gecko	None found
	Tiliqua scincoides	Common bluetongue	None found
	Trimeresurus flavoviridis	Habu	H
	Uta stansburiana	Northern side-blotched lizard	None found

[a] H = health, ECN = economic, ECL = ecological.

[b] No impacts found in the literature, but undocumented impacts may exist.

Construction materials are items used in the building process and can consist of packed or containerized cargo goods, and break-bulk items like lumber, wood and metal paneling, molding, plumbing pipes, and fixtures. Construction equipment is items and tools used for building, like generators, compressors, table saws, nail guns, ladders and scaffolding, and machinery parts and accessories. Construction vehicles include earth moving machinery like bulldozers, excavators, and bobcats, as well as forklifts, concrete mixers and their pumps, dump trucks, and all-terrain vehicles. Estimates of construction material, equipment, and vehicle needs were partly based on a projection of the amount of land that would need to be cleared to accommodate military relocation on Guam (Section 0).

Construction material shipped as break-bulk cargo is items that exceed the dimensions of a standard cargo container. The carriers Matson and Horizon transport these materials on a 40-foot flat rack system (Matson 2006; Horizon Lines 2008). Cargo that exceeds the dimensions of a flat rack can be accommodated by these carriers by special arrangement. Kyowa uses a similar system but will ship smaller break-bulk cargo as well (Kyowa Shipping Company 2010a).

The actual points of origination for much of the construction materials, equipment, and vehicles have not been identified. We assessed risks posed by construction cargo brought to Guam from elsewhere in the United States or Asia. Construction cargo entering the Micronesia Region is shipped in by boat to the Port of Guam or flown in by air to Guam International Airport (commercial) or Andersen AFB (military). The major shipping companies for cargo in the Micronesia Region are Horizon, Matson, Kyowa, and Mariana Express Lines (PB International 2008). Information from these companies was used to determine the routes by which cargo is likely to be shipped (Horizon Lines 2010b, c, d, a; Kyowa Shipping Company 2010a, b; Mariana Express Lines 2010a, b; Matson 2010a, b). All of these companies provide containerized and bulk cargo transport.

A4.1.3.7.1 *Inspection of Construction Materials, Equipment, and Vehicles*

Because construction supplies and some equipment will be shipped as either containerized or break-bulk cargo, the cargo regulations provided in Section 0 apply. Details of each regulation can be found in that section. Most cargo undergoes both customs and agricultural inspections upon arrival. The International Health Regulations govern inspections related to human health concerns (WHO 2005b). The CFR gives authority for cargo inspections and disinfection in Titles 7 and 9 (7 CFR 318, 9 CFR). The Brown Treesnake Control and Interdiction Plan makes it the responsibility of all federal agencies to prevent the movement of BTS, and covers inspection of cargo (U.S. Navy 2005b). The military is bound to conduct inspections of cargo by Parts 2 and 5 of the Defense Transportation Regulations, the Quarantine Regulations of the Armed Forces, and OPNAVINST 6210.2 (DoD 1992, DoD 2009b). The

APHIS-PPQ Manual for Agricultural Clearance contains a chapter on clearing cargo (USDA-APHIS-PPQ 2013).

Construction vehicle inspections emphasize agricultural risks for transporting invasive plants, insects, or agriculturally significant diseases vectored in soil. Inspection scrutiny increases with equipment arriving from an origin of concern that may pose an agricultural risk. Agricultural inspections are overseen in Guam and CNMI by APHIS-PPQ. Additionally, construction vehicles shipping from Guam are inspected for the presence of the BTS by an APHIS-WS detector dog team (Vice 2010a). Because construction vehicles are so large, searches by BTS detector dogs may not be as effective as for smaller vehicles. Construction vehicles arriving in CNMI will be placed in a BTS barrier and inspected for BTS (Pangolinean 2010).

A4.1.3.7.2 *Summary of Findings*

All pathways were considered to be high risk due to their ability to transport species capable of harming human health and safety. The primary risk associated with this pathway is that current inspection procedures do not include inspection for vertebrate invasives because they have an agricultural pest or human health risk emphasis. Inspections are directed at cargo arriving from an origin of concern or cargo that may pose an agricultural risk. Containers likely to be inspected will have a manifest identifying the cargo as an agricultural product. Bulk cargo containing wood or transported on/in wood conveyances such as pallets will be inspected to ensure the wood complies with ISPM 15 requirements (FAO 2006e). Because almost no specific information could be obtained regarding the needs and acquisition of construction cargo for the military relocation on Guam and CNMI, the risk assessment is incomplete.

A4.1.3.7.3 *Specific Risk Factors*

The specific risk factors we found to be associated with the construction materials, equipment, and vehicles pathways are as follows:

- Customs agencies are constrained by resources to inspect only a portion of cargo or vehicles. These inspections tend to be of material that has insufficient documentation, is from a country of concern, or contains agricultural material.
- The paperwork associated with arriving construction cargo needs to be automated to allow for more rapid selection of cargo to be screened.
- Documentation is lacking with regard to interception of vertebrates in or on break-bulk cargo, construction materials, and construction vehicles. Often a species is identified as moving in cargo or in a vehicle, but the specifics are not available.
- X-ray container scanners are not available on Guam. They are available on Saipan but not used due to funding limitations.
- The actual origin of much of the break-bulk cargo and construction materials associated with the relocation has not been identified.

A4.1.3.8 *Plant Pathways: Plant Materials and Plant and Nursery Trade*

The plant pathways are well-known routes for the transport and introduction of species such as amphibians like the coqui and greenhouse frogs to Hawai'i. Soil may transport anuran eggs, and anurans can be difficult to detect in certain plants such as bromeliads (Kraus et al. 1999; Christy et al. 2007c). The rapid shipment of live plants, and the cool, moist environment plants are shipped in, make survival of invasive species more likely (Christy et al. 2007c). Importation of ornamental plants for landscaping and nursery plants and materials is expected to increase due to the military relocation on Guam. Examples of the types of plants currently imported into Guam are given in Section 0. Although risk assessments to date have focused primarily on insects and diseases of concern to plants, vertebrate invasives also have the potential to be spread by this pathway (Table A4-16). The plant pathway covers growing mediums, fertilizer, and potting soil; bedding and sod; above-ground plant parts; and below-ground plant parts. A contaminating or hitchhiking pest is carried by a commodity and, in the case of plants and plant products, does not infest those plants or plant products.

Table A4-16: Invasive Species Transported in the Plant Pathways

Class	Scientific name	Common name	Risk type[a]
Amphibians	*Eleutherodactylus coqui*	Coqui frog	ECN, ECL
	Eleutherodactylus planirostris	Greenhouse frog	ECL
	Osteopilus septentrionalis	Cuban tree frog	H, ECN, ECL
	Pseudacris regilla	Pacific frog	ECL
Birds	None likely	None likely	
Mammals	*Clethrionomys rutilus*	Northern red-backed vole	H, ECL
	Microtus californicus	California vole	H, ECN, ECL
	Mus musculus	Common house mouse	H, ECN, ECL
Reptiles	*Anolis distichus*	Hispaniolan gracile anole	ECL
	Anolis sagrei	Cuban brown anole	ECL
	Calotes versicolor	Eastern garden lizard	ECL
	Diadophis punctatus	Southern ringneck snake	None found[b]
	Elaphe guttata	Red corn snake	None found
	Gekko hokouensis	Kwangsi gecko	None found
	Hemidactylus frenatus	Common house gecko	ECL
	Hemidactylus garnotii	Indo-Pacific gecko	None found
	Hemiphyllodactylus typus	Common dwarf gecko	None found
	Lampropholis delicata	Delicate skink	ECL
	Saproscincus mustelina	Weasel skink	None found
	Tarentola mauritanica	Common wall gecko	None found
	Thamnophis spp.	Unknown	None found

[a] H = health, ECN = economic, ECL = ecological.
[b] No impacts found in the literature, but undocumented impacts may exist.

Growing media like potting soils and fertilizers are likely to transport amphibians and their eggs, and the blind snake, *Ramphotyphlops braminus* (Nussbaum 1980; Crombie and Pregill 1999; Christy et al. 2007c). *Ramphotyphlops braminus* was not included in the analysis because it is already present in Guam, CNMI, FSM, and Palau. Although not currently reported to be present in CNMI, fossil records show that it was once a naturally occurring part of the herpetofauna (Pregill 1998). Sod is not typically imported to Guam, although grass stolons are (Campbell 2010b). Bedding material is likely to transport a variety of amphibians, mammals, and reptiles, but little of this material is "imported" to Guam because it comes mainly from the continental United States (Campbell 2010b). Above-ground plant parts can transport a variety of amphibians and reptiles (Christy et al. 2007c; Berringer 2010a; Campbell 2010d). Below-ground plant parts are likely to transport primarily mice, and corn snakes.

A4.1.3.8.1 ***Inspection Procedures***

International Standards for Phytosanitary Measures

The IPPC is an agreement among countries on plant health and measures taken to prevent the introduction and spread of pests. One of its products is the publication of the ISPM. Several of these are particularly pertinent to the movement of plant materials. Principles outlining how countries should implement phytosanitary measures are discussed in ISPM 1 (FAO 2006f). Thailand began full implementation in 1995, and China began full implementation of ISPM 1 in 2001 (FAO 2006g, j). Japan has mostly implemented this standard (FAO 2007a). New Zealand, the Philippines, and South Korea report that they have fully implemented this standard, but do not give a date when full implementation began (FAO 2006h, i, 2009). No information on the implementation of ISPM 1 in the other countries could be found. However, of the countries listed, only Hong Kong and Taiwan are not signatories to the IPPC.

A glossary of phytosanitary terms is given in ISPM 5 (FAO 2010b). Some definitions of particular importance to this pathway are given in the following paragraphs. Thailand began full implementation in 1995, and China began full implementation of ISPM 5 in 2005 (FAO 2006g, j). Japan, New Zealand, the Philippines, and South Korea have fully implemented the standard, but give no date when implementation began (FAO 2006h, i, 2007a, 2009). No information on the implementation of ISPM 5 in the other countries could be found.

Bulbs and tubers refer to the dormant underground parts of plants intended for planting, and include corms and rhizomes. Commodities refer to types of plants, plant products, or other articles being moved for trade or other purpose. Cut flowers and branches refer to the fresh parts of plants intended for decorative use and not for planting. A growing medium is any material in which plant roots are growing or intended for that purpose. Plants refer to living plants and parts thereof, including seed and germplasm. A regulated article is any plant, plant product, packaging, conveyance, container, soil and any other organism, object or material capable of harboring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved. Seeds refer to a commodity class of seeds for planting or intended for planting and not for consumption or processing.

Preventative measures taken within the plant pathways include various treatment methods. Treatment is an official procedure for the killing, inactivation, or removal of pests, or for rendering pests infertile or for devitalization. Fumigation is treatment with a chemical agent that reaches the commodity wholly or primarily in a gaseous state. Heat treatment is a process in which a commodity is heated until it reaches a minimum temperature for a minimum period of time according to an official technical specification. Irradiation is treatment with any type of ionizing radiation.

Further preventative measures include screening procedures and regulatory compliance. Clearance refers to the verification of compliance with phytosanitary regulations. An inspection is an official visual examination of plants, plant products, or other regulated articles to determine if pests are present and/or to determine compliance with phytosanitary regulations. A visual examination is the physical examination of plants, plant products, or other regulated articles using the unaided eye, lens, stereoscope, or microscope to detect pests or contaminants without testing or processing.

Imports through these pathways are subject to regulations. A certificate is an official document that attests to the phytosanitary status of any consignment affected by phytosanitary regulations. The country of origin is the country where the plants were grown or where regulated articles were first exposed to contamination by pests. An import permit is an official document that authorizes the importation of a commodity in accordance with specified phytosanitary import requirements. A point of entry is an airport, seaport, or land border point officially designated for the importation of consignments, and/or entrance of passengers. A re-exported consignment is a consignment that has been imported into a country from which it is then exported.

Equivalence of phytosanitary measures refers to situations where different phytosanitary measures achieve a contracting party's appropriate level of protection for a specified pest risk. Phytosanitary import requirements refer to specific phytosanitary measures established by an importing country concerning consignments moving into that country. A phytosanitary measure is any legislation, regulation, or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests. A phytosanitary procedure is any official method for implementing phytosanitary measures including the performance of inspections, tests, surveillance, or treatments in connection with regulated pests.

An outline for the development of a national system for issuing phytosanitary certificates is described in ISPM 7 (FAO 2006a). Thailand began full implementation in 1997, and China began full implementation of ISPM 7 in 1998 (FAO 2006g, j). Japan, New Zealand, the Philippines, and South Korea all fully implement the standard, but give no date when full implementation began (FAO 2006h, i, 2007a, 2009). Guidelines for preparing and issuing phytosanitary certificates and phytosanitary certificates for re-export are given in ISPM 12 (FAO 2001). Thailand began full implementation in 2001, and China began full implementation of ISPM 12 in 2003 (FAO 2006g, j). Japan, New Zealand, the Philippines, and South Korea all fully implement the standard, but give no date when full implementation began (FAO 2006h, i, 2007a, 2009). ISPM 23 outlines the guidelines for conducting inspections of plant materials (FAO 2006c). Both China and Thailand began full implementation of ISPM 23 in 2005 (FAO 2006g, j). Japan, New Zealand, the Philippines, and South Korea all fully implement the standard, but give no date when full implementation began (FAO 2006h, i, 2007a, 2009).

Guidelines to assist countries in determining the equivalence of phytosanitary measures is given in ISPM 24 (FAO 2006d). China began full implementation of ISPM 24 in 2005, and Thailand began partial implementation in 2008 (FAO 2006g, j). Thailand rates the relevance of ISPM 24 to its phytosanitary procedures as low. Japan, New Zealand, and South Korea fully implement the standard, but give no date when full implementation began (FAO 2006i, 2007a, 2009). The Philippines does not implement ISPM

24, and rates its relevance as low (FAO 2006h). The selection of an appropriate sampling scheme for inspection is discussed in ISPM 31 (FAO 2008). No information could be obtained on implementation of ISPM 31 in any of the countries.

Australia Export Regulations

In Australia, goods that are to be exported have to be free of pests as determined by inspection, and cannot be exported without an export permit. These goods cannot then be loaded after inspection into containers unless the containers are free from pests. Likewise, goods cannot be loaded after inspection with other goods that could cross-infect the prescribed goods (Australia OLDP 2007). A notice of intent to export goods must be given not less than three working days prior to export by ship or in sufficient time to obtain an export certificate for export by aircraft. The notice must contain the following information:

- Name and address of the consignor and consignee
- Intended port of loading of the goods
- Intended ship and voyage number or airline flight number
- Intended date of departure
- Intended port of discharge of the goods
- Country of origin if it is not Australia
- Country of intended final destination of the goods
- Place where goods can be inspected
- Date on which goods can be inspected
- State or Territory in which application for a certificate with respect to the goods, if sought, will be made
- Number allotted to the registered establishment in which processing last occurred
- Shipping or other identifying marks relating to the goods
- Identification number appearing on a container system unit that will contain the goods if available
- Number and kind of packages (if different from the number passed for export, list the number passed for export; if all passed for export, the phrase "as submitted")
- True description of the goods
- Quantity of goods available for inspection
- Any other information required by the Secretary

- Declaration by the exporter that the orders that apply to the goods have been complied with, information contained in the notice is true and correct, and conditions in the importing country have been complied with

If goods do not pass inspection and a treatment exists, the treatment must be applied prior to the issuance of a phytosanitary certificate. Currently, Australia treats plants for export for invertebrate pests rather than vertebrate pests. Only certain plants likely to carry particular invertebrate pests, such as the green snail, are treated (South Australia 2010). Such plants are treated with methyl bromide, a steam/air mixture at 60°C for 30 minutes, or fumigation with Basamid. Only plants that are within 25 km (15.5 miles) of a known green snail infestation are subject to treatment.

After inspection, the authorized officer must make sure the identification number appearing on a container system unit is entered on the notice of intent to export if not already present. The officer must also arrange for the number of the official mark, if applied to the container system unit, to be entered on the notice of intent to export next to the number of the container unit. A phytosanitary certificate will also be issued containing the following information:

- Name of an approved inspector
- Written declaration of disinfestation or disinfection treatments carried out by the exporter if not supervised by an approved inspector, or ruling out of the appropriate area on the form to indicate such treatments are not required
- Additional declarations such as free of weed seeds, specific pests, or pest or fumigation treatment applied; if no such declarations are needed, this must be indicated on the certificate
- Signature of authorized officer and the Departmental seal
- Description of the consignment (container system unit numbers, import and export permit numbers if known, approved officer has to check off each column entry prior to signing the certificate; if the back of the certificate or an additional sheet is used, it must contain the number of the certificate and name of the exporter and be signed by the officer)
- Common and botanical name of the goods, or a general term or description if a botanical name is not appropriate
- Consignee’s name and address if known, or “to order” otherwise
- Point of entry, or actual port of importation if known

China Export Regulations

Any material exported from China is subject to a quarantine inspection by Ministry of Agriculture personnel. The shipper has to submit, prior to export, an application for quarantine inspection. Plants are quarantined by the port animal and plant quarantine office until an inspection can be performed. Once inspection is passed (or an unspecified suitable treatment applied), material is allowed to leave the country. Customs officials release the shipment on the basis of quarantine certificates or stamps on the customs declaration forms from the port animal and plant quarantine office. Transport of plant material for export is expected to comply with regulations on plant quarantine and epidemic prevention (China 2009).

After inspection, a phytosanitary certificate is issued to the shipper. The phytosanitary certificate contains the following information:

- Name and address of both the consignor and consignee
- Botanical and common names of the products
- Quantity of product
- Number and type of packages
- Place of origin
- Port of destination
- Mode of conveyance
- Date of inspection
- Any disinfestation or disinfection treatments applied
- Place and date where the certificate was issued

Interception records and patterns indicate a week enforcement for for export criteria in China.

Commonwealth of the Northern Mariana Islands Export Regulations

No regulations pertaining to plant export requirements or treatment of plants and plant propagative material could be accessed.

Federated States of Micronesia Export Regulations

No regulations pertaining to plant export requirements or treatment of plants and plant propagative material could be accessed.

Guam Export Regulations

The only information that could be found regarding plant exportation from Guam pertains to shipments of nursery stock. The Guam Administrative Rules and Regulations (GARR) state that GDOA certifies nursery stock shipments for export when required, but does not give information regarding what the certification process involves. GDOA issues nursery stock certificates to nurseries complying with their inspection regulations, although these are also not stipulated (GDOA 2007a).

Hong Kong Export Regulations

No regulations pertaining to plant export requirements or treatment of plants and plant propagative material could be accessed.

Japan Export Regulations

Exporters must prepare an export declaration for Japan Customs describing the nature, quantity, and value of the goods to be exported. The Plant Protection Station (PPS) conducts inspections of plant material after an application by the shipper for an export inspection. Inspections are carried out at the PPS located at the airport or seaport of export. What these inspections cover depends on the requirements of the importing country. After a physical examination of the goods, an export permit and phytosanitary certificate must be obtained by the shipper. Phytosanitary certificates contain the following information:

- Name and address of consignor and consignee
- Number and description of packages
- Distinguishing marks
- Place of origin
- Means of conveyance
- Declared point of entry
- Name of produce and quantity declared
- Botanical name if applicable
- Disinfestation or disinfection treatment if applied

It is unknown whether inspections and phytosanitary certificates apply to plant propagative material. Treatment of infected material is dependent on the pest found in the material. Several of the approved treatments are as follows: hydrogen cyanide fumigation, methyl bromide fumigation, and phosphine fumigation. No information could be found on treatment of plant propagative material prior to export from Japan.

Korea Export Regulations

The National Plant Quarantine Service conducts export inspections of plant materials and issues phytosanitary certificates in South Korea. Plants being exported to countries not requiring a phytosanitary certificate are not inspected. Inspections and phytosanitary certificates conform to the requirements of the importing country (KNQS 2008). South Korea uses methyl bromide fumigation, chemical treatments, cold, heat, and irradiation to treat plant materials. No information could be accessed for North Korea.

Netherlands Export Regulations

The Ministry of Agriculture, Nature, and Food Quality transferred responsibility for inspections to four horticultural inspection bodies on September 1, 2007. These agencies are as follows: Netherlands General Inspection Service for Agricultural Seed and Seed Potatoes; Netherlands Inspection Service for Horticulture; Flower Bulb Inspection Service; and Quality Control Bureau for Vegetables and Fruit. These four agencies are responsible for inspecting exported plants for diseases (NMA 2007). No additional information could be found on further export requirements or treatments for plant materials.

New Zealand Export Regulations

Exporters in New Zealand must meet the phytosanitary requirements of the country to which they wish to ship material. Biosecurity New Zealand delegates authority for export inspections to authorized Independent Verification Agencies (PMACI 2006; Biosecurity New Zealand 2009b). Shipments for export are inspected in accordance with the requirements of the importing country and a phytosanitary certificate is issued. Random samples of homogeneous lots are inspected, with samples being large enough to provide a minimum 95% confidence level that pests do not exceed a specified threshold. Inspections include both the product and the packaging. If pests are found, treatment may be applied prior to shipment (Biosecurity New Zealand 2006). New Zealand uses several different treatments depending on the plant material and the pest involved. These include methyl bromide fumigation, hot water or chemical treatment for dormant material, or chemical treatment with either a spray or a dip (Biosecurity New Zealand 2010).

Suppliers are required to maintain inspection records that include the following information:

- Product type inspected
- Line/grower/packing period
- Time of sampling
- Lot size
- Sample size
- Date of inspection
- Number and type of quarantine pest found per sample
- Country/crop maximum pest limit, or combination (as appropriate) used in the decision-making process resulting from the inspection
- Action taken as a result of the inspection
- Inspector’s name and validation

In addition, suppliers must maintain records of equipment calibrations where applicable, security checks undertaken while plant products are stored in registered facilities, and non-approved organizations that are supplied with plant products eligible for phytosanitary certification. These records must be maintained for a minimum of 2 years (Biosecurity New Zealand 2006).

Palau Export Regulations

In Palau, an exporter may request an export inspection that will be conducted according to the guidelines of the importing country. Inspectors may apply official seals to inspected packages, and issue a phytosanitary certificate for plants produced in Palau (Palau BAMR 1999). Phytosanitary certificates are modeled after the guidelines produced by the IPPC in ISPM 12 (FAO 2001). Any plant material transiting through Palau must be clearly marked as intended for re-export. Inspectors will issue a re-export phytosanitary certificate for such material provided there is a valid phytosanitary certificate from the country of origin and the material is as described on the certificate (Palau BAMR 1999). The only decontamination measure mentioned in Palau's Quarantine Manual is methyl bromide treatment (Chambers and Englberger 1998).

Philippines Export Regulations

Exporters wishing to export plant material from the Philippines must submit an application for inspection to a Plant Quarantine Service Office at least 48 hours prior to shipment. However, if the inspection is to be conducted on the exporter's premises, it must be submitted 3 to 7 days prior to export. Inspectors require additional documentation at the time of the inspection, which includes an import permit from the importing country if required, Convention on International Trade in Endangered Species (CITES) permits if needed, and an application for a phytosanitary certificate. Inspectors perform the inspection in accordance with the requirements of the importing country. A random sample consisting of 10% of the total shipment is used for inspection. Both visual and laboratory inspections are made of the random samples. If the material passes the inspection, a phytosanitary certificate will be issued. Only the Bureau of Plant Inspection/Plant Quarantine Service is authorized to issue phytosanitary certificates in the Philippines. The Bureau only issues re-export phytosanitary certificates if they are required by the importing country. The Philippines has modeled its export certification and phytosanitary certification systems on guidelines established by the IPPC (FAO 2001, 2006a).

If the shipment fails inspection, the exporter has the option of applying an internationally approved treatment to rid the shipment of infestation. Treatment can be waived if it is not required by the importing country. Treatment can be performed either at Plant Quarantine Service facilities or by a private firm that is licensed to operate fumigation facilities. If performed by a private firm, the entire operation must be supervised by a plant quarantine officer (Philippine PQS). Specific treatments are not mentioned.

Puerto Rico Export Regulations

No regulations pertaining to plant export requirements or treatment of plants and plant propagative material could be accessed.

Singapore Export Regulations

Exporters in Singapore are responsible for knowing the import requirements of the importing country. The Singapore Agri-Food and Veterinary Authority will provide a phytosanitary certificate based on the requirements of the importing country. An application for a phytosanitary certificate must be filled out prior to inspection (Singapore SRS 2005). Exporters may become members of an Accredited Certification Scheme that allows them to assume the inspection function for their own goods. To participate, members must implement and document an Agri-Food and Veterinary Authority approved quality assurance system to ensure the export product is free of pests. The Agri-Food and Veterinary Authority conducts regular audits of members to ensure compliance. Under this arrangement, exporters are issued phytosanitary certificates as long as they submit an application for a phytosanitary certificate and provide documentation ensuring the material is pest free. Documentation can include an import permit, regulations of importing countries, fumigation certificates, and test reports.

Pest control agencies in Singapore are required to obtain accreditation if they are performing phytosanitary treatments. Registration under this accreditation scheme allows pest control operators to perform phytosanitary treatments and issue certificates of treatment on behalf of the Singapore Agri-Food and Veterinary Authority. Treatments mentioned in the official document covering pest control agencies in Singapore are methyl bromide fumigation and heat treatment (Singapore SRS 2003). These agencies must specify the types of treatments they intend to perform and for which plant materials. They must describe in detail a quality assurance system that will ensure products have been properly sanitized. The agencies are subject to audits by the Singapore Agri-Food and Veterinary Authority.

Taiwan Export Regulations

No regulations pertaining to plant export requirements or treatment of plants and plant propagative material could be accessed.

Thailand Export Regulations

It is unclear from Thai regulations whether phytosanitary certificates for export are required unless required by the importing country. However, to obtain a phytosanitary certificate, an inspection by a plant quarantine official is required. Plants that are considered by the Minister of Agriculture as being likely to export plant pests are considered controlled plants and must be accompanied by a phytosanitary certificate. Exporters can request registration of their facilities with the Department of Agriculture to have plant quarantine officials inspect their facilities and make recommendations regarding pest control. The only information that could be obtained regarding treatment of plants in Thailand referred to fumigation or treatment with chemicals by means of spraying without giving specifics.

United States (California, Florida, and Hawai'i) Export Regulations

Phytosanitary certificates and export certification are not required to export plants and plant propagative material from the United States, but are issued if the importing country requires them. Exporters requiring a phytosanitary certificate may request an export inspection. Only authorized government officials and accredited agencies may perform export inspections. The exporter is responsible for providing the import requirements of the destination country to inspectors if they are different from what PPQ currently has (USDA-APHIS). These may be in the form of an official communication or an EXCERPT. An EXCERPT is a publication containing phytosanitary requirements. The entire shipment must be sampled in order for a phytosanitary certificate to be issued. Samples must be of sufficient size and must be representative of the entire shipment. If a shipment is not considered high risk (not defined), the sample size is 2% of the inspectional unit. An inspectional unit can be a box, bag, tray, or similar unit. If inspection of 2% of the material is not practical, the sample size may be determined from the hypergeometric table published in the export manual. Inspection of nursery stock is to be 100%, or as close to 100% as practical. At a minimum, a visual inspection is performed. A laboratory analysis may be required by the importing country. No specific information could be found for screening procedures used for soil, fertilizer, or growing media. If treatment is required and available, it must be applied prior to issuance of the phytosanitary certificate (USDA-APHIS-PPQ 2010b).

The APHIS-PPQ Treatment Manual describes the use of authorized fumigants, which are methyl bromide, sulfuryl fluoride, and phosphine. Methyl bromide concentrations above 5 parts per million require the use of a self-contained breathing apparatus by the operator; therefore, it can be assumed it would be toxic to animals. Both sulfuryl fluoride and phosphine can be toxic to humans and animals. In addition, the treatment manual describes the use of aerosols and micronized dusts. Non-chemical treatments that are described are hot water immersion, steam, vapor heat, forced hot air, cold treatment, and irradiation. Steam, dry heat, freezing, incorporation of granular pesticides, and methyl bromide fumigation are all mentioned for treating soil (USDA-APHIS-PPQ 2008). It is unknown whether these treatments are required for other plant propagative materials such as growing media or fertilizer.

California

The California Department of Food and Agriculture currently inspects nurseries using county commissioners as often as needed to ensure compliance with nursery stock regulations regarding pests. Any entity that produces or sells nursery stock in California is required to comply with the cleanliness standards outlined in the Nursery Inspection Procedure Manual. Cleanliness is defined in the manual as follows: “Commercially clean shall mean that pests are under effective control, are present only to a light degree, and that only a few of the plants in any lot or block of nursery stock or on the premises show any infestation or infection, and of these none show more than a few individuals of any insect, animal or weed pests, or more than a few individual infestations of any plant disease” (CA DFA 2001a, b).

Florida

The Division of Plant Industry under the Florida Department of Agriculture and Consumer Services requires nursery registration and currently inspects nurseries several times a year. Nurseries cannot advertise in newspapers unless they can provide documentation that they are registered with the state (FDACS, 2004; Florida Legislature 2009). Inspection tags are required on every container in a shipment (Division of Plant Industry 2008).

Hawai’i

The Hawai’i Department of Agriculture provides plant inspection, plant fumigation, and plant and nursery certification services. Plants to be exported from Hawai’i are required to be brought to a plant inspection station where an inspection is performed according to the regulations of the importing country. Once plant material passes inspection, it is packed, sealed, and stamped at the plant inspection station, and a phytosanitary certificate is issued. Nurseries can bypass the inspection at the plant inspection station if they obtain certification. Nursery certification requires that plants are grown according to a specific set of conditions agreed to by the nursery and the Hawai’i Department of Agriculture. Compliance inspections are conducted once every 6 months. Each certified nursery receives an official certification stamp with a unique identifying number (Hawai'i Department of Agriculture 1981).

Idaho

The Idaho State Department of Agriculture licenses and inspects Christmas tree nurseries. Idaho state regulations require a producer to be issued a permit prior to shipping trees. The producer must acquire a phytosanitary certificate and have valid nursery license prior to exporting the trees (ID DoA 2010).

Oregon

The Oregon Department of Agriculture Plant Division, Nursery and Christmas Tree Program performs inspection of Christmas tree producers in Oregon. Christmas tree producers must be licensed by the state and are required to obtain a phytosanitary certificate for trees to be exported to destinations that require them. The requirements for each phytosanitary certificate depend on the destination market for the trees. Fee-based inspection services are available for both production and harvest. Regulations governing phytosanitary requirements are detailed in Oregon Regulations Chapter 571 (Oregon State Legislature 2009).

Washington

The Department of Agriculture of the State of Washington is required to license all commercial Christmas tree producers that harvest more than 100 trees per year for sale to the public. All producers are subject to phytosanitary inspection by state inspectors and failure to grant access may result in revocation of the license (Chapter 15.13 RCW) (Washington State Legislature 2010). The Plant Services Program provides phytosanitary inspection permits for trees on a fee basis for licensed producers. All licensed producers are inspected for compliance with Washington State regulations.

Commonwealth of the Northern Mariana Islands Import Regulations

No regulations pertaining to plant import requirements or treatment of plants and plant propagative materials could be accessed.

Federated States of Micronesia Import Regulations

No regulations pertaining to plant import requirements or treatment of plants and plant propagative materials could be accessed.

Guam Import Regulations

Guam requires a phytosanitary certificate for the importation of rooted plants and seedlings; cuttings and grafts of woody plants, ornamental plants, horticultural plants; cut flowers; flower bulbs, corms, tubers, rhizomes, and other vegetative plant propagating materials; and seeds meant for propagation purposes. The phytosanitary certificate has to have been issued within 14 days of shipment and be in English. If the material is not coming directly from the country of origin, it needs to be accompanied by a certificate from the country of origin and a re-export certificate from the country of dispatch (GDOA 1997).

An import permit is required by anybody receiving plant materials in Guam. Immediately upon arrival in Guam, GDOA must be notified in writing of the materials and given the following information:

- Way-bill number
- Container number
- Name and address of both the consignor and consignee
- Marks
- Number of packages
- Description of the contents of each package
- Port at which laden
- Any additional information necessary to locate and identify the shipment

The only approved ports of entry into Guam are air- and sea ports and the post office. Any package coming in must be plainly and legibly marked in English with the name and address of the shipper and receiver; name of country, state, or territory and locality therein where the product was grown; and a description of the contents of the package (GDOA 2007a).

Guam requires a phytosanitary certificate for the importation of soil, but it is not known if this applies to other types of plant propagative material (GDOA 1997). An import permit is also required for anybody receiving soil. The definition of soil in Guam is as follows: "Soil means that part of the upper layer of earth in which plants can grow; this material may or may not contain organic matter and includes such planting media as deteriorated peat, except clean coral, sand, pottery and industrial clay, volcanic cinders and other similar soil-free material." Soil itself may only be imported in limited quantities for research, unless it is commercially manufactured and packaged potting soil (GDOA 2007a; Berringer 2010a). No specific information could be found for screening procedures for plant propagative material.

Guam requires that imported Christmas trees be mechanically shaken prior to netting for shipping (Oregon Department of Agriculture 2010).

After inspection, the inspector places a tag, label, or stamp indicating the package has been inspected and has passed inspection. Guam currently inspects 100% of all declared plant material entering the country at its Plant Inspection Facility. All FedEx and United Parcel Service shipments are subject to inspection without a search warrant because they are private companies. However, any packages coming into Guam through the U.S. Mail that are not properly labeled as containing plants or plant propagative material will not be inspected. United States Mail coming into Guam is considered domestic and requires a search warrant to inspect (Shimizu 2010a).

The advent of e-commerce has made it much easier to buy plant parts online. Although this material is required to be clearly marked so that it undergoes inspection upon entry into Guam, material may not always be properly labeled either willfully, or through ignorance of the regulations. The person receiving the shipment is also required to have an import permit (GDOA 1997). Plants shipped to Guam must be free of soil. Persons buying plants online may be unaware of this regulation. This could potentially allow plant material to bypass the inspection process, allowing entry of vertebrate invasives.

Palau Import Regulations

Any person entering Palau with plant material or any entity importing plant material into Palau must notify the proper officials of the arrival of the material. For individuals entering Palau, this would be the Customs agent. For importers, Customs officials and the Chief of Agriculture must be notified. Import permits are required for any material being imported. Permits must include the following information:

- Name and address of both the shipper and exporter
- Origin of the goods
- Quantity
- Common and scientific names
- Mode of transport
- Point-of-entry
- Approximate date of arrival

All imported plants are required to be free from soil, and only approved packing material (e.g., sterile peat moss, sphagnum moss, perlite, vermiculite, sawdust, shredded paper, or inert material) can be used around the roots of imported live plants. All plant material requires a phytosanitary certificate. Imported material is inspected for the presence of soil and pests. A subsample of each shipment of cut flowers that consists of four or more containers is taken for inspection, and every stem in the sample is inspected. Shipments of three or fewer containers are all inspected. Quarantine officials are supposed to inspect 100% of imported nursery stock (Chambers and Englberger 1998; Palau BAMR 1999). No specific information could be found for screening procedures used for soil, fertilizer, or growing media. The only treatment measures mentioned for imported material in Palau are spraying, methyl bromide fumigation, immersion in glyphosate, or quarantine (Palau BAMR 1999).

A4.1.3.8.2 ***Summary of Findings***

The primary difference in risk rankings is related to the types of species transported and whether they are associated with health, economic, or ecological impacts. These pathways are considered high risk because they are likely to transport and introduce species such as mice that can negatively impact human health, and amphibian species that will cause impact to the region’s economy and ecology. Material intentionally moved in these pathways that harbor hitchhikers unintentionally presents a primary risk in that inspections of these commodities focus on insects and plant diseases, and terrestrial vertebrate species are likely missed, particularly when hiding in places not normally inspected for insects. Due to the large volume of material that may be shipped, inspections can only cover a small portion of the total shipment, increasing the likelihood that a vertebrate invasive will be missed (Christy et al. 2007c). Although some differences in inspection procedures do exist among the various countries for which regulations could be obtained, the general procedure used is the same. Further, there is a high risk for intentional transport of plants to bypass inspection processes. For example, packages coming into Guam through the U.S. Mail that are not properly labeled as containing plants or plant propagative material will not be inspected; U.S. Mail coming into Guam is considered domestic and requires a search warrant to inspect. This is important because the Internet allows individuals to order plants and plant propagative materials and have them shipped directly to themselves. If such material is not clearly marked, it may not undergo inspection.

A4.1.3.8.3 *Specific Risk Factors*

The specific risk factors we found to be associated with the plant pathways are as follows:

- Australia does not treat plants being exported unless they come from within 25 km (15.5 miles) of an area that is infested with the green snail or pests are detected during the export inspection process. Current treatments target invertebrates rather than vertebrates.
- Some countries tailor their export inspections to the requirements of the importing country, and therefore, may be likely to miss vertebrate invasives.
- Singapore relies on the exporter to supply inspection officials with the requirements of the importing country before conducting export inspections.
- The United States relies on the exporter to supply inspection officials with the requirements of the importing country if they are different from what PPQ currently has.
- Intentional transport of material entering Guam through the U.S. Mail that is not clearly marked as containing plant material will not be inspected as this requires a search warrant and poses a high risk of unintentionally transporting and introducing terrestrial vertebrate pest species.
- The Internet allows individuals to order plants and plant propagative materials and have them shipped directly to themselves. If such material is not clearly marked, it may not undergo inspection.
- New Zealand uses authorized independent verification agencies to conduct export inspections of plant material for Biosecurity New Zealand. These agencies are only audited once per year by Biosecurity New Zealand to ensure compliance with accreditation standards (Biosecurity New Zealand 2009b).
- Exporters in the Philippines have the option to waive treatment of plants if it is not required by the importing country.
- Exporters in Singapore may become members of an accredited certification scheme that allows them to assume the inspection function for their own goods. The Agri-Food and Veterinary Authority conducts regular audits of members to ensure compliance.

- Exporters in Thailand are not required to have a phytosanitary certificate unless required by the importing country or the plant is deemed by the Minister of Agriculture to be likely to export plant pests.
- Currently, Hong Kong and Taiwan are not signatories to the IPPC.
- Export inspections generally look for insects and signs of plant disease, which may miss vertebrate invasives.
- Due to the large volume of many shipments, generally only a sample of each shipment will be inspected. Sampling schemes are designed to detect insects and plant disease, rather than vertebrate invasives.
- Counterfeit phytosanitary certificates have been used. Phytosanitary certificates can be purchased on eBay, with no way for the buyer to know whether they are authentic. Some of these can be purchased in the absence of a plant purchase (eBay 2010).

A4.1.3.9 *Aquaculture*

Aquaculture is a well-known pathway for the introduction of anurans as shown by the list of species in Table A4-17 (Christy et al. 2007c; Kraus 2009). Regulations regarding aquaculture and invasive species pertain to the prevention of introducing exotic fish rather than anurans into an ecosystem. The shipments of commodity fish that are of concern with respect to the introduction of anurans are freshwater fish (Brown 2010b). In the Micronesia Region, this typically means tilapia and catfish.

Table A4-17: Invasive Species Transported in the Aquaculture Pathway

Class	Scientific name	Common name	Risk type[a]
Amphibians	*Fejervarya cancrivora*	Crab-eating frog	ECL
	Fejervarya limnocharis	Asian cricket frog	ECL
	Microhyla pulchra	Marbled pygmy frog	ECL
	Polypedates megacephalus	White-lipped tree frog	ECL
	Rana catesbeiana	American bullfrog	ECN, ECL
	Rana guentheri	Guenther's frog	H, ECL
	Rana nigromaculata	Dark-spotted frog	H
Birds	None likely	None likely	
Mammals	None likely	None likely	
Reptiles	None likely	None likely	

[a] H = health, ECN = economic, ECL = ecological.

A4.1.3.9.1 *Aquaculture Regulations*

The United Nations Food and Agriculture Organization developed a working definition of aquaculture, which is as follows (Maryland DoA and NASAC 1995): "…the farming of aquatic organisms including fish, mollusks, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc." Most countries use regulations that would affect other industries to regulate aquaculture, such as regulations pertaining to clean water and endangered species.

China

The Bureau of Fisheries under the Ministry of Agriculture regulates aquaculture in China (FAO and Spreij 2010a). The only regulation that could be found pertaining directly to aquaculture in China is the Fisheries Law of the People’s Republic of China. This mainly formalizes the investment of the country in the development of aquaculture (SCNPC 2004). This regulation does stipulate that aquaculture licenses are granted, but these only give a person or entity the right to use water surfaces and tidal flats. Export of fish is covered under plant and animal export regulations, but these do not mention inspections other than to say that material must be free of quarantine pests (People's Republic of China 1991). Presumably, these inspections look primarily for diseased fish.

Indonesia

The aquaculture industry in Indonesia is regulated by the Ministry of Marine Affairs and Fisheries through the Directorate General of Aquaculture Development (FAO and Skonhoft 2010a). The Indonesian Fisheries Act No. 31 2004 is similar to China’s Fisheries Law (Republic of Indonesia 2004; FAO and Skonhoft 2010a). Fish that are to be exported are checked to ensure they are not infected with quarantine pests or diseases, and that they are accompanied by the proper documents. Any fish to be exported from Indonesia has to be accompanied by a health certificate if required by the importing country (Wardoyo 1990). Unless prohibited by the importing country, carriers of fish quarantine pests and diseases are not subject to quarantine actions. If a quarantine pest or disease is detected, the fish are treated specifically for that pest or disease, but no particular treatments are mentioned. If no pests or diseases are detected, a certificate of release is issued.

Malaysia

Regulation of aquaculture in Malaysia falls under the Ministry of Agriculture and Agro-based Industry (FAO and Skonhoft 2010b). Export of live fish from Malaysia requires a permit from the Director General of Fisheries (Malaysia CLR 2006). The Director General has the discretion to add provisions to the permit to ensure communicable fish diseases are not spread and that non-indigenous species of fish are not released. Nothing is stated regarding export inspections or what these might entail.

Philippines

Aquaculture regulation falls under the Department of Agriculture’s Bureau of Fisheries and Aquaculture Resources in the Philippines (FAO and Spreij 2010b). The Philippines Fisheries Law governs leases for aquaculture, and directs the Department of Agriculture to develop a code of aquaculture practice. It also provides for aquaculture facilities to be covered by insurance, and prohibits the prevention of human or fish movement because of aquaculture facilities. The law prevents the exportation of live fish unless they were produced in accredited hatcheries and ponds, although nothing is mentioned regarding accreditation requirements. A permit is required for export, but no specifics are given for permit requirements. An export inspection for fish diseases and pests must be performed and fish must meet quality standards if they are known carriers of pests or disease. No details are given on what the standards entail, other than that they should be internationally accepted (Republic of the Philippines 1998). A health certificate will be issued if required by the importing country (Philippine Department of

Agriculture 2009). The code of practice stipulated in the Fisheries Law gives guidelines on site selection, facility design and construction, water use and discharge, use of drugs, stocking practices, feed, and fish health (Philippine Department of Agriculture 2001).

United States

Aquaculture in the United States is mainly regulated by the Food and Drug Administration, the Department of Health and Human Services, USDA, and the Environmental Protection Agency. Other federal agencies involved in aquaculture regulation include the National Oceanic and Atmospheric Administration, the Joint Subcommittee on Aquaculture, the Food and Drug Administration Center for Veterinary Medicine, APHIS, and the USFWS. In addition, each State has its own regulations regarding aquaculture. Exporters must keep records for a minimum of 3 years that fish meet the requirements of the Federal Food, Drug, and Cosmetic Act and comply with the requirements of the importing country. If a health certificate is required by the importing country, it will be issued by APHIS (FAO and King 2010). The National Aquaculture Act of 1980 was designed to promote and develop aquaculture in the United States by developing a national plan (United States Congress 2002). Hawai'i has regulations that cover quality, use and discharge of water; areas where aquaculture can be developed; activities in coastal zones; historic sites; and construction of facilities (Maryland DoA and NASAC).

Taiwan

No information could be found on any requirements for the exportation of fish or regulation of aquaculture in Taiwan.

Guam

Guam requires an excavation permit, plan review and building permit, clearing and grading permit, well permit, water quality certificate permit, wetland permit, and a U.S. Army Corps of Engineers permit. In addition, Guam has regulations covering the construction of wastewater systems and the discharge of storm water and dredged material. Fish coming into Guam are required to have an import permit if coming from elsewhere in the United States, and a certificate of origin if coming from a foreign source. In addition, a health certificate is required stating the fish are free from disease (Maryland DoA and NASAC). The University of Guam aquaculture facility does not import much stock, but ships stock all over the world. To minimize the risk of anurans being transported with stock, the facility ships in 34 parts per trillion salinity deep well water and individually hand packs the animals (Brown 2010b).

Commonwealth of the Northern Mariana Islands

Importation of fish into CNMI requires an import permit from the Division of Fish and Wildlife, an animal quarantine entry permit from the Department of Agriculture, and an import license from the USFWS. International sources for the purpose of permitting in CNMI include Palau, RMI, and FSM. In addition, a USFWS-Designated Port Exception Permit is required. International shipments arriving in CNMI have to be cleared by the USFWS at the port of first entry into the United States. USFWS only has nine ports in the United States that are designated to approve fish and wildlife shipments, and these are in the continental United States and Hawai'i. The Designated Port Exception Permit is required if Guam or

CNMI is the first port of entry for a fish shipment. Shipments may or may not be physically inspected, and may require a federal wildlife inspector to come from Guam (CTSA 2003).

A4.1.3.9.2 *Summary of Findings*

Pathways were considered high risk when they were capable of transporting Rana nigromaculata or Rana guentheri, both of which are capable of harming human health and safety. Pathways were considered a moderate risk when they transported Rana catesbeiana which can cause economic damage to aquaculture facilities by preying on fish fry. Information on treatments and screening procedures related to ensuring that shipments of aquaculture stock are pure could not be found, other than information from the University of Guam. One major risk in this pathway is the difficulty in distinguishing tadpoles from fish fry (Brown 2010c). Another major risk of this pathway is that jurisdiction for aquaculture is spread across several agencies, and regulations can vary at the State level (United States Congress 2002). Very few, if any, permits exist that are specific to aquaculture transport. Most permits apply to other industries such as agriculture or industries that impact the environment. Permits generally cover water use, waste discharge, and endangered species (Maryland DoA and NASAC 1995; CTSA 2003).

A4.1.3.9.3 *Specific Risk Factors*

The specific risk factors we found to be associated with the aquaculture pathways are as follows:

- It is difficult to distinguish tadpoles from fish fry.
- Anurans may have access to areas where aquaculture stock is being raised.
- Packing procedures for most aquaculture facilities are unknown.
- Inspections of aquaculture stock are geared to look for signs of fish diseases and pests on fish.
- Jurisdiction for aquaculture is often diluted across various agencies.
- Laws governing aquaculture are often not specific to aquaculture, but pertain to various industries as a whole.
- *Fejervarya limnocharis* tadpoles can withstand salinity up to 13 parts per trillion, and may survive fish fry shipments packaged in lower salinity water.

A4.1.3.9.4 *Plants and Plant Parts as Food*

The importation of produce has been identified as a potential pathway for the introduction of amphibians into Guam (Vice et al. In preparation). In addition to amphibians, mammals and reptiles may also be transported in produce (Table A4-18). The importation of vegetables and fruit into Guam is heavily regulated; however, the emphasis is on preventing the importation of plants infested with insects or diseases of agricultural significance (GDOA 1997). The Aquatic Nuisance Species Task Force and National Invasive Species Council document used as a template for this risk assessment lists plants used as food as a pathway of major concern (ANSTF and NISC 2007). The amount of produce imported into Guam is expected to increase in association with the military relocation. An example of the types and amounts of produce imported into Guam is given elsewhere in this document. The only pathway analyzed was food being shipped from the continental United States to Guam.

Table A4-18: Invasive Species Transported in Plants and Plant Parts Used as Food

Class	Scientific name	Common name	Risk type[a]
Amphibians	*Eleutherodactylus coqui*	Coqui frog	ECN, ECL
	Hyla cinerea	Green tree frog	ECL
	Pseudacris regilla	Pacific tree frog	ECL
Birds	None likely	None likely	
Mammals	*Clethrionomys rutilus*	Northern red-backed vole	None found[b]
	Microtus californicus	California vole	H, ECN
	Mus musculus	Common mouse	H, ECN, ECL
	Rattus norvegicus	Norway rat	H, ECN, ECL
	Rattus rattus	Black rat	H, ECN, ECL
Reptiles	*Anolis cristatellus*	Common Puerto Rican anole	ECL
	Calotes versicolor	Eastern garden lizard	ECL
	Chondrodactylus bibronii	Bibron's thick-toed gecko	ECN

[a] H = health, ECN = economic, ECL = ecological.
[b] No impacts found in the literature, but undocumented impacts may exist.

A4.1.3.9.5 *Inspection Procedures*

Federal Inspection Regulations

Fruits and Vegetables Import Manual. The APHIS-PPQ Fruits and Vegetables Import Manual contains guidance for PPQ and CBP inspectors regarding shipments of fresh fruits and vegetables (USDA-APHIS-PPQ 2010c). Inspectors first review the documentation accompanying a shipment of produce to determine whether the produce has restrictions placed on its entry. Next, a sample of the shipment is taken for inspection. In general, 2% of the shipment is taken as a sample for inspection. The size of the sample may be adjusted depending on the size of the shipment and past history with the shipper. Samples are to be representative of the whole shipment to avoid being misled by shippers placing the cleanest samples at the front of containerized shipments. If produce has been loaded in bulk, samples are to be taken at a minimum from the top 15.2 cm (6 in) of the shipment. Samples are inspected for plant pests such as insects, mites, mollusks, nematodes, noxious weeds, pathogens, plant debris, and soil. Depending on the type of commodity, there may be additional inspection procedures to be followed, and these are listed in the manual. The following paragraphs describe some general guidelines for broad categories of produce.

The entire surface of fleshy or pulpy fruits and vegetables is inspected for pests or signs of pest boring or feeding. Fruits and vegetables are to be sliced open to look for internal pests, such as larvae. The top and bottom of the fruit or vegetables are to be inspected closely as these are areas that are known to harbor insects. Signs of disease include discolored spots, lesions, and surface irregularities. Fruits and vegetables are also inspected for contaminants such as soil and plant parts, as these are not admissible. An example of a plant part contaminant is leaves still attached to an apple.

The surface of leafy herbs and vegetables is inspected for snails and slugs, or signs of their presence such as slime trails. Leaf surfaces are to be examined for insect larvae or signs of their presence, such as holes in the leaves, discolored paths under the leaf surface, and powdery insect excrement. If paths are found under the leaf surface, the end of the path is pricked with a knife or probe to look for larvae. Leafy vegetables that grow close to the ground are to be inspected for soil.

The pods and seeds of legumes are inspected for holes, as this may be a sign that insects or larvae are present. In particular, legumes from Mexico, Central America, South America, and the West Indies may contain significant pests. Legumes are also inspected for signs of disease such as discoloration, surface irregularities, or malformed pods and seeds.

Root crops and bulbs are inspected for signs of insect boring. If holes are found, the root or bulb is cut to look for insects. Both adults and larvae may be present in root crops, whereas bulbs most commonly harbor larvae. Root crops and bulbs are also inspected for signs of nematodes such as surface discoloration, surface blisters, depressions, or other irregularities. A cross section of the root is examined under a hand lens or dissecting microscope for nematodes. Root crops and bulbs are also inspected for soil that may be attached, or for loose soil present in the containers. Species found during inspection are addressed using the following documentation as protocols and guidelines.

Treatment Manual. Chapter 5 of the APHIS-PPQ Treatment Manual contains the treatment schedule for fruit, nuts, and vegetables (USDA-APHIS-PPQ 2008). The treatments listed in the schedule include methyl bromide fumigation, water treatment, high temperature forced air, irradiation, vapor treatment, cold treatment, and quick freeze. Treatments are listed either by commodity or by pest. Each particular commodity has its own treatment schedule.

Manual for Agricultural Clearance. Cargo manifests are reviewed to determine whether it contains items of agricultural interest such as fruits and vegetables (USDA-APHIS-PPQ 2013). Cargo of agricultural interest is to be held until it can be cleared by CBP. Clearance of fruits and vegetables may be done by an inspection of the paperwork, an inspection of the commodities, or both. Inspections may be random, routine, or targeted. Guidance for inspections is provided in the APHIS-PPQ Fruits and Vegetables Import Manual (USDA-APHIS-PPQ 2010c).

Code of Federal Regulations. Title 7 Part 319 of the CFR governs the importation of fruits and vegetables. All fruits and vegetables are required to have an APHIS import permit. Fruits and vegetables are subject to inspection upon arrival. Inspectors are to examine shipments for unauthorized plant parts, plant pests, and noxious weeds. Disinfection is required if these are found in the shipment. If the shipment is known to have been associated with another shipment that was infested, treatment may also be required. A shipment may be refused entry if the commodity is prohibited, lacks the proper documentation, or is infested in such a way that disinfection cannot be adequately accomplished. Part 319.56-7 contains a list of fruits and vegetables that can be imported into Guam without treatment unless required in Part 319.56-3(d).

Guam Regulations

Title 8 (Division 2, Chapter 10) of the Guam Administrative Rules and Regulations governs the importation of plants and plant products into Guam (GDOA 1997). Import permits and phytosanitary certificates are required to ship regulated articles into Guam. The phytosanitary certificate must have been issued from the country of origin. Shipments of plants are subject to inspection upon arrival. Specific restrictions on certain commodities are given in this regulation. For example, commodities that could be infested with the European corn borer are required to have been fumigated prior to shipment and have documentation showing fumigation was conducted.

A4.1.3.9.6 *Summary of Findings*

This pathway was considered high risk because of its ability to transport rodents that may harm human health. One of the primary risks for this pathway is that inspections tend to be focused on insects and plant disease. Because of this, vertebrate invasives may get missed, particularly when hiding in places not normally inspected for insects. Due to the large volume of material that may be shipped, inspections can only cover a small portion of the total shipment, increasing the likelihood that a vertebrate invasive will be missed (Vice et al. In preparation). This is particularly true for commodities shipped in bulk where only the top layer may get inspected.

A4.1.3.9.7 *Specific Risk Factors*

The specific risk factors we found to be associated with the plants and plant parts as food pathways are as follows:

- Import inspections generally look for insects and signs of plant disease, which may miss vertebrate invasives.
- Insufficient agricultural inspection staff and other resources are available on Guam.
- Only the top portion of bulk shipments may get inspected.
- Inspectors may be misled by shippers if samples are not representative of the entire shipment. For example, a shipper may place the lowest risk commodities at the front of a container.

A4.1.3.10 *Ecosystem Disturbance*

Natural spread and ecosystem disturbance have the ability to move invasive species into locations they previously did not inhabit (Table A4-19). In addition, ecosystem disturbance may poise invasive species near locations where they can easily enter the transportation pathway, increasing the likelihood of their introduction elsewhere (Engeman et al. 2002). The Aquatic Nuisance Species Task Force and National Invasive Species Council document used as a template for this risk assessment lists natural spread and ecosystem disturbance as major pathways of concern (ANSTF and NISC 2007). A formal risk analysis was not conducted for the natural spread of populations because of the low likelihood this would move invasive species off of Guam. However, the general risks are discussed below, particularly as they pertain to the maintenance of the BTS population on Guam.

Table A4-19: Invasive Species Moved in the Ecosystem Disturbance Pathway

Class	Scientific name	Common name	Risk type[a]
Amphibians	*Eleutherodactylus planirostris*	Greenhouse frog	ECL
	Litoria fallax	Eastern dwarf tree frog	ECL
	Polypedates megacephalus	Hong Kong whipping frog	ECL
	Rana guentheri	Guenther's frog	H, ECL
	Rhinella marina	Cane toad	H, ECN, ECL
Birds	*Dicrurus macrocercus*	Drongo	ECL
	Francolinus francolinus	Black francolin	ECL
	Lonchura malacca	Black-headed mannikin	ECN
	Streptopelia bitorquata dusimieri	Philippine turtle dove	ECL
Mammals	*Mus musculus*	Common mouse	H, ECN, ECL
	Rattus exulans	Polynesian rat	H, ECN, ECL
	Rattus norvegicus	Norway rat	H, ECN, ECL
	Rattus rattus	Black rat	H, ECN, ECL
	Rattus tanezumi	Asian house rat	H, ECN, ECL
	Suncus murinus	Musk shrew	H, ECN, ECL
Reptiles	*Anolis carolinensis*	Green anole	ECL
	Boiga irregularis	Brown treesnake	H, ECN, ECL
	Carlia ailanpalai	Curious skink	ECL
	Pelodiscus sinensis	Chinese soft-shelled turtle	H, ECL
	Trachemys scripta	Red-eared slider	H, ECL

[a] H = health, ECN = economic, ECL = ecological.

A4.1.3.10.1 *Natural Spread of Established Populations*

Natural dispersal of invasive species currently on Guam can occur due to increases in population size forcing the dispersal of individuals. Species with high reproductive rates (r selected) tend to have an advantage as an invasive species (Sax and Brown 2000). As a population increases and more dispersal occurs, more populations will become established. This increase is of concern because of the potential for several of the species listed to act as a prey base for BTS. These include *Eleutherodactylus planirostris*, *Litoria fallax*, *Polypedates megacephalus*, and *Rana guentheri* (Christy et al. 2007a). An increase in the prey base would allow the BTS population to persist, or perhaps even increase (Christy et al. 2007a). Reducing the prey base has been suggested as a means of controlling BTS population on Guam (Gragg et al. 2007).

In large part, the likelihood of migration off Guam to neighboring islands is negligible. The closest island to Guam is Rota, which is approximately 80 km (50 miles) away. Of the bird species listed, only the drongo (*Dicrurus macrocercus*) is documented to have migrated this distance, having migrated from Rota to Guam sometime after 1935 (Lever 1987). The only other possible method of migration off the island is the transport of animals on flotsam or swimming. None of the species listed are likely to swim the distances required to reach neighboring islands, although it has been suggested that anoles may be able to float for short periods of time (Schoener and Schoener 1984). *Anolis sagrei* was able to remain afloat for at least 24 hours in the laboratory in a seawater wave tank, suggesting floatation may be responsible in part for its success at long distance dispersal (Schoener and Schoener 1984). Anoles may be able to survive in seawater longer than previously expected (Heatwole and Levins 1973, Schoener and Schoener 1984). *Rhinella marina* may have reached Cayo Santiago from Puerto Rico on flotsam (Heatwole et al. 1963; Heatwole and Levins 1972). Green iguanas (*Iguana iguana*) were able to reach Anguilla on flotsam produced by a hurricane (Censky et al. 1998).

A4.1.3.10.2 Man-made and Natural Disturbances

The relocation of the Marines onto Guam will create man-made ecosystem disturbances in the form of construction of facilities and utilities, roadway projects, land clearing, and landscaping (U.S. Navy 2009h). In addition to man-made ecosystem disturbance, Guam is prone to typhoons and earthquakes. Although typhoons are more likely to be of a magnitude to cause widespread ecosystem disturbance, the possibility of a large-magnitude earthquake cannot be ruled out. In addition, fire sometimes creates ecosystem disturbance.

One of the characteristics of a successful invasive species is that it is often found in association with disturbed or man-made habitats (Lozon and MacIsaac 1997; Sax and Brown 2000; Ineich 2010). Many of these species are commensal with humans, such as the common mouse (*Mus musculus*) and rats (*Rattus* species). Environments that are prone to invasion by invasive species are often disturbed naturally or have a high amount of human activity (Lozon and MacIsaac 1997; Sax and Brown 2000). Although unclear as to exactly why disturbance facilitates invasion, one hypothesis is that more opportunities exist in disturbed habitats for human-mediated introductions (Simberloff 1989).

Typhoons play an important role in invasive species movement and establishment. Damage from typhoons is due to several factors such as storm velocity, storm diameter, and storm severity (Tanner et al. 1991). During a typhoon, most of the methods of BTS detection are inoperable. Mice must be removed from traps, and traps may be taken down altogether. The typhoon itself can damage traps, the habitat the traps are placed in, and the barrier fences used to exclude BTS (Vice and Engeman 2000). Because emergency equipment is being shipped from Guam to neighboring islands during this time, the likelihood of transporting BTS increases dramatically. Defoliation of trees by typhoons or high winds can cause long-term alterations to the microhabitat that include a reduction in humidity and higher temperatures near the forest floor (Reagan 1991; Waide 1991; Greenberg 2001). These changes tend to be detrimental to amphibians that require moisture, but beneficial to some reptiles reliant on warmer temperatures for egg incubation and hatchling development (Reagan 1991, Waide 1991, Greenberg 2001). The sheer impact of the typhoon, and associated rain and moving objects, can cause mass mortality of amphibians (Schriever et al. 2009), birds (Waide 1991), and reptiles (Woolbright 1991; McCoid 1996; Spiller et al. 1998). Habitat specialist lizards were more prone to mortality than were habitat generalist lizards in the Marianas (McCoid 1996).

Typhoons may facilitate overwater dispersal of lizards and lizard eggs (Censky et al. 1998; Schoener et al. 2001). Green iguanas (*Iguana iguana*) arrived on Anguilla in the Caribbean on a mat of logs and uprooted trees a month after Hurricane Luis (Censky et al. 1998). Results of genetic examination of Anolis lizards in the Caribbean suggest island colonization followed prevailing ocean currents, providing evidence for overwater dispersal (Calsbeek and Smith 2003). Lizard eggs and lizards appear to be more resilient to exposure to seawater than previously thought. Eggs that are hard-shelled remained viable for at least 11 days during exposure to salt water (Brown and Alcala 1957). *Anolis sagrei* eggs remained viable in saltwater for 3 to 6 hours, which was predicted to be the length of the storm surge during Hurricane Floyd (Losos et al. 2003).

Typhoons can readily facilitate the movement of pests within individual islands or between closely located neighboring islands. On Guam typhoons typically create mountains of debris and this debris ultimately may get moved around the island and may in fact transport pest species such as the little fire ant and the coconut rhinoceros beetle, potentially ultimately assisting in the spread of these and other pests. Protocols for dealing with these types of situations need to be established both for civilian and military authorities.

A4.1.3.10.3 *Specific Risk Factors*

The specific risk factors we found to be associated with the ecosystem disturbance pathways are as follows:

- Most BTS control measures are inoperable during a typhoon, leaving detector dogs the primary line of defense.
- Emergency equipment is shipped from Guam to neighboring islands during typhoons, increasing the likelihood of transporting BTS.
- Man-made disturbances may increase the risk of invasive species entering the transportation pathway.

A4.1.3.11 *Garbage*

Movement of invasive vertebrate species in garbage is a significant pathway, moving primarily rodents (Table A4-20). Although other species besides rodents can be moved in garbage, only rodents were analyzed because they are the primary species moved and are a significant health concern. The Aquatic Nuisance Species Task Force and National Invasive Species Council document used as a template for this risk assessment lists garbage as one of the major pathways of concern (ANSTF and NISC 2007). Ships and aircraft arriving on Guam and CNMI unload regulated garbage upon arriving. Additionally, with the relocation of the 3rd Marine Expeditionary Unit from Okinawa to Guam there is an anticipated increase in the amount of training that will occur on Tinian. Garbage generated during these training activities is to be shipped back to Guam for disposal (U.S. Navy 2009g). This analysis also includes garbage that is generated during transit for both aircraft and ships.

Table A4-20: Invasive Species Moved in the Garbage Pathway

Class	Scientific Name	Common Name	Risk Type[a]
Amphibians	None likely	None likely	
Birds	None likely	None likely	
Mammals	*Mus musculus*	Common mouse	H, ECN, ECL
	Rattus exulans	Pacific rat	H, ECN, ECL
	Rattus norvegicus	Norway rat	H, ECN, ECL

	Rattus rattus	Ship rat	H, ECN, ECL
	Rattus tanezumi	Asian house rat	H, ECN, ECL
Reptiles	None likely	None likely	

[a] H = health, ECN = economic, ECL = ecological.

A4.1.3.11.1 *Garbage Regulations*

Garbage is defined in 7 CFR § 330.400 and 9 CFR § 94.5 as waste material derived in whole or in part from fruits, vegetables, meats, or other plant or animal material (7 CFR § 330.400, 9 CFR § 94). Any other refuse that has been associated with such materials is also considered garbage. Incineration is defined as reducing garbage to ash by burning. Sterilization is the cooking of garbage at an internal temperature of 212°F (100°C) for 30 minutes. Garbage is considered regulated if the means of conveyance it is on has been outside the United States and Canada within the previous 2-year period. Garbage is also considered regulated if the means of conveyance the garbage is on has been moved within the last year between the continental United States, U.S. territory, U.S. possession, or Hawai'i. Non-regulated garbage that has been commingled with regulated garbage is also considered to be regulated. Regulated garbage is monitored to prevent the movement and dissemination of pests and diseases of plants and livestock. Tightly covered, leak-proof containers must be used to store regulated garbage. These containers must be kept inside the guard rail on a ship. Garbage may only be moved from a conveyance for disposal if it is stored in the proper container, and can only be moved under the direction of an inspector to an approved garbage handling facility.

The APHIS-PPQ Treatment Manual gives a choice of three treatments for destroying garbage that may be infested with insects pests or pathogens (USDA-APHIS-PPQ 2008). Garbage may be incinerated to ash, or ground up and discharged into an approved sewage system. An approved sewage system is one in which effluents are not discharged onto land or stationary waters, and prevents dissemination of plant pests and livestock diseases. Garbage may also be heated with steam or dry heat to an internal temperature of 212°F (100°C) for 30 minutes, followed by burial in a landfill.

The APHIS-PPQ Manual for Agricultural Clearance provides guidance on handling foreign regulated garbage (USDA-APHIS-PPQ 2013). The primary concern is preventing the spread of plant pests and animal diseases. Entities that handle garbage must be approved by USDA and either have a compliance agreement with, or be directly supervised by, CBP and/or APHIS personnel. The approved methods of disposing of garbage listed in the Manual for Agricultural Clearance are the same as those given in the APHIS-PPQ Treatment Manual (USDA-APHIS-PPQ 2008). Garbage may only be removed from a ship if USDA-approved garbage facilities exist at the port. Arrangements for disposal of the garbage must be made in advance with CBP. In this case, the only approved methods of garbage disposal are incineration or sterilization by heating to an internal temperature of 212°F (100°C).

The APHIS-PPQ Manual for Agricultural Clearance also instructs inspectors to monitor garbage handling on ships while they are in port (USDA-APHIS-PPQ 2013). This may involve monitoring visually from shore or boarding the vessel. Inspectors monitor garbage handling to ensure it is not disposed of in an unauthorized manner, garbage containers are not leaking and are covered, and garbage containers are not placed outside the ship's railing. Garbage chutes and containers built into the railings are sealed while in U.S. territorial waters. All garbage is regulated when ships are traveling between the continental United States and foreign countries. Garbage aboard military vessels is handled in the same manner as garbage aboard private or commercial vessels.

Garbage from commercial and military craft can only be unloaded if the port or military base facility is given the approval to handle garbage by APHIS-PPQ (USDA-APHIS-PPQ 2013). On Guam, Naval Facilities Engineering Command (NAVFAC) Marianas at the Apra Harbor Naval Station and Pacific Environmental Resources Incorporated at Andersen AFB are approved to handle garbage. Compliance enforcement visits to ensure garbage is being handled and disposed of properly should be conducted quarterly at a minimum.

The responsibility for monitoring the garbage handling activities of airports, caterers, cleaners, cruise ships, fixed base operators, hauling/cartage firms, marinas, military facilities, storage facilities, and transfer stations falls to CBP (USDA-APHIS-PPQ 2013). APHIS-PPQ is responsible for monitoring the activities of all non-military processing facilities that incinerate or sterilize regulated garbage. Garbage handlers are responsible for ensuring that birds, rodents, and other vermin do not have access to garbage.

The Quarantine Regulations of the Navy (OPNAVINST 6210.2) state that garbage must be placed in leak-proof, covered containers. Garbage may only be disposed of following authorized port procedures under the supervision of a PPQ representative. The only approved methods of disposal are incineration or sterilization. Disposal of garbage from foreign flights in a landfill is not an approved method. The Quarantine Regulations of the Armed Forces defines garbage as being derived in whole or in part from fruits, vegetables, other plant products, animals, meat, meat products, or animal products (DoD 1992). These regulations also state that garbage cannot be disposed of in a landfill unless it has first been sterilized by heating to an internal temperature of 212°F (100°C). The Naval Supplemental Publication 486 contains similar guidance (NAVSUP 2004).

Both Guam and CNMI have their own customs and quarantine procedures with respective agencies for enforcement. Customs officers on Guam focus ship inspections on compliance with regulated garbage regulations (Merfalen 2010). Commercial transport companies handle the waste streams from commercial vessels in the ports of Guam, Tinian, and at the airports on Guam and CNMI (Merfalen 2010, Pangolinean 2010). Regulated garbage is incinerated on both Guam and CNMI.

A4.1.3.11.2 *Summary of Findings*

All pathways were considered high risk because they could harm human health due to their association with the transport of rodents. Provided regulated garbage is handled properly, rodents should have limited access to garbage or to other pathways from garbage containers. Garbage that is considered non-regulated with respect to movement between Guam and CNMI does not contain plant or animal parts. However, it could still harbor rodents because it contains items, such as cardboard, that provide bedding material. Disposal of this type of garbage in a landfill is associated with the risk of introducing or spreading non-native rodents.

A4.1.3.11.3 *Specific Risk Factors*

The specific risk factors we found to be associated with the garbage pathways are as follows:

- Customs agencies focus on cleanliness and container integrity.
- Documentation is lacking with regard to interception of vertebrates in regulated trash.
- Processes for handling garbage generated during training exercises on Tinian may not preclude the transport of a significant invasive vertebrate species.
- Non-regulated garbage may transport rodents that could be missed during inspections of regulated garbage and during transport.

A4.1.3.12 *Discussion and Conclusions*

The Aquatic Nuisance Species Task Force and National Invasive Species Council document used as a template for this risk assessment was designed for risk analyses in the United States. It also contained frames of reference more applicable to insects and aquatic species. As a result, portions of the process needed to be modified to be more amenable to a risk analysis for vertebrate invasive species in a larger region of the world. Although this assessment attempts to be as objective as possible in assigning risk rankings, the process is inherently subjective. Despite these difficulties, the process allowed us to identify pathways and gaps in security measures that could increase the likelihood of transporting vertebrate invasive species.

We were not able to access all the information needed to accurately assess the risk of transporting vertebrate invasive species associated with each pathway. For example, customs procedures for various countries in Asia were often lacking or scant in nature. We did not have interception data for the numbers and types of species transported in each specific pathway. For some pathways, such as WPM, species lists were generated using reports of species that have been moved in cargo. Often reports could be found of species being moved in cargo with no information on what type of cargo or where in the cargo the species was found. Although some of the species are well known, others have little biological information available. One of the key pieces of information that was lacking in this regard was ability of a species to utilize various habitat types. Another critical piece of information concerned the ability of a species to establish new populations in previously uninhabited areas through natural dispersal. Therefore, this risk analysis should be re-evaluated as more information becomes available.

The pathways associated with the most risk of transporting invasive species were cargo and vehicles used for military training exercises and military maritime and air transportation. This is due in part to the fact that military ships and aircraft can be mobilized on a moment’s notice for emergency missions that preclude pre-departure inspections. There is a memo of understanding between PPQ and GCQA which charges GCQA with the authority to inspect military ships and aircraft.

Commercial maritime and air traffic, as well as cargo containers, were also associated with a high degree of risk for transporting invasive species. One of the primary factors is the current lack of adequate staff, equipment, and funding in the Micronesia Region to conduct inspections. Volume will increase with the military relocation in each of these pathways. Unless adequate resources become available, risk of transporting vertebrate invasive species will also increase. Inspections are often limited to ships, aircraft, and cargo arriving from a destination that harbors an agricultural pest or disease vector, or has had previous violations. Additionally, inspections are focused on preventing the movement of agricultural pests, and inspectors may not be looking for amphibians and reptiles. These limited inspections increase the likelihood a vertebrate invasive species could be transported undetected.

Construction materials and equipment can be considered containerized cargo and bulk cargo, and are associated with the same risks listed in the previous paragraph. Construction vehicles may undergo an agricultural inspection for soil and plant parts to prevent the movement of plant pests and diseases. APHIS-WS in Guam inspects construction vehicles for BTS, but the efficacy of these inspections may be questionable due to the size and complexity of the vehicles themselves.

Although WPM is heavily regulated by international phytosanitary standards, inspections do little to prevent the movement of vertebrate invasive species. Vertebrate invasive species are most likely to enter WPM in the post-manufacturing phase when it is being used as packing material for cargo. Although customs agencies do inspect WPM in cargo, they are limited by time and resources to inspect only WPM present in the portion of the cargo selected for inspection. Due to the somewhat non-random nature of the selection process as described above, vertebrate invasive species could go undetected.

Plants are inspected for plant pests and diseases rather than vertebrate invasive species. Amphibians may hide in areas inspectors might not be likely to inspect. Due to the large volume of plants and plant materials arriving in any particular shipment, only a sample of the plants can be inspected. Inspectors rely on phytosanitary certificates from the country of origin, and these can be counterfeited. As with other types of cargo, the process of selecting a sample for inspection may not be entirely random, leading to a greater likelihood that vertebrate invasive species might not be detected. In terms of preventing the establishment of pests, much of the plant industry is self-regulating. For example, nurseries can be certified to be free of certain pests.

Regulated garbage, when properly handled, presents a relatively low level of risk of transporting vertebrate invasive species. Because regulated garbage is to be stored in leak-proof containers with tightly fitting lids, animals should have very little access. Additionally, it cannot be disposed of without first being incinerated or heated to 212°F (100°C) for 30 minutes, making species survival impossible. The largest risk is associated with non-regulated garbage. Garbage that is considered non-regulated with respect to movement between Guam and CNMI does not contain plant or animal parts. Because non-regulated garbage does not contain plant or animal parts, it is not required to be stored in leak-proof containers with tightly fitting lids. Such garbage may contain materials that can be used as bedding or nesting material, and may attract rodents. Non-regulated garbage can be disposed of in a landfill without undergoing any kind of treatment, making it more likely rodents could survive.

Household goods are packed indoors and are often individually handled. This decreases access for vertebrate invasive species and makes detection highly likely. However, if household goods are packed outside or left in an open container outside, animals could gain access. Personally owned vehicles are a larger risk for the relocation pathway. Although vehicles owned personally by military personnel are inspected closely for plant material, soil, and animals, vehicles in the private sector may not undergo the same level of scrutiny. Additionally, used cars are shipped throughout the Micronesia Region. The short transport time makes survival of hitchhiking vertebrate invasive species highly likely.

Natural dispersal was associated with a relatively low level of risk of moving invasive species because there are few species likely to migrate from Guam to the nearest island. Although the Micronesia Region is vulnerable to typhoons, it is unlikely typhoons will move species from one island to another because of the distance between most of them. The risk associated with typhoons and man-made disturbance is the increased potential for vertebrate invasive species to be moved into the transportation network. This is because preventive measures, such as BTS traps, are inoperable during a typhoon. Increased vigilance immediately following any type of disturbance should help mitigate any risks.

Aquaculture is known to transport anurans, and will likely increase with the increased population due to the military relocation. The primary risk associated with this pathway is the difficulty in distinguishing between fish fry and tadpoles primarily due to the way they are packed. Some of this risk can be mitigated by changing packing and shipping practices. Individually handling and packing fish fry may increase the resources needed, but will decrease the likelihood of packing undetected tadpoles. Where possible, shipping in higher salinity water decreases the survival probability of anurans.

Finally, plants used as food were considered the least risky of the 12 pathways. This is because fruits and vegetables are inspected very closely for small insects and larvae, making it unlikely a vertebrate invasive species could go undetected during inspection. However, some risk still exists because time and resources only allow for inspections of a representative sample of each shipment. If a shipper places the cleanest material closest to the front or top, and samples are not representative of the entire shipment, a vertebrate invasive species could be missed.

In general, the risk of transporting vertebrate invasive species throughout the Micronesia Region will increase due to the military relocation. Preventing the movement of vertebrate invasive species will require increasing awareness of the risks in both the public and private sectors. Inspectors at ports in particular need to be given training to make them aware of and enable them to identify other species of concern. Resources need to be identified and made available to allow for additional training, equipment, and personnel to improve the inspection processes. Emphasis should be placed on preventing the movement of vertebrate invasive species, rather than on eliminating them once they have become established. Prevention is more effective and less costly than elimination. Finally, a high degree of cooperation among agencies will be required to minimize the risk of transporting vertebrate invasive species.

A4.1.3.13 ***Recommendations***

This section will discuss some overall, general recommendations for mitigating the risk of transporting vertebrate invasive species unintentionally. More specific recommendations are covered in other sections. These general recommendations should not be considered as the only, or the most important, recommendations. Rather, they should be viewed as a starting point for more formalized recommendations. Five key issues are central to successful implementation of the recommendations given here. These key issues are: funding, coordination and communication, education and training, control methods development, and regulatory drivers and enforcement.

A4.1.3.14 ***Funding***

Regardless of the biosecurity strategy developed, lack of sufficient and properly managed funds will be the weak link in any effort implemented. Military presence in the region calls for long-term allocation and ongoing management of biosecurity funds. Current funding for regional biosecurity is distinctly inadequate relative to the magnitude of the existing problems posed by invasive species, the emerging problems and associated risks to other islands, and the scope and magnitude of military activity in the region.

Short-term funding cycles hamper necessary methods development and interdiction activities and restrict the forward momentum needed for effective control programs. For example, because BTS efforts are currently underfunded, much higher costs are expected in the future to resolve expanding threats not addressed now, such as eradicating the incipient population on Saipan. Cost-sharing among agencies and the transportation industry has advanced greatly, with still more room for more improvement. The Office of Insular Affairs is carrying much of the funding responsibility at present, along with an incorrectly perceived primary ownership of the problem. Greater and sustainable investment by the DoD is warranted as part of their doing business in high-risk areas for invasive species dispersal and their overall stewardship of natural resources on their lands (USDA-APHIS WS 2008a).

A4.1.3.15 ***Coordination and Communication***

The multiple human health and safety, economic, and ecological impacts of invasive species create complex challenges in policy formation and governmental coordination (Williams et al. 2007). The National Invasive Species Council was established by Executive Order 13112 to provide coordination and planning, and facilitate cooperation among the diverse federal agencies and to take a more comprehensive approach to invasive species. The National Invasive Species Council is co-chaired by the Secretaries of Agriculture, Commerce and the Interior; and includes a total of 13 federal agencies and departments that have a role in invasive species management (Williams et al. 2007). Communication and coordination needs improved at all levels and in all directions. Micronesia and Hawai'I cover an extensive area with numerous levels of authority for multiple sovereign nations as well as numerous local, regional and international NGOs, all of which have roles to play in enhancing biosecurity and IAS control and management for the region.

Federal agencies that must work in coordination to maintain a biosecurity plan include APHIS, the USFWS, CBP, and the Departments of the Interior, Defense, Commerce, Energy, Homeland Security, and Transportation, among others. Interagency coordination is effective to the implementation of planning, and is sustained and enhanced by frequent and comprehensive communication. This communication network still needs to be improved and more importantly expanded to insure that all levels including non-U.S. nations are appropriately networked in order to facilitate a truly regioinal effort at improving biosecurity and reducing the risk of IAS transport and establishment. The communication network that occurs between government agencies results in information that can be compiled, consolidated, and reproduced in a manner suitable and clear to the general public and private industry (e.g., transportation, construction). Local capacity-building is needed to support research, operations and program management, and to improve local recruitment pools. Efforts could include cooperative university and government programs, such that funding is utilized in a most resourceful manner (Colvin et al. 2005). For example, the public outreach program on Saipan is a model, particularly the partnership with private industry. This public outreach effort, fielded by the Office of Economic Adjustment and the Military Integration Management Committee, conducts Community Outreach Dialogue sessions on Saipan to hear concerns of citizens. This and other demonstration projects illustrate attempts at achieving biological, social, and economic objectives through managing invasive species on islands (Saunders et al. 2007).

A4.1.3.16 *Education and Training*

Gaps in invasive species management can be bridged by increased education and training, with an emphasis placed on public outreach including both military and civilian populations. Public perception and lack of support have affected efforts to manage or eradicate vertebrate species in the United States, as elsewhere in the world (NISC 2001). Knowledge levels regarding invasive species and the harm they can cause are relatively low amongst the general public (NISC 2001). For example, reports on invasive species management in Hawai'i (TNC and NRDC 1992, OTA 1993) concluded an overall gap in public awareness of invasive species. This resulted in the formation of the Coordinating Group on Alien Pest Species (CGAPS), a voluntary government/non-government partnership, formed in 1995 to increase public awareness of invasive species. Following the formation of the partnership, CGAPS launched phase two of the campaign in 2006, with television and print media and a new toll-free hotline number regarding the dangers of BTS. Encouragingly, follow-up surveys confirmed a rising awareness about BTS (Martin 2007).

Furthermore, staff involved in the enforcement aspect of invasive species (e.g., inspection agents) need to be educated on biological risks on which they act daily. Knowledge of the impacts of introduction is bound to increase staff motivation and efficiency in the workplace. Training should include the taxonomic identification of species, continued education on species status updates, changes to regulations, and new pest species listings (e.g., White-List). In complement, multimedia educational material, such as the Distance Diagnostic and Identification System (University of Florida 2010), can further facilitate proper identification of species, with written descriptions, physical attributes, and animal behavior, as well as immediate human health and safety concerns.

Rapid response programs are designed to implement immediate action upon the detection of invasive species. They are comprehensive programs that require the melding of coordination, communication, education, and training. Rapid response actions and sightings are documented in incident reports and response times are substantially reduced by emphasizing training and public awareness, as shown in CNMI in 2003 (Colvin et al. 2005). The BTS review by Colvin et al. (2005) found rapid response to be most successful when the following aspects are incorporated into the program: extensive training, public awareness and outreach, use of technological advances, centralized documentation (e.g., SOPs), and networking that allows the program to operate on a regional level. These aspects are central to the recommendations for rapid response programs outlined in the review. Currently, the most developed rapid response programs exist in Guam, Saipan, and Hawai'i but training and organizational efforts in other archipelagoes in the Pacific Basin is underway. For example, the U.S. Geological Survey Rapid Response program has conducted training throughout the Micronesia Region, including CNMI, Palau, Chuuk, Pohnpei, Kosrae, Kwajalein, Ebeye, and Majuro (Stanford and Rodda 2007) with the goal of expanadding the capacity regional rapid response program for alien snakes.

A4.1.3.17 *Control Methods Development*

Methods development is also needed to facilitate prevention measures occurring at the pre-border stage, but its largest application in mitigation at the post-border stage of introduction of invasive species. Methods development is most productive when closely coordinated and integrated to maximize efficient use of funds and execution in the field (Colvin et al. 2005).

While extensive progress has been made on many aspects of BTS biology and control measures, additional ecological research is needed to facilitate control and interdiction, including topics such as population dynamics, reproductive biology, bait and attractants, application of control agents and logistics of control measures (Colvin et al. 2005). Unlike BTS, there remains a lack of methods development for particular invasive species, such as the Asian beauty snake, gecko species, and house shrew. Certain species require integrative solutions for effective control methods; characteristics inherent in their biology and behavior may make some species more difficult to control. For example, effective baited trapping of BTS is feasible due to their large movements, while bait and attractants are not as effective on the more sedentary Habu snake (Hattori 1999). Successful methods development relies heavily on sufficient funding to fuel the education, training, human resources, and facilities required to pursue a comprehensive, integrative approach to control and management of invasive species.

A4.1.3.18 *Regulatory Drivers and Enforcement*

Regulatory drivers are in place to prevent the transport of vertebrate species, but these regulations are only realized under well-funded, comprehensive enforcement. For example, pertinent regulatory drivers include the Brown Treesnake Control and Eradication Act of 2004 and the National Defense Authorization Act, Public Law 110-181, Section 314, requiring implementation of control, eradication, and reporting efforts, as well as actions prohibiting the transport and spread of BTS from Guam. The BTS Control and Eradication Act of 2004 required formation of the Brown Treesnake Technical Working Group under authority of the Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990. The Brown Treesnake Technical Working Group specifies 100% BTS interdiction on Guam, which requires inspections of aircraft, vessels, and cargo departing Guam, as described in the Brown Treesnake Control Plan of 2009. Enforcement of these regulatory drivers for BTS depends upon coordination and communication of several agencies such as APHIS-PPQ, Military Customs Inspection, CBP, the USFWS, and the Transportation Security Administration across water and air related pathways. One caveat of regulations in application to biosecurity lies in the fact that enforcement of the regulation may differ by sector. For example, biosecurity inspections of aircraft differ for military and commercial aircraft, with military aircraft themselves being exempt from inspection, and only contents such as passengers and cargo being subject to inspection (U.S. Navy 2009k). Also, in the United States, regulatory drivers have the tendency to differ in enforcement by State. This is seen in the implementation of biocontrol where policies can differ vastly in stringency by State leading to disjointed implementation of the regulation (Messing and Wright 2006). Therefore, monitoring and surveillance of enforcement such as detailed reports, summaries of prosecution of regulation breaches, and corresponding trends of introduction incidences are all necessary checks and balances to evaluate the efficacy of the upholding of regulations regarding invasive species through enforcement.

A4.1.3.19 *General Recommendations*

Address funding issues necessary for regional biosecurity. Regardless of the biosecurity strategy developed, lack of sufficient, consistent, and properly managed funds will be the weak link in any effort implemented, allowing for biological invasions of terrestrial vertebrates to occur in the region.

Military funding for biosecurity efforts in the region must be continued. Military presence in the region calls for long-term allocation and ongoing management of biosecurity funds, as many risks to biosecurity are associated with the relocation.

A centralized group should be responsible for creating avenues for funding within the Micronesia Region. Regional funding is necessary because many of the risks are interrelated and require efforts that cross political boundaries and sustained efforts are required to effectively minimize risk.

Mandate and enforce regulations for handling cargo, including packing, transport, cargo-staging, palletizing, and loading. Funding is required to adequately develop and enforce regulations for movement of cargo by military and civilian sources.

Centralize biosecurity efforts. The National Invasive Species Council was established by Executive Order 13112 to provide coordination and planning, and facilitate cooperation among the diverse federal agencies and to take a more comprehensive approach to invasive species. However, the multiple economic, ecological, and human health impacts of invasive species create complex challenges in policy formation and governmental coordination (Williams et al. 2007), such that efforts must be centralized in order to operate cohesively and effectively. A central group acting as a liaison can bridge gaps between formal and informal, and military and civilian communications. A central group would outline the current network of the biosecurity communications in the Micronesia Region, identify communication gaps, provide information in the appropriate format for public, private, and military sectors, and be a representative for media and news releases concerning biosecurity.

Develop a biosecurity surveillance system for improved data collection, reporting, and information sharing network. There is a paucity of available information to fully assess risks associated with the unintentional and accidental movement of terrestrial vertebrate species, posing significant risks and undermining biosecurity efforts in the Micronesia Region. Sustained surveillance of biosecurity risks to lead an adaptive response will decrease the risk due to changing threats and changes in the way cargo and people are moved in the future.

Encourage and participate in action to preserve biodiversity. Include actions taken by joint agency collaborations, such as the Micronesia Challenge (Micronesia Challenge 2009).

Create community funding sources for local programs. Promote “environmental citizenship” (Barry and Knab 2005) for local training, education, eradication efforts, etc.

Expand and manage university research efforts and programs. The universities of the region can serve as local facilities for methods development, education, and training to enhance biosecurity measures.

Comprehensive and continued education is needed. Educate everyone that can help or positively influence the campaign against invasive species. Elements can include disseminating reports and newsletters to educators, journalists, lawmakers, and business and community leaders; establishing local reporting systems for rapid response teams; developing curricula for the schools; and conducting a pre-campaign poll of island residents to gauge levels of awareness regarding species introductions/invasions and subsequent impacts (Holt 1997). Include military and military-civilian personnel.

Implement biosecurity measures for detecting myriad terrestrial vertebrate species. Biosecurity activities need to account for several species of terrestrial vertebrates in the Micronesia Region, but hazards and regulations currently driving biosecurity efforts on Guam are aimed primarily at preventing the transport and spread of BTS. Detection methods for various terrestrial vertebrate species would involve an increase in awareness, adequate training, and proper equipment for dealing with inceptions and the capabilities to report all incidences, including incidental sightings. Such an integrative approach also permits assessment of the cumulative effects of terrestrial vertebrate species movement in the region.

Increase the number of USDA-APHIS-WS canine inspection teams at Apra Harbor, at the Commercial Port, and at Naval Base Guam. To adequately protect movement of snakes on military and commercial boats, the number and capacity of USDA canine inspection teams should be increased in response to adequately cover outgoing boats.

Create regionally based canine inspection stations for USDA-APHIS-WS canine teams on Guam. Make the existing canine housing facility a central inspection headquarters that houses the majority of canine teams. Build smaller housing units regionally around the island for one to three canine teams that are rotated regularly and randomly; these smaller units would reduce inspection team travel time, save fuel costs, and allow for more inspections to occur on island. These sub-stations could also serve as community collection points for vertebrate terrestrial species information, and awareness/training programs, and also where the public can report observations and bring specimens.

Establish a role for USDA-APHIS-WS BTS canine inspection teams in CNMI. USDA-APHIS-WS does not have a presence in CNMI for BTS inspections of materials and vessels departing Saipan, Tinian, and Rota. Establishing USDA-APHIS-WS canine teams in CNMI can enhance screening abilities performed by CNMI Division of Fish and Wildlife canine teams by increasing the number of personnel and canine teams available, increasing ability to conduct random inspections, and increasing the number of inspections and amount of materials that can be inspected.

Develop a labeling and tracking system for all cargo. Cargo that originates in areas with high BTS densities is considered high risk. Implement a barcode-based data collection system and incorporate it into a centralized biosecurity system. A barcode-based system will typically be comprised of any or all of the following components: barcode scanners, barcode-based mobile computers (including wireless scanners, pen/key-based terminals, and vehicle-mount computers), barcode printers, barcode labels and ribbons, and barcode data collection software.

Manage the grounds around ports to reduce populations of target invasive species. Unintentional transport of hitchhiking terrestrial vertebrate species may occur in a number of ways. Hitchhiking species may be initially attracted to certain physical or chemical conditions, such as rats (*Rattus* spp.) nesting in aircraft wheel wells (Vice 2010b), BTS sheltering inside shipping containers or packing material (Fritts et al. 1999), and mice (*Mus* spp.) feeding on grain and garbage shipments transported overseas (Baker 1994). Use vertebrate-proof staging areas, spot-lighting checks at night, etc.

Expand capacity of control methods for BTS. While progress has been made on many aspects of BTS biology and control measures, additional or improvement of methods would facilitate control and interdiction procedures, including bait and attractants, large area suppression, additional interdiction techniques, and logistics of control measures (Colvin et al. 2005). Sustained funding to refine existing strategies and develop new methods would decrease the long term costs of interdiction, improve efficacy, and reduce risk.

Improve detection methods for rodents on vessels and in cargo. NAVMED P-5010-8 is the Naval Manual of Preventative Medicine, Chapter 8, Navy Entomology and Pest Control Technology (U.S. Navy BMS 2004) and outlines preventive measures for rodent control on ships. This includes proper sanitation, pierside inspections, rat guards, illumination and movement restrictions, glue boards, snap traps, and limitations on access points to the vessel. The information available on rodent prevention measures is more extensive than that of aircraft. Currently, control methods for rodents in cargo consist of anti-coagulant bait, snap traps and sticky traps. Most efforts regarding rodent presence on vessels and in cargo remain in the control realm, while methods on rodent detection are underdeveloped.

Assign trained, uniformed USFWS personnel to law enforcement at commercial and military ports. USFWS personnel can assist in preventing incidences of smuggling, help handle and process confiscated animals, provide permits, provide education, assist in the handling and processing of terrestrial vertebrates detected by USDA-APHIS-WS inspectors, enforce laws, and be part of Rapid Response Plans at the border.

A4.2 INTENTIONAL PATHWAYS

A4.2.1 Summary

There are 10 pathways by which terrestrial vertebrates may be intentionally introduced into the Micronesia Region. These pathways are evaluated for their risks to the region by analyzing for each the component risks of importation, establishment, and hazard (or impact). The pathways of greatest risk to the Micronesia Region are the pet trade, release for aesthetic purposes, and release for food use. The first two of these also present the greatest range of species associated with release, making it difficult to mitigate risk via those pathways using a species-based approach such as reliance on banning a few species. The four pathways of zoo releases, game-hunting, biocontrol, and scientific research present moderate risks of introducing new invasive vertebrates. With the exception of the zoo pathway, each presents only a narrow range of species liable for introduction, but several of these pose high risks of impacts should they become established. The final pathways of fur-ranching, religious release, and bioterrorism present only low probabilities of leading to new vertebrate invasions in the Micronesia Region under current circumstances, although the second of these could increase in importance should the proportion of Buddhists in the region increase in coming years. Several of these species also pose high hazard, but risk will be directly related to propagule pressure (numbers released), which is currently small.

Mitigation of these risks is feasible for many pathways because of the intentional nature of the introductions. The most reliable mitigation actions involve expanding regulations of importation and ensuring enforcement and public outreach regarding the regulations. Future methods development may make it feasible to develop more specific screening models to determine comparative risks on a species-by-species basis for a broad array of taxa, but that goal is not yet scientifically available. Until that goal is met, banning certain well-known, high-risk invasives from importation into the region is a reasonable measure for the avoidance of the potential spread of these invasive species. Supplementation of explicit efforts to remove or highly restrict certain pathways (zoological gardens, game hunting, scientific research, fur farming) would go some way toward providing the Micronesia Region greater biosecurity for the near future.

A4.2.2 Introduction

Vertebrates have been among the most spectacularly destructive groups of alien species transported by humans, with many species creating threats to human health and safety, the economy, and ecology in the regions where they have been introduced (Greenway 1967; Honegger 1981; Morgan and Woods 1986; Ebenhard 1988; Case and Bolger 1991; Henderson 1992; Pimentel et al. 2000; Pimentel 2002; Blackburn et al. 2004; Pimentel et al. 2005; Jenkins et al. 2007; Kroeger 2007). Progress has been made in recent years toward reversing some of these impacts by removing certain alien vertebrates from some invaded regions (Bell 2002; Burbridge and Morris 2002; Merton et al. 2002; Tershy et al. 2002; Nogales et al. 2004; Campbell and Donlan 2005; Clout and Russell 2006; Howald et al. 2007). In most instances, however, perpetual control of widespread or abundant alien vertebrates is required to minimize damage to especially important areas or resources. But such eradication and control operations are achieved at high cost and can only be successful in limited circumstances, making them an unreliable foundation upon which to base a nation's biosecurity future. A much more efficient and cost-effective means of managing alien species is to prevent their introduction (Naylor 2000; Touza et al. 2007). Consequently, prevention of future invasions should form the centerpiece of any region's alien-species management program.

To date this has been rarely attempted. Australia and New Zealand have taken measures to develop proactive systems to prohibit the introduction of new vertebrate species onto their shores unless they are first evaluated and shown likely to be safe for importation. Most jurisdictions, however, if they prohibit the importation of a species at all, only ban species famous for being pests elsewhere. This approach is of some use for avoiding additional damages from known invasives having high impact, but it is inherently reactive and can only be applied to species already creating damage elsewhere. It cannot identify pests from the large pool of species not yet introduced anywhere or of those introduced elsewhere but not yet having erupted into pest status.

In developing a meaningful prevention system for terrestrial vertebrates, assessment of risk must take into account the means of introduction. This is important because different taxa are introduced for different reasons and via different pathways (Kraus 2003). For example, the most important introduction pathways for all terrestrial vertebrates are intentional pathways, with mammals being introduced mostly for game hunting, food use, and fur farming; birds primarily for the pet trade and for game hunting; and reptiles and amphibians mostly for the pet trade, for related aesthetic reasons, and for food use (Kraus 2003; 2009). As well, some taxa are moved via more than one pathway. For example, the invasive North American bullfrog (*Lithobates catesbeianus*) has been introduced via the pet trade, for food use, and for aesthetic reasons, and the Chinese soft-shelled turtle (*Pelodiscus sinensis*) has been introduced via the pet trade, for food use, and for religious purposes, with different pathways applying in different locations (Kraus 2009). Pathway importance also varies temporally, with some pathways increasing in importance through time (e.g., the pet trade since the 1960s) and others generally decreasing in importance (e.g., biocontrol since the 1930s). As a result of the taxonomic, temporal, and geographic variation among pathways, the proper means of assessing biosecurity risk will vary by pathway, location, and time, as will the appropriate means of managing that risk (Kraus 2009).

Pathway definitions differ depending on which class of pathways is under consideration; intentional are pathways based on the motive for importation. As a result, intentional pathway categories are diverse in their introduction methods. For example, use of animals as pets may involve purchase via commercial pet shops, purchase from websites, or direct smuggling of desired animals; their release may be deliberate with the intent to establish new populations, deliberate to remove the burden of unwanted animals, or accidental due to poor caging conditions.

In mitigating risk of intentional introductions, public education can prevent deliberate importation or release of new invasive vertebrates and should be included in the arsenal of tools used for invasive-species management. However, it is an insufficient tool in itself, so it is also desirable to prohibit the intentional import and keeping of high-risk species (Reed 2005), and seek to remove the economic or social incentives for some of the intentional pathways. Prevention of dangerous introductions via the assorted intentional pathways can be most effectively achieved by means of adopting scientific screening systems to evaluate proposed importations for likelihood of invasiveness. This would enable quarantine authorities to permit the import of low-risk species, while identifying and excluding high-risk species (Kolar and Lodge 2002; Bomford 2003). Yet how these risks can be reliably assessed is still a matter for debate, and it is likely that simple generalizations across all taxonomic groups are not feasible (Williamson 1999b; Kolar and Lodge 2001; Heger and Trepl 2003; Cassey et al. 2004). But risk assessment across a particular taxonomic group (e.g., birds) may be feasible. So, ecologists continue to suggest and test a large number of attributes for these different vertebrate groups in search of a set that is consistently predictive of establishment success for each group, and risk analysts continue to recommend their use in risk-management schemes (Kolar and Lodge 2002; Stohlgren and Schnase 2006; Hayes and Barry 2008).

To that end, a number of studies have sought to identify such attributes for birds (Moulton and Pimm 1986; Brooke et al. 1995; Duncan 1997; Sol and Lefebvre 2000; Blackburn and Duncan 2001; Cassey 2001; Duncan et al. 2001; Cassey 2002; Cassey et al. 2004; Allen 2007a; Blackburn and Cassey 2007; Blackburn et al. 2009), mammals (Forsyth et al. 2004; Bomford et al. 2006), and reptiles and amphibians (Bomford et al. 2009). Different attributes have been found to be important in these various studies, depending in large part on the taxon and region investigated. Hayes and Barry (2008) examined 24 of these studies, and they found that only three parameters (climate match between native and host ranges, successful prior establishment elsewhere, and propagule pressure) consistently predicted establishment success across all taxa, although other factors were sometimes important for a particular taxon, such as birds. The results of these assorted studies have been used by Bomford (Bomford 2003; Bomford et al. 2005; 2006; Bomford 2008; Bomford et al. 2009) to construct simple models for assessing the likely invasiveness of vertebrates proposed for introduction to Australia and New Zealand. Some of the relevant variables (e.g., prior history of invasion, propagule pressure) are uniform across regions because they are taxon specific, but the climate-matching variables need to be adjusted for each separate jurisdiction under consideration because climate varies so widely among regions.

Even with proper application of an effective screening system for intentional introductions, smuggling of pest species by uninformed or malicious individuals will continue to be attempted. So, effective enforcement of biosecurity laws prohibiting pest importations is also a requisite part of any meaningful preventive system for intentionally introduced vertebrates. Developing a screening system without some form of enforcement capability is a sterile exercise and will compromise biosecurity.

In considering the risk of introduction of alien vertebrates into the Micronesia Region via intentional pathways, the most sensible approach at present is to identify all relevant motives, consider the most hazardous types of animals that are likely to arrive by that motive, and assess the degree of threat posed. For some pathways, only a few taxa are able to be transported; for other pathways, many taxa may be moved (e.g., zoological garden stocking). This threat will be the product of likelihood of introduction, likelihood of establishment, and the hazard posed by the taxa arriving by that pathway. Likelihood of introduction will be a function of the volume of material arriving by the pathway, degree to which the pathway is inspected or regulated, and degree to which compliance with regulations occurs.

Likelihood of establishment can be dependent on many things, but factors scientifically assessed and proven useful for birds and mammals include degree of climate match, whether the species is already established somewhere else outside its native range, overseas range size, taxonomic order, diet, ability to inhabit disturbed habitats, and non-migratory behavior (Bomford 2008). Factors proven useful for reptiles and amphibians include degree of climate match, whether the species is already established somewhere else outside its native range, and taxonomic family (Bomford and Kraus 2008; Bomford et al. 2009). For all terrestrial vertebrate taxa, climate match is best ascertained by using a formal climate-matching algorithm, such as CLIMATE (Bomford 2008; Bomford et al. 2009). However, such comparisons rely on quantitative matching between meteorological stations within a species' total range and those in the jurisdiction of concern. These comparisons are not easily made for oceanic islands because the sampling of meteorological stations in such regions is often too sparse to sample the full range of climatic variation, especially that variation due to ascending elevation. So, for this risk assessment, climatic suitability of the Micronesia Region for a species was assessed by determining whether that species occurred in similar climatic zones or ecoregions elsewhere in the world. A caveat to the application of climatic suitability is that it does not account for other parameters or pressures that may make the given region unsuitable for reasons other than climate.

Hazard (or pest status, or invasiveness) posed by a species has been moderately well assessed for birds and mammals (Bomford 2008) but has been poorly evaluated for reptiles and amphibians. For both birds and mammals, hazard is a function of taxonomic group as well as other factors. Factors that also heighten risk of establishment for both taxa (overseas range size, whether it is a pest elsewhere, and climate match) also predict invasiveness, as do whether a species is harmful to humans, their property, or their domesticated animals, either by direct action or by transmitting disease or parasites. Mammal orders that have a demonstrated history of detrimental effects on prey abundance or habitat quality (Artiodactyla, Carnivora, Lagomorpha, Marsupialia, Perissodactyla, and Rodentia) and mammal families that are prone to causing agricultural damage (Bovidae, Canidae, Cervidae, Leporidae, Muridae, and Mustelidae) are of higher hazard, as are those that are strict carnivores, or strict browsers/grazers. Bird taxa that cause high agricultural damage (Anatidae, Corvidae, Fringillidae, Ploceidae, Sturnidae, and Psittaciformes) or which frequently hybridize with native species (e.g., Anatidae, Cacatuidae, Phasianidae) are of higher hazard. Species in both Aves and Mammalia can also be social hazards because they invade buildings, have communal nests that create large amounts of waste, or generate large amounts of noise. Hazard for reptiles and amphibians is more tentatively assigned, but factors that clearly impinge on hazard include risk to human health via envenomation or constriction, noise production, whether the species has been a pest elsewhere, or whether it is congeneric with isolated native species and thereby increases the risk of hybridization (Kraus 2009). The first of these hazard categories for herpetofauna is unambiguously determined, but the last three have received little attention, although some species clearly fall into each category.

Because risk assessment for alien vertebrates is still in the process of development, probabilities of introduction, establishment, and hazard are often only qualitatively ranked by category at present. In the United States, categories used by USDA and the Environmental Protection Agency are "high", "medium", and "low" (Simberloff 2005). In this approach, the total risk is taken to be the lowest-ranked probability across the three categories, an approach that is in accord with a juridical tradition of presuming innocence until proven otherwise, but which seems inadequate to stopping additional invasions (Simberloff 2005). Thus, e.g., a species having a low probability of introduction, a medium probability of establishment, but a high probability of hazard would be assigned a total risk score of "low". The Australian government provides a slightly more expanded set of risk ranks, including "low", "moderate", "high", and "extreme", and addresses contrasting risks across the categories of introduction, establishment, and hazard in a more quantitative and directly comparable fashion. In this system, values for each variable contributing to risk, whether for introduction, establishment, or hazard, are given numerical values, with assigned values depending on how much the attribute contributes to the particular risk. These numerical scores are then summed across all pertinent variables among the three stages of invasiveness and the final risk is determined by the overall score, with high scores meriting assessments of "extreme" risk, while low totals merit a "low" overall ranking (Bomford 2003; Bomford et al. 2006; Bomford 2008). As noted above, as attributes predictive of risk become better identified, these quantitative models may be expanded to provide a finer degree of risk assessment than can currently be achieved.

A4.2.3 Risk Assessment

Ten pathways potentially contribute to the risk of intentional introduction of vertebrate pests into the Micronesia Region, with the first nine being well-documented pathways from around the globe, and the last being hypothetical. Different sets of taxa characterize each pathway. Most pathways have a relatively small set of taxa of primary concern, but the pet trade and aesthetic pathways move a large and open-ended set of species, making assessing specific risks from those pathways more challenging. For consideration of risk to the Micronesia Region, a set of representative taxa of greatest likely risk is here identified for each pathway, basing this on species known to be involved in these pathways and of ecological, economic, or social hazard elsewhere. This allows for quick comparison of relative risk among the pathways, points out the potential risks that invasive terrestrial vertebrates can pose to the Micronesia Region, and highlights biological and transport issues relevant to developing appropriate biosecurity mitigation measures.

As stated earlier, each pathway can typically involve several different routes of ingress. Specimens may be either purchased or carried personally into the jurisdiction in question. Purchases may be through commercial local businesses (such as pet shops) or via the Internet (Derraik and Phillips 2010), in which case, transportation may be via commercial freight carrier or the mail. Personally carried items may be legally brought into the jurisdiction of interest or may be smuggled. In the Pacific islands, smuggling is generally very easy because of poor inspection of arriving passengers and baggage for contraband animals (see for example Kraus and Cravalho 2001 for Hawai'i). Although there are no data to indicate that it is happening, smuggling would be very easy for personnel arriving on military craft. When developing biosecurity programs for intentional pathways of introduction it will be important to ensure that the public and military are educated about prohibited items, that rigorous inspection of each potential route of arrival is provided, and that enforcement of laws is politically and financially supported. Otherwise, merely identifying source pathways and noting their hazards are of little benefit.

For this risk assessment for the Micronesia Region, insufficient information is available to meet the detailed, quantitative standards followed by the Australian system (Bomford 2003; Bomford et al. 2006; Bomford 2008). However, the USDA approach, which chooses an overall risk score by automatically defaulting to the lowest of the three constituent risk scores, is of dubious justification or utility in stopping invasions (Simberloff 2005). For the purposes of this risk assessment, the best that can be done at present is to assign a risk of "low," "moderate," or "high" to each component of introduction risk (importation, establishment, and hazard), similar to the approach adopted by USDA. But then a score is assigned to each of these risk levels (low=1, moderate=2, high=3), and the scores summed across the three components of risk to achieve a final score, with the overall risk of introduction being "low" if the sum score is 3-5, "moderate" if 6-7, and "high" if 8-9. This provides a more balanced means of adjudicating overall risk among the three constituent components of introduction risk.

Historically, the Pacific region, and especially the oceanic islands, have been heavily impacted by introductions of alien terrestrial vertebrates. Virtually no island in the region has been immune to them. More than 40% of bird introductions around the world have been to Pacific islands (Long 1981; Kraus 2003), as have large numbers of mammals (Lever 1985; Long 2003) and reptiles and amphibians (Kraus 2009). Many of these have been deliberate introductions. As a result of this heavy introduction history, some of the most heavily impacted jurisdictions (especially New Zealand and Hawai'i) have served as cautionary tales for much of the remainder of the Pacific islands and have been at the vanguard of research into the impacts and invasion processes on these species. This research, as well as that from lower-elevation islands (e.g., Guam, Ogasawara Islands, see Fritts and Rodda, 1998; Kawakami and Okochi, 2010), has made clear how susceptible oceanic islands are to introduced alien species generally (Fritts and Rodda 1998; Kawakami and Okochi 2010). Thus, even though many areas of the Micronesia Region currently lack most of the invasive terrestrial vertebrates that plague other regions, without thoughtful assessment of the risks of acquiring these species, protection of those islands from these pests is compromised.

One important component of risk is whether eradication of a species is feasible should it become established. It is politically easy to think that prevention of additional invasions can be neglected because too many species are involved, and that instead management can be focused on removing the worst invasive species that do become established. Invasive species are difficult to eradicate once established, and the same holds equally for most vertebrate species. It is true that several species of mammals were successfully eradicated from islands with new techniques developed in the past 20 years (Nogales et al. 2004; Campbell and Donlan 2005; Howald et al. 2007). However, only a very few species, primarily rats, cats, and ungulates, have widely benefited from this attention. There are very few instances of successful eradication efforts for amphibians, and none for reptiles (Kraus 2009) or birds, although ongoing efforts in Britain against ruddy ducks (*Oxyura jamaicensis*) seem successful (Genovesi 2005; Henderson 2010). One important reason for these failures is that detection of these species is usually sufficiently difficult that not all members of the targeted population are liable to control, a precondition for successful eradication operations (Bomford and O'Brien 1995). Another reason is that control methods have not been developed for many species beyond those few mammals mentioned above (Kraus 2009). Even for the few species that are sometimes feasibly eradicated, costs are almost always high (Martins et al. 2006; Donlan and Wilcox 2007; Howald et al. 2007), restricting such actions to only the most damaging invasions. The importance of this is that the impossibility or difficulty of eradication increases the hazard of virtually all species considered below because damage usually continues in perpetuity.

A4.2.3.1 *Pet Trade*

This pathway includes all acquisitions of animals for use as pets, whether purchased from commercial pet stores, purchased from Internet dealers, or directly captured and imported by interested individuals. It also involves the deliberate release of animals to establish populations that will then be harvested to sell to the pet trade. Globally, the pet trade is the largest source of introductions for reptiles and amphibians and is one of the two largest pathways for birds, with introductions of those taxa increasing exponentially (Kraus 2003, 2009). But the pathway is a relatively insignificant source for mammal introductions, with a few notable exceptions. For reptiles, amphibians, and birds this pathway has exploded in importance since the 1960s and shows no sign of abating in the near future (Kraus 2003, 2009). Furthermore, although the pathway has been of greatest importance in the wealthier countries, there is virtually no part of the world untouched by it (Kraus 2009). The diversity of bird, reptile, and amphibian species spread via this pathway numbers in the hundreds (Jenkins et al. 2007), and the numbers of individuals moved is in the millions (e.g., Beissinger 2001; Franke and Telecky 2001). The most commonly spread mammals via this pathway are cats, dogs, rabbits, and an assortment of rodents, again moved worldwide by the millions.

Importation risk via this pathway is high and growing. A large and diverse array of species is available through the pet trade, and there are few restrictions in the Micronesia Region on what is available for importation. Pet stores occur in at least Guam, CNMI, and FSM, and even where pet stores are lacking, travelling citizens will often bring animals of interest back with them from overseas trips (e.g., Buden et al. 2001). Occasionally, visitors arriving on private boats or on foreign fishing vessels also bring in pets that escape captivity. Even when import restrictions on some pets do apply, smuggling and release or escape of banned species is sufficiently common that risk remains high. An example of this is from Guam, where ball pythons have recently been confiscated or turned over to officials even though the possession of snakes in the territory is banned (Vice 2010a). Smuggling is probably more frequent than that single example suggests, judging from the experience in culturally similar Hawai'i (Kraus and Cravalho 2001). The magnitude of the pet-trade problem will generally co-vary with population size, meaning that smaller jurisdictions will have fewer problems, but these will not disappear entirely. This is well illustrated by the appearance of turtles brought into Pohnpei for use as pets and maintained there, in at least one instance, by government officials (Buden et al. 2001). The CNMI has three or four active pet stores. IAS which are typical of the pet trade and which are known to have feral populations in the CNMI include the red-eared sliders (*Trachemys scripta*), orange-cheeked waxbills (*Estrilda melpoda*), rock doves (*Columba livia*), and quails (Williams 2010). Importation risk via this pathway will entail the risk of species legally allowed for import for commercial sale or ownership as well as the risk of smuggling, done either by direct personal transport of an animal or by Internet purchase and shipment via postal service or private carrier service (Derraik and Phillips 2010). Experience in Hawai'i has shown that smuggling of banned animals is generally easy because of lax inspection standards (Kraus and Cravalho 2001). The same will be true for much of the Micronesia Region.

Establishment risk via the pet trade is high overall, although there is tremendous variation among species. Quantification of establishment success for reptile and amphibian introductions indicates this pathway to be one with the lowest probability of successful establishment per release. However, because the total number of releases via this pathway is so vast, overall establishment risk is high, and the pathway has contributed the greatest number of herpetofaunal introductions worldwide (Kraus 2009). A similar pattern holds for birds (Kraus 2003). Although not explicitly tested, the same pattern may be expected for mammals, although mammals seem to establish more easily than do the other two groups. Many species of birds, reptiles, and amphibians introduced through the pet trade have become established in numerous countries around the globe, including tropical Pacific islands (Long 1981; Kraus 2009). Other taxa frequently kept in the pet trade are predicted to pose high establishment risks even though populations have not yet established (Bomford et al. 2005; Reed 2005; Carrete and Tella 2008; Bomford et al. 2009). At least among birds, wild-caught animals appear at greater risk of establishment than do species that have been bred in captivity for many generations, which seem to have lost much of their ability to live in the wild (Carrete and Tella 2008). It is doubtful whether the wild-caught vs. captive-bred distinction in establishment success will hold for reptiles and amphibians because their behavior is probably less environmentally dependent, so few species have been genetically modified in captivity, and, even when they have, there is evidence that mutant forms can survive when released into novel environments (e.g., Pether and Mateo 2007). However, at least one exception exists: wild-caught pythons are at greater risk of release and present a greater risk of impact because behavioral irascibility promotes release by owners and parasite loads present an added risk to native wildlife when released (Reed 2005). The most widely kept mammals (cats, dogs, rabbits, mice, rats) have well-established histories of successful establishment around the globe in a broad diversity of environments, including tropical islands (Lever 1985; Long 2003), and there is no doubt that they can easily establish populations if released in new islands in the Micronesia Region.

Hazard for species transported via this pathway is just as variable as is establishment risk, and for the same reason: the large pool of species travelling via this pathway are diverse in biological attributes, providing some species that are highly hazardous invaders and others that are of little concern. Especially hazardous among mammals are predatory cats (Lever 1985; Pimentel et al. 2000; Nogales et al. 2004; Vázquez-Domínguez et al. 2004; Pimentel et al. 2005; Denny and Dickman 2010; GISD 2010), dogs (Lever 1985; van’t Woudt 1990; Pimentel et al. 2000; Bergman et al. 2002; Pimentel et al. 2005), and grazing rabbits (Lever 1994; Courchamp et al. 2003; Long 2003). Rats and mice are also highly invasive across the globe (Atkinson 1978, 1985; Towns et al. 2006; Hilton and Cuthbert 2010), but it is uncertain whether domesticated pet varieties survive well upon release. Among the most destructive birds imported for pets are mynahs, bulbuls, pigeons, and a wide variety of parrots and finches, which damage agriculture, disperse seeds of invasive plants, harass native birds, compete with native birds for food and nest sites, and serve as reservoirs or vectors for diseases (Long 1981; van Riper and van Riper III 1985; van Riper III et al. 1986; Lever 1987; Meyer and Florence 1996; Pell and Tidemann 1997; Pimentel et al. 2000; Loope et al. 2001; Bergman et al. 2002; Bomford and Sinclair 2002; Thibault et al.

2002; Blanvillain et al. 2003; Eguchi and Amano 2004; Pimentel et al. 2005; Koopman and Pitt 2007; Bomford 2008; Atkinson and LaPointe 2009; Linnebjerg et al. 2009; Feare 2010; Linnebjerg et al. 2010). Some of these species are known to be actively sold as pets in the Micronesia Region. Hazard from reptiles and amphibians moved via the pet trade is less clear, but is likely to be large in some cases, especially on oceanic islands. In particular, snakes of many species are likely to be of high risk to native wildlife via predation (Kraus and Cravalho 2001; Loope et al. 2001), and venomous snakes and large constrictors, which pose obvious threats to human welfare and have become established on several tropical islands (Martínez-Morales and Cuarón 1999; Ota 1999, 2000; Nishimura 2005; Quick et al. 2005) as well as in the sub-tropical United States (Greene et al. 2007; Snow et al. 2007) are of considerable risk (Fritts et al. 1990; Fritts et al. 1994; Rodda et al. 1997; Nishimura 2005; Reed 2005). But snakes are not the only herpetofaunal threat. Predatory lizards are a potential problem, including monitor lizards (Varanidae) and chameleons (Chameleontidae) (Loope et al. 2001; Campbell 2003; Enge et al. 2004; Holland et al. 2009), due to predation on native wildlife, although large monitors can be a danger to humans as well. North American bullfrogs (*Rana catesbeiana*) have been introduced into some countries via the pet trade, and these frogs pose a large number of risks to native wildlife, including from predation, competition, and disease vectoring (summarized in Kraus 2009). Perhaps the most frequent impact from established populations of invasive reptiles and amphibians will be from changes in food-web dynamics occasioned by the high densities formed by novel predators in tropical island ecosystems. This can serve to either keep populations of other invasive pests unnaturally high by serving as a large food resource, or such species may act as energy sinks, making nutrients unavailable to native species (Fritts and Rodda 1998; Kraus et al. 1999; Moore et al. 2004; Greenlees et al. 2006; Kraus 2009). Many species of small frogs (e.g., Hylidae, Ranidae) and lizards (e.g., Gekkonidae, Scincidae) kept in the pet trade have the potential to induce such effects if released and established in the right environments. A final risk of considerable importance for all taxa is the risk of transmitting disease to humans or native species. Mammals, of course, pose a higher risk of transmitting diseases to humans because of their closer phylogenetic affinity (e.g., Daszak et al. 2000; Karesh and Cook 2005), but birds and reptiles also serve as vectors or reservoirs for human diseases (e.g., Haddock et al. 1990; Haddock and Nocon 1993; Mermin et al. 1997; Reed et al. 2003; Mermin et al. 2004). Spread of diseases to native wildlife is of even higher probability and threatens to reduce global biodiversity, with several spectacular examples emerging in recent years (Daszak et al. 2000, 2001; Fisher and Garner 2007).

Total risk via the pet-trade pathway is high in the Micronesia Region. Importation risk for many species is virtually assured by moderate to high public interest, lack of government regulation of the industry, and poor inspection and enforcement capabilities. Also, establishment risk and hazard are high for many of the most popular pet species. This is clearly the riskiest intentional pathway for terrestrial vertebrates in the Micronesia Region and in many other parts of the world. Given the relatively modest scope of the commercial pet trade in the Micronesia Region, the largest risk at present is probably the transport of cats and dogs to islands on which they currently lack feral populations, but a wide diversity of species, both mammalian and non-mammalian, pose a significant risk to the region.

- Risk of importation 3
- Risk of establishment 3

- Hazard 3
- Total risk 9 **HIGH**

A4.2.3.2 *Aesthetic Releases*

This pathway is very closely related to the pet-trade pathway and involves intentional release of animals to establish populations because the species is considered in some sense desirable by the releaser (this is the "intentional" pathway of Kraus 2009). Examples of this include birds (largely songbirds and some parrots), frogs, or lizards released around a home because they remind the owner of a place they lived previously or because they like the appearance of the species or the calls made by it (e.g., Long 1981; Kraus and Campbell III 2002). Historically, this has been an important, but uncommon, introduction pathway for birds, but a more important pathway for mammals, reptiles, and amphibians (Kraus 2003, 2009). Animals introduced via this pathway may be obtained directly from the pet trade for release, but often those introducing the animals collect the species directly from the wild and release them in an extralimital location. One variant of this pathway of particular concern is the desire by some resort hotels to release colorful birds such as ducks and parrots on their grounds to amuse tourists and increase the appearance of these resorts as “exotic.” Among other problems created by this practice is the release of mallard ducks (*Anas platyrhynchos*) in Hawai’i, which hybridize with and threaten the native koloa ducks *(Anas wyviliana*) (Browne et al. 1993; Engilis Jr. and Pratt 1993; Fowler et al. 2009).

Importation risk for this pathway will be largely the same as that for the pet trade, with animals available in the pet trade or available for personal legal importation typically being those chosen for release. However, this pathway also includes animals smuggled into a jurisdiction that bans their ownership, as has repeatedly been demonstrated in Hawai’i (Kraus 2002). Given the overlap with the pet trade for legal importations (see above) and the additional risk of importation posed by smugglers of banned wildlife, importation risk via this pathway is just as high as for the pet-trade pathway.

Risk of establishment via this pathway is a function of three variables: the number of individuals within a population desiring to establish a new species, the availability of animals for release, and the number of animals released (propagule pressure). For smaller jurisdictions, the first number will generally be low because relatively few people want new species in their environment that they will go through the trouble (sometimes including smuggling) to attempt establishing new populations. Availability of animals in the Micronesia Region varies depending on size of the local commercial pet trade and frequency with which citizens travel overseas and, therefore, have the opportunity to return with animals. Both of these are likely highest for Guam and CNMI because their large military presence leads to high passenger volume and frequent turnover of personnel. Lastly, propagule pressure via this pathway is usually high once a decision has been made to try to establish a species because everyone knows that multiple animals will increase the probability of founding a population. For most countries in the Micronesia Region, it is probably safe to assume that interest in establishing novel species is low. Across the region, availability of animals varies, but may be summed as moderate in Guam and CNMI and low in the other countries. But propagule pressure will generally be high. In sum, these three variables make establishment risk via this pathway moderate.

For the same reasons described above for the pet-trade pathway, hazard of animals released via this pathway will be of wide variability, but should generally be considered high because of the large number of clearly hazardous species transported. Hence, as for the aesthetic release pathway, overall risk is high. Opportunity for release is high, establishment risk is moderate, and impact risks are high. The only uncertainty is the will to release animals for this purpose, and experience around the globe shows that a significant (but small) percentage of most human populations are willing to engage in this behavior (see data in Long 1981, 2003; Lever 1985, 1987; Kraus 2009). Once that decision is made, animals are generally sufficiently available that a determined individual can acquire the needed material.

- Risk of importation 3
- Risk of establishment 2
- Hazard 3
- Total risk 8 **HIGH**

A4.2.3.3 *Animals for Entertainment*

Releases by zoological gardens are also closely related to the previous two categories inasmuch as the species displayed (and sometimes released) are chosen for their aesthetic interest. However, species available via this pathway present an even wider array of taxa than those available in the pet-trade or aesthetic pathways. Zoos range from large publicly funded, well-secured institutions to small, private, poorly secured tourist facilities. Most records of release come from the latter end of the spectrum; however, there have clearly been several instances of intentional releases of animals by personnel at larger, public zoos too (Shaw 1946; Long 1981). Releases include those done deliberately as well as escapees from poor caging conditions. Releases via this pathway have not been as well documented as for other pathways, but those involving reptiles and amphibians have recently been summarized (Kraus 2009), and some records of bird and mammal releases have also been noted (Long 1981; Washitani 2004; Holzapfel et al. 2006; Jansson et al. 2008). But most mammals retained in zoos are larger and dangerous enough to attract immediate recapture efforts, so few records exist of mammals becoming established via this pathway (but see Washitani 2004).

There are relatively few zoos in the Micronesia Region, with one (previously two) on Guam, one on Rota, and one on Saipan (Stanford 2010). A recently captured skunk on Guam likely arrived via this pathway, suggesting that, although few zoos exist in the Micronesia Region, the pathway cannot be ignored. Low volume of activity via this pathway makes risk of importation rather low, but the rather poor maintenance standards evinced by many private zoos make risk of release into the wild rather high. So overall, risk of importation and release/escape is moderate.

Risk of establishment is probably lower than for the pet-trade pathway because most species retained in zoos are kept only in small numbers. However, when large colonies of a species are kept, risk of establishment will increase. Information on what stocks are currently held in zoos in the Micronesia Region is not easily available, so establishment risk is currently uncertain for most jurisdictions. However, the zoo on Saipan has multiple individuals of some species (Calindas 2006), including some that are invasive elsewhere, so establishment risk will be higher for those. Given this uncertainty, establishment risk is here scored as “moderate.” Assuming that governments have the interest to mandate that zoos retain only one or two individuals of each species, however, establishment risk can be kept low.

Hazard via this pathway is high. Current regulations on Guam and possible elsewhere are likely not adequate to deal with this pathway effectively (as was demonstrated when the animal facility on Guam closed a few years ago where it appears that the ultimate repository of some of the captive animals from that facility were never ascertained (Pers Comm. Bassler). This high hazard results from all the same reasons given above under discussion of the pet-trade pathway as well as the fact that zoos frequently exhibit a number of species dangerous to humans. As well, some of the species exhibited at the Saipan Zoo (and obtained from a prior zoo on Guam) are known invasives elsewhere. These include parrots, cockatoos, and green iguanas (Calindas 2006).

- Risk of importation 2
- Risk of establishment 2
- Hazard 3
- Total risk 7 **MODERATE**

A4.2.3.4 *Food Use*

Transport of animals for use as food sources has historically been one of the largest pathways for mammal introductions but has been an important source of bird, reptile, and amphibian introductions as well (Kraus 2003, 2009). Introductions of domesticated mammals and birds via this pathway were a fundamental characteristic of European colonization efforts around the world (Crosby 1986), but most of these introductions tapered off by the start of the 20th century because virtually worldwide spread of their domesticated mammals had been completed. Prior to that, Polynesians and Micronesians had spread pigs and red jungle fowl widely across the Pacific, and Polynesians also moved iguanas (*Brachylophus* spp.) regionally (Gibbons 1981). However, there still remain many Pacific islands that lack feral populations of these Eurasian domesticated animals. Introductions of reptiles and amphibians for food use intensified during the 20th century and still continue around the world, with the most well-known example being the continued farming and spread of the North American bullfrog (*Lithobates catesbeianus*) for frog legs. Several of the most notoriously invasive mammals (pigs, goats, sheep, cattle, rabbits), reptiles (Chinese soft-shelled turtles, *Pelodiscus sinensis*), and amphibians (North American bullfrogs) have been spread via this pathway. Most of the alien vertebrates currently used for food in Micronesia include the usual assortment of ungulates (pigs, cattle, goats, caribou, sheep) and birds (chickens, quail, geese, ducks). Some members of the Asian communities in this region also eat dogs.

Risk of continued importation via this pathway is high. Most humans view their domesticated mammals and chickens as a natural part of their environment and do not think of them as invasive. As a consequence, transport and release of domesticated food species onto islands lacking them is typically viewed as simply exercising one’s right to feed oneself, and the practice continues around the globe.

Many of these introductions will involve transport between islands within nations, although others involve importation across national boundaries. Other food introductions are for more directly commercial purposes. North American bullfrogs and other large frog species continue to be touted as an easy way to raise protein in one's backyard either for direct consumption or, more often, for commercial sale. This despite the fact that frog farming is logistically difficult and most farms fail, with leftover animals released or escaping into nearby habitats. Despite decades of evidence that this is a difficult way of making money, agricultural extension agents around the world still promote the practice. As a result, regions naive to the experience of trying to farm frog legs are susceptible to the claims of easy profits and, therefore, to future invasions by these animals. None of the Micronesian Region countries has suffered commercial attempts to farm frogs before and, hence, each may be liable to persuasion that it is worthwhile. This inexperience makes risk of introduction of these species high for the region. In addition, new food species often attend the immigration of new ethnic groups into countries as they bring in preferred food resources from their home regions. For example, birds and turtles were introduced into Hawai'i by Chinese immigrants in the late 1800s/early 1900s for this purpose (Brock 1947; McKeown and Webb 1982). CNMI, Guam, and Palau all have significant populations from East Asian countries (56.3%, 32.6%, and 22.6%, respectively) (CIA 2010) and would be most liable to these sorts of introductions, although risk would increase should other countries also allow increased immigration or tourism from these regions.

Risk of establishment via the food pathway is high. Bird, reptile, and amphibian establishment rates have all been quantitatively shown to be very high for this pathway (Kraus 2003, 2009), and the same is certainly true for mammals, judging from the widespread distributions of the most popular food species (Lever 1985; Long 2003). High establishment rates reflect the persistent, deliberate attempts by humans to establish such species, which has led to frequent and widespread releases of large numbers of animals, and, consequently, provided the high propagule pressure needed for successful establishment (Forsyth et al. 2004; Lockwood et al. 2005; Hayes and Barry 2008). Given this continued motivation, there is no reason for establishment risk to decline through time.

Hazard of species released via this pathway is also very high. The assorted feral ungulates are among the most widely distributed and most destructive invasive species globally (Coblentz 1978; Cuddihy 1984; Ebenhard 1988; Atkinson 1989; Tunison et al. 1995; Pimentel et al. 2000; Donlan et al. 2002; Pimentel et al. 2005; GISD 2010), as is the bullfrog (Kraus 2009). Many other species known to be introduced as food sources (e.g., rabbits [*Oryctolagus cuniculus*], banteng [*Bos javanicus*], water buffalo [*Bubalus bubalis*], Polynesian rat [*Rattus exulans*], spotted turtledove [*Streptopelia chinensis*], and water frogs [*Rana ridibunda*]) are also highly invasive in one or more countries (Crook 1973; Atkinson 1978; Long 1981, 2003; Lever 1994; Arano et al. 1995; Pagano and Schmeller 1999; Athens et al. 2002; Courchamp et al. 2003; Pagano et al. 2003; Vorburger and Reyer 2003; Towns et al. 2006; Hunt 2007). Less frequently released species have not been well studied, but, on average, this pathway has generated a tremendous amount of ecological and economic damage worldwide. The fact that relatively few vertebrate species are moved via this pathway, and that a large percentage of those have figured among the most destructive invasive species in the world gives this pathway a very high risk of continued hazard.

Overall risk via this pathway is high for the Micronesia Region. Component risks of importation, establishment, and hazard are all high; social constraints on moving food animals are minimal and, hence, regulation and enforcement against such movements are likely to remain low in the Micronesia Region, as elsewhere.

- Risk of importation 3
- Risk of establishment 3
- Hazard 3
- Total risk 9 **HIGH**

A4.2.3.5 ***Game Hunting***

This pathway is not entirely separate from the previous one inasmuch as game hunting is engaged in both to provide food as well as for recreation, and animals are not actively farmed. However, the species pools in each category are largely non-overlapping because the domesticated animals transported for food use are generally not transported for use as game animals, although feral populations may be secondarily utilized as a game resource. Further, the motivations behind the pathways are not entirely the same, so separate consideration of them is warranted. Game introductions include only mammals and birds; reptiles and amphibians are not transported for this purpose (Kraus 2003, 2009). Globally, this has been the most important pathway for mammals, accounting for 25% of total introductions; it has been the second most important pathway for bird introductions, accounting for 35% of the total (Kraus 2003). For both groups, introduction rates have exploded since the mid-1900s and continue to be high (Kraus 2003).

Importation risk for mammals in the Micronesia Region would appear to be moderate via this pathway. The only mammals currently hunted in the region were introduced centuries ago, although some of them continue to be moved to new islands within countries (Long 2003; Vogt and Williams 2004). The only birds introduced into the region for this purpose appear to be the black francolin (*Francolinus francolinus*) and bluebreasted quail (*Coturnix chinensis*) (Long 1981; Fritts and Rodda 1998; Vogt and Williams 2004), introduced in the 1960s. However, large numbers of game birds have been introduced elsewhere in the Pacific (Long 1981; Wodzicki and Wright 1984; Moulton et al. 2001), and interest in additional releases of game animals has recently been expressed in at least CNMI (Williams 2010), so the Micronesia Region may not be immune to this pathway. In recent decades most introductions via this pathway have occurred under government auspices, so proper education of authorities about the risks of game animals may serve to keep future risk low via this pathway.

Establishment risk via the game pathway is moderate. Globally, this pathway has had a rather low probability of success for birds (35%, Kraus 2003). Although information was insufficient for assessing establishment probability for mammals via this pathway, it is probably somewhat higher because many of the widely used game mammals are less susceptible to extinction via predation than are the game birds. Against this rather low establishment rate must be counted the frequently persistent attempts at establishment via this pathway, which have often resulted in ultimate success. This combination of persistence with a low establishment probability per attempt results in an overall moderate risk of establishment. As for probability of importation, risk of establishment largely depends on what local governments will tolerate in this regard because so many of these efforts have involved either direct government sponsorship or at least governmental acquiescence in importation and release of large numbers of animals.

Hazard from this pathway is very high for mammals and moderate to high for birds. Many of the ungulates introduced for game purposes (primarily involving a variety of deer [*Cervus, Odocoileus*], tahr [*Hemitragus jemlahicus*], and mouflon [*Ovis ammon*]) have proven very destructive of native ecosystems on Pacific islands and elsewhere (Stone 1985; Conry 1988b; Wardle et al. 2001; Wiles 2005; Hughey and Hickling 2006; GISD 2010). This is both because of direct herbivory on native vegetation as well as trampling of the substrate (e.g., Duncan and Holdaway 1989), both of which lead to loss of vegetation and increased erosion. Galliform game birds may benefit local ecosystems by dispersing seeds of native plants previously dispersed by extinct avifauna (Cole et al. 1995), but they may also threaten native ecosystems by dispersing invasive plant seeds, preying on rare native invertebrates, or serving as reservoirs for parasites or diseases that threaten native species (Lewin and Mahrt 1983; Lewin and Lewin 1984; van Riper and van Riper III 1985; Cole et al. 1995). Mallard ducks are notorious for having hybridized with many other native duck species in North America, Asia, and Australia (Rhymer and Simberloff 1996), and introduced populations have threatened native ducks with introgressive hybridization in Hawai'i (Browne et al. 1993; Engilis Jr. and Pratt 1993; Fowler et al. 2009) and New Zealand (Gillespie 1985; Rhymer et al. 1994). Similar problems would be expected to attend establishment of mallards in Palau or Chuuk, FSM, where the native Pacific Black Duck (*Anas superciliosa*) occurs.

Overall introduction risk to the Micronesia Region via this pathway is moderate. Recent importation risk has been low, and governmental control over this pathway is rather easily established, so with proper attention by government authorities, risk of importation can readily be kept low. Similarly, establishment risk can be kept low by proper government regulation of the practice, but without this, releases for game purposes have often involved large numbers of animals, so establishment risk must be considered moderate without explicit governmental policy discouraging this practice. Absent governmental attention, risk would increase because of the tendency for some people to move animals regardless of broader societal risks. Hazard from many of the most frequently distributed species is high, and some of these have already colonized parts of the Micronesia Region.

Proper education of authorities regarding the risk associated with game animals would undoubtedly assist with keeping future risks low to moderate. The hunters should also be educated about the impacts of the animals they hunt and how hunting can helps the environment and sustainability of natural resources.

- Risk of importation 2
- Risk of establishment 2
- Hazard 3

- Total risk 7 **MODERATE**

A4.2.3.6 *Fur Ranching*

The majority of alien mammals introduced for fur ranching have involved the three species mink (*Mustela vison*), muskrat (*Ondatra zibethicus*), and nutria or coypu (*Myocastor coypus*), although a few introductions have involved raccoon (*Procyon lotor*), raccoon dog (*Nyctereutes procyonoides*), and brush-tailed possum (*Trichosurus vulpecula*) (Lever 1985; Long 2003). Virtually all of these introductions have been to temperate areas; none has been to an oceanic island (Lever 1985; Long 2003).

Risk of importation of species for this purpose in the Micronesia Region is very low. There is no record of historical interest in the fur trade in that region, and it is doubtful that the industry could establish in that climate with any of the species historically released through the trade.

Risk of establishment is low for the same reason: it is unlikely that any of the species historically released through the trade would survive the climate and habitat, although raccoons might be an exception, given their wide habitat tolerance and adaptability.

Hazard from the species involved in the fur trade is high. Mink depredate native vertebrates in Europe and may interfere with metapopulation dynamics, thereby increasing chances of population extinction; they also cause some economic damage from their depredations (Telfer et al. 2001; Banks et al. 2004; Bonesi and Palazon 2007). Coypu and muskrats depredate crops; undermine human structures; and graze vegetation, thereby depressing native plants, altering community structures of plants and invertebrates, and sometimes resulting in complete loss of marsh habitat (Danell 1996; Carter and Leonard 2002; Nummi et al. 2006; DAISIE 2008; GISD 2010). Raccoons depredate and compete with native animals, depredate crops, damage buildings, and potentially spread serious human diseases (Ikeda et al. 2004; Hayama et al. 2006). Raccoon dogs depredate and compete with native animals and serve as an important vector of rabies and other diseases in Europe (DAISIE 2008). Brush-tailed possums browse on native plants, leading to forest dieback, shifts in community structure, and endangerment of native flora; they also serve as disease reservoirs for humans and livestock (Veblen and Stewart 1982; Norton 1991; Rose et al. 1992; Crump et al. 2001). All of these species are invasive and should not be imported to the Micronesia Region.

Overall risk to Micronesia from the fur trade is low. Although hazard from the species involved is high, probabilities of importation and survival of these species are low in that region.

- Risk of importation 1
- Risk of establishment 1
- Hazard 3
- Total risk 5 **LOW**

A4.2.3.7 *Biocontrol*

Biocontrol introductions are those made for the purpose of providing predatory control of another pest species. Most of these releases have failed to control the pests they were intended to destroy; rather, the biocontrol species have become pests themselves. The classic examples involving vertebrates released for this purpose are cats (*Felis catus*) and weasels (*Mustela erminea, M. nivalis, M. putorius, M. sibirica*), widely released around the world for controlling rodents and rabbits damaging to agriculture (Lever 1985; Parkes and Murphy 2003; Denny and Dickman 2010); mongoose (*Herpestes edwardsi*, *H. ichneumon*, and *H. javanicus*), widely released around the world for controlling rats and vipers (Lever 1985; Long 2003); and cane toads (*Rhinella marina*), widely released across the tropics for controlling insect pests of sugarcane (Easteal 1981; Lever 2001). Although these are the classic species typically associated with biocontrol releases, a wide array of bird, frog, lizard, snake, and turtle species has been introduced for these purposes too. For example, at least 19 species of birds and 32 species of reptiles and amphibians have been introduced for biocontrol (Long 1981; Kraus 2009). Early releases of vertebrates for biocontrol often involved official government sponsorship (Thomson 1922; Easteal 1981; Long 1981; 2003), although private action was also common. Nowadays, government release of vertebrates is rare because the damage caused by prior releases is widely known, and, consequently, these actions have lost official favor. However, education about this subject among the general public is less advanced, and private individuals still frequently retain the simplistic notion, largely lacking in factual merit, that animal pests can be controlled simply by introducing a predator. Even so, if a target group with specific behavior changes is identified, this is where effort should begin. As a result, more recent vertebrate introductions for "biocontrol" purposes have tended to be private actions, often done for the purpose of providing local control (sometimes restricted to a single building) of pest insects such as cockroaches.

Because of negative fallout from prior vertebrate introductions and government eschewal of those releases, the global risk of introduction via this pathway has declined dramatically since the 1960s (Long 1981; Kraus 2009). Such private actions that still occur often involve either translocation of species easily obtained from nearby source areas or from the pet trade. Hence, importation risk for the biocontrol pathway will be correlated to these two factors. In the Micronesia Region, ready access to foreign faunas for private importation is generally limited, although individuals may be able to translocate invasives already established on nearby islands. The species of greatest concern for movement that way would be cats and some lizards, which are present as pests on some islands in the Micronesia Region but not on all. Control of the pet trade via proper regulation (see above) could limit access to hazardous species via the biocontrol pathway as well. The long flight times to the Micronesia Region from most parts of the world also make obtaining live animals via internet purchase of doubtful reliability. Hence, risk of importation for biocontrol purposes is probably generally low at present (except for animals available in the pet trade) and likely to stay that way for the foreseeable future. One exception to this rule is the ease with which U.S. servicemen can import pet animals from overseas stations by hand-carrying them on military aircraft. This route of importation is worsened by the fact that the USFWS and national quarantine services do not typically have inspectors stationed at military bases in the region, so the probability of interception of such imports is remote. This route has led to numerous illegal importations of banned reptiles into Hawai'i (Hawai'i DoA 2010), and some of these species include those released elsewhere for control of house pests. Similar activities likely occur on military bases in the Micronesia Region and would likely increase with the relocation of military personnel to Guam and in CNMI, making this the likeliest source of importations via the biocontrol pathway.

Vertebrate biocontrol releases have tended to have high probabilities of successful establishment (Kraus 2003; Long 2003; Kraus 2009). This is because these releases were often the result of well-funded programs supported by scientific or agency personnel and often resulted in the coordinated release of many individual animals (Kraus 2009), which is highly correlated with successful establishment across a wide variety of taxa (Lockwood et al. 2005; Hayes and Barry 2008; Bomford et al. 2009). Even when releases were not the result of scientific effort, the widespread release of a preferred species by numerous interested parties often created sufficient numbers of propagules that successful establishment was ensured (Long 2003). As well, even releases by single parties often involve multiple animals because the intent of release is to establish viable populations of the vertebrates, and everyone recognizes that multiple individuals are needed for this purpose. Thus, because propagule pressure is typically high, this pathway presents a very high risk of successful establishment, whether done under the auspices of an official governmental or scientific program or enacted solely by private parties. This would hold true in the Micronesia Region as elsewhere.

Hazard of the species involved in this pathway can be high. Indeed, biocontrol using vertebrates was largely discontinued for precisely this reason, with wide recognition of the ecological and economic impacts from cats (Lever 1985; Pimentel et al. 2000; Nogales et al. 2004; Vázquez-Domínguez et al. 2004; Pimentel et al. 2005; Denny and Dickman 2010; GISD 2010), mongooses (Honegger 1981; Case and Bolger 1991; Pimentel et al. 2000; Roy et al. 2002; Yamada and Sugimura 2004; Pimentel et al. 2005; Hays and Conant 2007; GISD 2010), weasels (Thomson 1922; McLennan et al. 1996; Basse et al. 1999; Dowding and Murphy 2001; GISD 2010), and cane toads (Freeland 1994; Williamson 1999a; Crossland 2000; Lever 2001; van Dam et al. 2002; Phillips et al. 2003; Boland 2004b, a; Doody et al. 2006a; Doody et al. 2006b; Greenlees et al. 2006; Smith and Phillips 2006; Griffiths and McKay 2007). What are less well studied are the impacts attending the dozens of other species introduced for purported biocontrol purposes. Mynahs (*Acridotheres tristis*) are well-known pests on tropical islands (Long 1981; Pell and Tidemann 1997; Bergman et al. 2002; Feare 2010), as are several other birds (Long 1981), but most other released biocontrol species remain unstudied. Cats are still widely spread by humans, so islands in the Micronesia Region that currently lack them are susceptible to receiving this pest. The other notorious invaders via the biocontrol pathway are no longer moved intentionally, except perhaps rarely by ignorant private parties. Biocontrol introductions made by private individuals now rely largely on animals available in the pet trade, because most insectivorous vertebrates will easily be viewed as meaningful biocontrol agents by the general public, and because availability within the pet trade fluctuates based on fads and perceived novelty, the pool of vertebrates potentially available for “biocontrol” use is potentially unlimited. This makes precise estimation of hazard for species other than those discussed above impossible at this time. However, given the large pool of species potentially available, it is reasonable to assume that they range in hazard risk from low to high. Hence, hazard for future biocontrol introductions can perhaps be best viewed as an average across this gamut and summarized as “moderate.”

As a safeguard measure any proposed biocontrol releases should follow a standard SOP including conducting a risk assessment, environmental impact studies and host specificity testing prior to any releases.

In sum, risk for the Micronesia Region from the biocontrol pathway is low for probability of importation, high for probability of establishment, and moderate for probability of impact, providing an overall risk via this pathway of “moderate.”

- Risk of importation 1
- Risk of establishment 3
- Hazard 2
- Total risk 6 **MODERATE**

A4.2.3.8 *Scientific Research*

Vertebrates have frequently been released in association with scientific research enterprises. Releases have been of two main types: 1) intentional or unintentional releases from medical research facilities, and 2) intentional releases to study the ecology or behavior of the released species. The most destructive consequences have arisen from the first of these, which have involved the release primarily of monkeys and frogs. A variety of monkey species has been introduced into tropical and subtropical locations around the globe from medical and/or behavioral research labs (Long 2003). Release of these animals has sometimes been deliberate and sometimes resulted from poor caging. Most releases date from the 1930s through the 1960s (Long 2003), but some are still occurring (Kyes 1993). Monkeys are notoriously difficult to control once wild populations are established, with even decades-long control efforts failing (Evans 1989; Boulton et al. 1996; Breckon 2000). This is a consequence of their intelligence, which makes them elusive, and their ability to utilize a wide variety of food resources, which allows them to attain high population densities in a diversity of environments.

Frog releases stemming from medical research have largely involved formerly widespread use of *Xenopus laevis* (African clawed frogs) in pregnancy tests, a practice that is now obsolete. However, releases of this species from medical research facilities have continued through the 1990s, making it still a relevant concern. This species too has proven invasive in many areas of release, spreading quickly and widely and creating some ecological damage in at least Chile (Lobos et al. 1999; Lobos and Measey 2002; Lobos and Jaksic 2005), France (Grosselet et al. 2005; Eggert and Fouquet 2006), and California (Lafferty and Page 1997). Populations of this frog have not generally proven amenable to control although three small populations in the eastern United States were eradicated with the assistance of cold weather (Tinsley and McCoid 1996).

Several species of frogs, salamanders, and lizards have been released in the United States, Caribbean islands, and Europe with a view of determining what ecological results attended their establishment in novel circumstances (Kraus 2009). Most releases for ecological research occurred prior to the 1970s, and the practice is largely condemned now. But a few rogue researchers have continued such releases into more recent times (Kraus 2009).

Risk of importation to the Micronesia Region from this pathway appears relatively low. There is only one medical school in the area (Pacific Basin University Medical School in FSM). Inasmuch as that institution appears to provide only the basics of a medical education, it is unlikely to be involved in research involving hazardous vertebrates. Ecological research in the region involving movement of hazardous vertebrates also appears non-existent to the present time. Given the growing expansion of awareness of the risks posed in the Pacific region by invasive alien species, this seems unlikely to change. Furthermore, at least some countries in the region (e.g., Palau) explicitly prohibit the introduction of monkeys, which are the species of greatest hazard moving via this pathway.

Risk of establishment from this pathway is high. Monkeys could easily establish in the Micronesia Region, as they have elsewhere in the tropics (Lever 1985; Long 2003), but it is less certain whether the African clawed frog could do so. Populations have established on tropical Ascension Island in the Atlantic (Tinsley and McCoid 1996), and this frog inhabits tropical regions of Africa, so it is feasible that it is capable of colonizing tropical Pacific islands too.

The hazard of these species ranges from moderate to high. Impacts from monkeys can be severe, with them proving especially damaging to birds and plants in island ecosystems (Meier et al. 1989; Breckon 2000; Cheke and Hume 2008), but also depredating agriculture and serving as potentially serious vectors of human diseases (Boulton et al. 1996; Jensen et al. 2004; Engeman et al. 2010). Damage from Xenopus has also been observed, with the species resulting in displacement of native amphibians (Lobos et al. 1999; Lobos and Measey 2002; Grosselet et al. 2005; Lobos and Jaksic 2005; Eggert and Fouquet 2006). The Micronesia Region, however, lacks native amphibians, so hazard from this species would be correspondingly less; however, broader impacts on freshwater ecosystems from this species remain uninvestigated.

In sum, risk from this pathway appears moderate for the Micronesia Region under current regulatory regimes. Such risk could be lowered if importation of monkeys and *Xenopus laevis* were banned and such bans enforced.

- Risk of importation 1
- Risk of establishment 3
- Hazard 3
- Total risk 7 **MODERATE**

A4.2.3.9 ***Religious Ceremonies***

There have been two sources of vertebrate releases for religious purposes. The larger of the two is the common Buddhist and Taoist practice of releasing captive animals as an expression of compassion to improve one’s karma (Shiu and Stokes 2008). Typically, these releases occur during religious services once or twice per year, but some traditions involve monthly releases (Shiu and Stokes 2008), and a large percentage of releases may be conducted individually, not in organized groups (Severinghaus and Chi 1999). Birds and turtles are the most common terrestrial vertebrates used for release (Severinghaus and Chi 1999; Kraus 2009), but mammals, frogs, and snakes are targeted as well (Agoramoorthy and Hsu 2005; 2007; Corlett 2010). Many of these released animals are purchased from pet stores, with one study finding one-quarter of all birds stocked in Taipei pet stores slated for this purpose (Severinghaus and Chi 1999). Releases of terrestrial vertebrates via this pathway have been primarily documented from countries or regions with practicing Buddhists comprising a significant portion of the population, such as Cambodia, Hong Kong, Indonesia, Korea, Malaysia, Singapore, Taiwan, Thailand, and Vietnam (Severinghaus and Chi 1999; Kraus 2009; Corlett 2010), but they have occurred in Western countries too (Sherwood 2001; Shiu and Stokes 2008; Gochfeld 2010). Numbers released can be huge, with 0.5-1 million birds imported annually into Hong Kong for release (Shiu and Stokes 2008) and 200 million animals being released annually in Taiwan alone (Agoramoorthy and Hsu 2005; 2007), although most of these latter involve native species. In locations where ritual Buddhist release of animals occurs, risk of establishment is high because of the large volume of animals released and the high frequency of release, both of which lead to high propagule pressure. Hazard can also be high, first due to direct competition or hybridization with native species (Severinghaus and Chi 1999), and second via vectoring of diseases to native wildlife or to humans. The latter has been an especial concern with the avian flu virus (Shiu and Stokes 2008).

The second documented source of religious release has been by members of Christian snake-handling cults, who have released alien venomous snakes on occasion (Wilson and Porras 1983). This particular form of religious practice is largely limited to small numbers of individuals in the southern United States, and, to date, the release of only two alien cobras has been documented in the literature.

Risk of importation to the Micronesia Region for this purpose appears rather low at this time. The Micronesia Region presently contains few Buddhists (NationMaster 2010), although at least one Buddhist temple is present in Guam and at least one is present in the CNMI, suggesting the presence of a large community there (Williams 2010) that is not captured in the NationMaster database. The varieties of Christianity present in the region do not include snake-handling cults. Consequently, introduction volume along the religious pathway is likely to remain low through much of this region (CNMI may be an exception), and, correspondingly, risk will also remain low. However, risk will not be non-existent given that even small numbers of Buddhists can release significant numbers of animals in private ceremonies. Should immigration patterns change such that more Buddhists migrate to the region, this could become a pathway of greater importance. In that event, alien birds, frogs, and turtles of east or southeast Asian origin would be the taxa most liable to introduction and establishment because that would be the likely source of immigrating Buddhists and, hence, the easiest source from which to obtain animals. Many of those species have already proven successful in colonizing Pacific islands (Long 1981; Christy et al. 2007a; Christy et al. 2007c; Kraus 2009).

Risk of establishment is probably low for most species so long as propagule pressure is low. This will be a reflection of release effort, which will, in turn, reflect the size of the Buddhist population in the region, which currently is low. However, should release effort focus on one or a few species readily available in the pet trade, establishment risk would increase because of the greater propagule pressure per species.

Hazard for released species probably ranges from low to moderate. Most species bought for release are probably relatively inexpensive, which rules out rampant release of some species (like many parrots) that create much damage but are of greater monetary value. Some released birds (e.g., finches, bulbuls) may have higher hazard because of their depredations on agriculture, ability to spread weed seeds, and ability to transmit disease (Long 1981; van Riper and van Riper III 1985; van Riper III et al. 1986; Lever 1987; Pell and Tidemann 1997; Pimentel et al. 2000; Loope et al. 2001; Bergman et al. 2002; Bomford and Sinclair 2002; Thibault et al. 2002; Blanvillain et al. 2003; Eguchi and Amano 2004; Pimentel et al. 2005; Koopman and Pitt 2007; Bomford 2008; Atkinson and LaPointe 2009;, Linnebjerg et al. 2009; Linnebjerg et al. 2010). Most reptiles and amphibians associated so far with this pathway have relatively limited impacts, or their impacts have not been investigated (Kraus 2009).

In summary, risk from this pathway is low for the Micronesia Region at present, although this could change if larger numbers of Buddhists were to immigrate to the region.

- Risk of importation 1
- Risk of establishment 1
- Hazard 2
- Total risk 4 **LOW**

A4.2.3.10 *Bioterrorism*

Most vertebrates that are directly dangerous to humans are generally large and often rare. The use of vertebrate species for bioterrorism would be unlikely because of the number of animals required to produce the desired response. One possible exception would be that a large number of a common venomous snake could potentially be introduced for such a purpose, but the numbers required for importation for the task (hundreds to thousands would have to be released for the public to notice them in anything approximating real time) could likely not easily be overlooked by even a modestly functioning border-security system. Hence, volume of animals introduced for such purposes appears low, and degree of inspection and corresponding regulations are likely sufficient to deter massive importation of such animals. Establishment risk could be moderate to high for some venomous snake species, and risk to humans would be high by definition. In sum, because of low probability of importation and low probability of establishment, the risk of vertebrates being introduced for this purpose seems low.

- Risk of importation 1
- Risk of establishment 1
- Hazard 3
- Total risk 5 **LOW**

A4.2.3.11 *Discussion and Conclusions*

A large diversity of terrestrial vertebrates potentially threatens the human health and safety, economy, and ecology of the five Micronesian Region jurisdictions under consideration in this risk assessment. Risks come from 10 potential intentional pathways, with 3 (pet-trade, aesthetic, and food pathways) posing a high overall risk of introduction, 4 (zoos, game-hunting, biocontrol, and scientific research pathways) posing a moderate overall risk, and 3 (fur-ranching, religious, and bioterrorism pathways) posing a low overall risk. In each case, overall risk is a compound of risk of importation and release, risk of establishment, and risk of impact or hazard.

Risk at this time is rather broadly painted by pathway in order to allow government leaders in the region to decide how best to direct resources in protecting their islands from further invasions of terrestrial vertebrates. Except for species that have proven damaging elsewhere in tropical regions, it is difficult at this time to predict exact risk for each species on a case-by-case basis without a far more detailed examination of each species of concern. This is feasible for some taxa (Bomford 2003; Bomford et al. 2005; 2006; Bomford 2008; Bomford et al. 2009), with many mammal species and some bird species most amenable to this more detailed approach (Bomford 2008). But there are few comparable variables yet available for determining risk of reptiles and amphibians (Bomford and Kraus 2008; Bomford et al. 2009), and for many species in all taxa there are limitations in available biological knowledge that will hinder or prevent detailed species-by-species assessments. Lastly, not all of the world's tens of thousands of species amenable to human movement can feasibly be evaluated in politically meaningful time-frames. Hence, at this time, analysis of the important pathways of ingress provides the best guide for determining risk of additional introductions of terrestrial vertebrates to Micronesia.

Risks of introducing additional invasive vertebrates will expand with increasing population and increasing transport activities in the region, most notably with the relocation of additional military forces on Guam and in the CNMI. This is for the simple fact that numbers of alien introductions track both increase in population density and growth in trade (Levine and D'Antonio 2003; Costello et al. 2007; Westphal et al. 2008; Pyšek et al. 2010). So, with more people living in the Micronesia Region and transiting in and out of the area, intentional movement of desirable animals can be expected to increase. This increased risk may well be significant, at least for the pathways involving pets, aesthetic release, and the zoo trade, which will serve to better entertain the larger population.

Species invasions are not an ineluctable force of nature but simply reflect values and actions of humans. Hence, there is much that can be done to mitigate a predicted rise in risk of future introductions. For intentional pathways of introduction, such as those considered here, governmental efforts to restrict the availability of the most serious invaders can considerably mitigate such risk. That already occurs to some extent in the Micronesia Region. For example, Palau, CNMI, and Guam prohibit the importation and ownership of several highly invasive vertebrates, such as snakes, parrots, mink, mongoose, and bulbuls. Such limited lists are a good beginning to preventing some future invasions, but they are inherently reactive (to known invasives) and, hence, limited in preventing further disasters. For pathways moving only a few hazardous species (e.g., fur ranching, medical research), banning trade in those species could provide an effective degree of protection from the risk attendant upon those pathways. For pathways that move a greater diversity of species (e.g., pet trade and the other pathways largely dependent on it), simply banning a few species will provide insufficient protection, and broader regulation of the pathways themselves will be required. A more useful approach would be to allow for importation of only species known to be non-hazardous in the region, a so-called White List approach that has been adopted elsewhere in the Pacific Region. But application of this approach to a wide variety of vertebrates is currently hindered by insufficient biological information for most species that make prediction of invasiveness reliable. Hence, the former (so-called Black List) approach is a feasible beginning while better predictive models of vertebrate invasiveness are developed (Pyšek et al. 2010). But additional measures may be taken to better protect the Micronesia Region from these invasions as well. These are enumerated in the following section.

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A5 WILDLIFE DISEASES[7]

SUMMARY

The importation of animals and/or animal products involves an element of disease risk to the country that is importing the animal or their parts (OIE 2009d). For obvious reasons, this is the case whether animals are intentionally or unintentionally imported into the country in question. For example, monkeypox virus was unintentionally brought into the United States in 2003 from wild African mammals through the legal pet trade (Guarner et al. 2004). In addition, a shipment including 101 Silver-eared Mesia (*Leiothrix argentauris*) from Taiwan arrived at London's Heathrow Airport; subsequent laboratory analyses found Asian-strain H5N1 AIV in 13.5% of specimens tested. From these few examples, it is obvious that a wildlife disease introduction could occur almost anywhere in the world. Therefore, the objective of this document is to assess, given the data available, the risk of introduction of select wildlife-associated pathogens (where the pathogen has been found in wildlife in some region of the world), their hosts, and vectors during the DoD build-up in the Micronesia Region.

This document outlines potential disease threats in the Micronesia Region from wildlife-associated pathogens (Table A5-1). Ten primary pathogens associated with expected trade partners in the Pacific Rim were assessed using a qualitative risk assessment tool developed by Morgan et al. (2009) for emerging public health diseases in the United Kingdom. The tool was adapted to consider disease threats to humans, livestock, and endemic wildlife in the Micronesia Region. The 10 pathogens considered were hantaviruses, rabies virus, WNV, JEV, highly pathogenic AIVs, Plasmodium species (avian malaria), henipaviruses (Hendra virus and Nipah virus), NDV, Yersinia pestis (plague), and TBEV. The risk tool was divided into two parts such that we separately assigned a risk category (minimal, low, moderate, high) to the probability that a pathogen would be introduced into the Micronesia Region (Probability of Infection) and a risk category (minimal, low, moderate, high, very high) to the likely impact of a pathogen if it were introduced (Impact of Infection). Risk assignments ranged from minimal to very high for the various pathogens, depending whether probability or impact of infection was examined.

This document is not intended to provide data on all potential pathogens that could be imported into the Micronesia Region. Rather, it is intended to be a tool that focuses on select potentially important pathogens as assessed by the authors at the time of writing. Many aspects of the pathogen(s) in question, as well as the ecology of the wildlife associated with these pathogens, were evaluated for inclusion in this list. However, this document should be revised as more data become available, when new pathogens emerge in strategic locations, and when major changes in the Micronesia Region might

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affect the underlying assumptions of this risk assessment. As such, adaptive management is key to reduce this risk associated with the introduction of wildlife-associated pathogens to this region.

A5.1 INTRODUCTION

A5.1.1 Threat of Wildlife-Associated Diseases

Of the 1,415 infectious organisms (pathogens) known to cause disease in humans, the majority (61%) are zoonotic, i.e., transmissible between humans and animals (Taylor et al. 2001; Jones et al. 2008), and zoonotic pathogens are twice as likely to be associated with diseases that have recently emerged in humans (Taylor et al. 2001). In addition, the incidence of emerging infectious diseases has increased dramatically since 1940, and most of this increase has occurred in tropical regions (Jones et al. 2008). These recent incidents of emerging infectious diseases have been caused by 1) newly evolved strains of pathogens, such as drug-resistant strains of bacteria and the Asian-strain H5N1 AIV, 2) pathogens that have recently entered populations for the first time, such as a coronavirus causing SARS in humans and Nipah virus in domestic swine, and 3) pathogens that have been present historically but have recently increased in incidence, such as *Borrelia burgdorferi* causing Lyme disease in humans (Wolfe et al. 2007; Jones et al. 2008).

Wildlife plays a critical role in both the emergence of new pathogens in livestock and humans and the increased incidence of emerging diseases. Here, we define wildlife as non-domestic vertebrate species that can be either invasive (e.g., Norway rat, house mouse, etc.) or native and we focus on key pathogens that are associated with wildlife and have the potential to cause disease in humans, domestic animals, or native wildlife. Of the recent increases in incidence of emerging infectious diseases in humans, 71.8% were caused by pathogens originating in wildlife (Jones et al. 2008). In addition, there is an inextricable linkage among pathogens affecting wildlife, domestic animals, and humans, with these pathogens often originating in wildlife and subsequently moving to domestic animal hosts and then to humans (Wolfe et al. 2007). For example, Nipah virus recently moved from its wildlife host (fruit bats) to domestic swine where it caused disease and mortality in both swine and local agricultural workers (Epstein et al. 2006).

Box A5-1 – Near introduction of avian influenza Asian-strain H5N1 virus into England.

Although Asian-strain H5N1 already occurred in England at the time of this story, it serves as an example of how a disease of consequence can be introduced through the legitimate wildlife trade, much less the illegal trade.

On 27 September 2005, a shipment including 101 Silver-eared Mesia (*Leiothrix argentauris;* pictured below) from Taiwan arrived at London's Heathrow Airport and were subsequently transferred about 80 miles to the quarantine facilities in Essex, England where they were held (NEEG 2005). Four of the birds were dead on arrival and 10 more died shortly thereafter but none were tested for pathogens. Between 7 and 14 October 38 more died and were placed in cold storage. Subsequent laboratory analyses of 37 of these specimens found highly pathogenic Asian-strain H5N1 avian influenza virus in five (13.5%) of them. This strain of A/H5N1 was most closely genetically related to one found in wild ducks in China.

In this assessment, we examined the risk of wildlife-associated diseases relative to three primary categories of concern for pathogens transmitted from wildlife either directly or indirectly (i.e., through intermediate hosts):

- Human health–a public health threat because they cause morbidity and mortality in humans.
- Agricultural health–causing morbidity and mortality in livestock (including poultry)
- Wildlife conservation–threaten population viability of native wildlife species, especially those that are currently considered threatened and endangered.

In developing this assessment, we considered human disease only from a wildlife perspective (i.e., only those zoonotic diseases affecting humans that were associated with wildlife). There are a number of transmission routes by which wildlife-associated pathogens can be introduced into the Micronesia Region, including infected stowaway hosts (e.g., rodents, bats, etc.) on ships and aircraft, intentional and unintentional introductions of infected host and reservoir species, natural invasions by infected wildlife, and infected human travelers. These mechanisms and their pathways are described in more detail elsewhere in this document. In general, the role of wildlife and domestic animal movement in pathogen transmission has been well understood, with controls and legislation implemented to prevent such spread (Fèvre et al. 2006). Despite preventive and mitigation measures, disease outbreaks regularly occur because of legal and illegal movement of infected animals (Fèvre et al. 2006). International trade in both wildlife and livestock contribute to this problem; trade in livestock is discussed in more detail in Section A6, *Livestock and Poultry Diseases*. The global trade in wildlife involves billions of dollars and hundreds of millions of animals (Rosen and Smith 2010), with much of this trade being illegal. One example of how wildlife-associated pathogens can enter a country or region is described in Box A5-1. However, there are a number of requisite conditions before a novel or re-emerging pathogen can become established in an area and affect one or more of the categories of concern (human health, agricultural health, and wildlife conservation) (Wobeser 2006):

- Pathogen longevity and survival–how long the pathogen can remain infectious in the host and outside of the host under different environmental conditions.
- Environmental conditions–the optimal conditions outside of hosts under which the pathogen can persist and remain infectious.
- Pathogen infectivity–how infectious the pathogen is and at what doses.
- Host presence–whether the natural host species is present.
- Vector presence–for vector-borne diseases, whether a competent vector is present.
- Host density–whether the host is of sufficient density to spread and maintain long-term pathogen persistence.
- Contact rates–how often hosts and/or vectors contact each other to spread and maintain the pathogen and whether pathogens are transmitted between hosts by direct, air-borne and/or vector-borne transmission.

Because of these requisite conditions, it is often very difficult for most pathogens to become established in a new environment. In most cases, there needs to be a "perfect storm" of events where all the requisite conditions fall into place. For example, for WNV to become established on Guam from an infected human arriving there, the human needs to be viremic at a minimum threshold, the requisite mosquito vectors need to be present, the human individual needs to be bitten by an appropriate mosquito vector, and the mosquito needs to feed upon and pass on the virus to a suitable host, which in turn needs to be fed upon by a mosquito while the host is infectious and the virus passed on to another suitable host. While seemingly implausible, this is one hypothesis as to how WNV was first introduced into North America in 1999.

Not only are currently recognized diseases moving into new environments and regions around the globe, but novel diseases have emerged in the past two decades that include interactions among wildlife, domestic animals, and humans (Daszak et al. 2000; Cleaveland et al. 2001; Dobson and Foufopoulos 2001; Jones et al. 2008). In particular, the number of emerging infectious disease events for humans has increased significantly since the 1940s. These events have increasingly been zoonotic with wildlife as the primary origin, and the increases in emerging infectious disease events stemming from wildlife have been significantly associated with human population density and wildlife host richness (Jones et al. 2008), although in recent years more surveillance efforts and improved technology may have also contributed to increased detection of emerging infectious diseases.

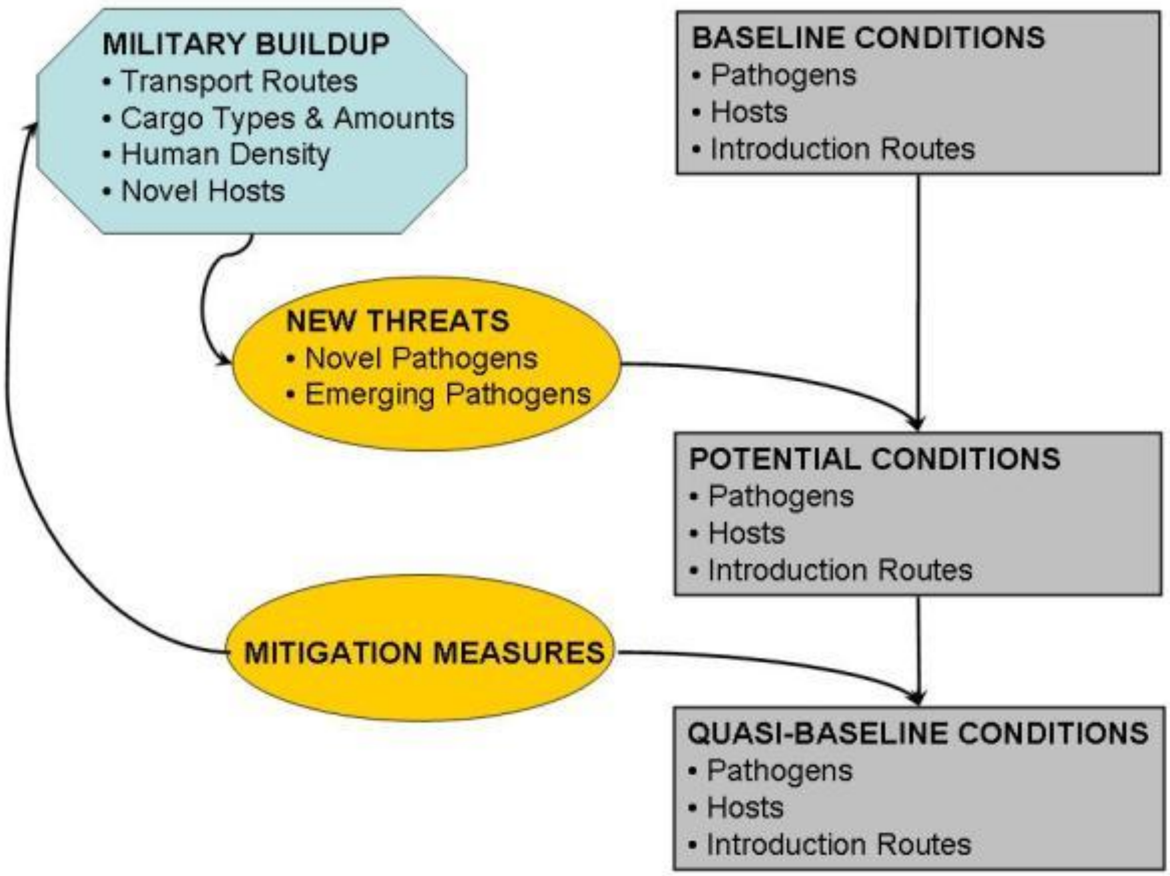
Here, our primary objective was to identify and qualitatively evaluate risk of introduction or re-introduction of wildlife-related pathogens causing disease in humans, livestock, and native terrestrial vertebrate fauna to the Micronesia Region as a result of the proposed U.S. military relocation in that region. Specifically, given the available data, we attempted to:

- Identify the risk of introduction of wildlife-associated pathogens causing disease in humans, agriculture, and native wildlife from wild and feral animals to the Micronesia Region as a result of the military relocation.
- Assess occurrence of pathogen and host introduction (given the probability of species introduction) through field sampling in the Micronesia Region.
- Assess pathogen introduction from a variety of potential pathways using risk assessment.
- Recommend mitigation measures based on risk assessment modeling.
- In order to accomplish these objectives, we used the following general strategy (Figure A5-1):
- Identified the baseline conditions in the Micronesia Region with respect to existing pathogens, hosts, and routes of introduction using existing information,
- Identified how the military build-up may add and/or modify those baseline conditions,
- Identified how the changes from the military build-up could provide opportunities for new threats from historically occurring pathogens that have not yet been introduced into the Region, recently emerged pathogens that are not yet found in the Region, or re-emerging pathogens

(pathogens that have been found in the Region, but have been eradicated, yet have the potential to be re-introduced) and how this will affect baseline conditions, and

- Developed mitigation measures targeted at eliminating and/or minimizing threats, such that baseline conditions are closely maintained.

Figure A5-1: General Strategy Used For Identifying and Mitigating Threats of Introduction of Wildlife-Associated Pathogens to the Micronesia Region



We collected data pertaining to relevant disease agents and pathways associated with wildlife. A focus was made on wildlife-associated diseases not currently found in the Micronesia Region that either are of high consequence or have a reasonable probability of introduction. Literature reviews were conducted for relevant pathogens using multiple databases. Data sources included published literature, government reports, and, in some instances, articles in the popular media (e.g., if they were the only source available). In addition, multiple interviews and/or site visits were conducted in Guam, Saipan, Tinian, and Palau to obtain additional information pertaining to wildlife and wildlife diseases. The interviews were conducted with government officials, nongovernmental organizations, and/or citizens of the islands.

The purpose of this risk analysis was to assess the increased risk of introduction of wildlife-associated diseases that the proposed military relocation could introduce into Guam and the rest of the Micronesia Region. The objective was to identify likely pathways of introduction of relevant wildlife-associated diseases directly and indirectly associated with the military relocation on Guam, assess the potential impacts of these pathogens if they are introduced, and recommend procedures for risk reduction. In developing this risk assessment, we focused on wildlife-associated diseases in the Pacific Rim (Asia, Australia, and North America), and wildlife-associated diseases and their potential hosts that could have significant morbidity and mortality in humans, livestock, and native wildlife. We did not consider wildlife-associated diseases already widespread throughout the Micronesia Region.

In addition, the scope of this risk assessment is limited to relevant pathogens of terrestrial vertebrate wildlife species (primarily birds and mammals) that could be associated with the military relocation in Guam (e.g., increased building materials and other commodities, temporary construction workers, military activity, etc.). Because the bulk of the DoD relocation is associated with Guam, it is our primary focus. However, several other islands in the Micronesia Region were considered in the risk assessment, with an additional emphasis on CNMI and Palau.

It is beyond the scope of this risk assessment to determine an overall risk on Guam for the introduction of all wildlife-associated disease agents. As such, a focus was made on potentially high-consequence pathogens not known from the Micronesia Region that could be introduced during multiple phases of the military relocation. In addition, wildlife-associated diseases from regions from which trade is likely to the Micronesia Region (e.g., Asia and the United States) are a focus of this risk assessment. Overall, we focused on wildlife-associated pathogens which could affect the health of humans, livestock, or native wildlife.

A5.1.2 Current Situation

A5.1.2.1 *Pathways of Introduction and Spread*

A5.1.2.1.1 *People*

Humans can become infected with zoonotic pathogens and act as direct introduction pathways by moving disease agents to novel locations. People also contribute to the spread of zoonotic pathogens by 1) acting as amplifying hosts for some pathogens, 2) interacting with livestock (increasing the probability of transmission to livestock from infected humans or transmission to humans from infected livestock), or 3) interacting with wildlife (increasing the probability of transmission to wildlife from infected humans or transmission to humans from infected wildlife).

A5.1.2.1.2 *Shipping*

Military

Maritime vessels can harbor rodent populations that are host competent for a variety of wildlife pathogens. The DoD has many established procedures to conduct rodent control on ships (U.S. Army et al. 1992).

Recently, a DoD memorandum directed Navy medical personnel with authority to inspect and issue ship sanitation certificates (ship sanitation control exemption certificate and ship sanitation control certificate) for Navy, Army, Military Sealift Command, Coast Guard, and National Oceanic and Atmospheric Administration vessels (U.S. Navy 2010b). The certificate, issued in accordance with Article 39 of the International Health Regulations 2005, has a section for observed rodent infestations and is valid for 6 months (U.S. Navy 2010c). Data pertaining to military seaports is included in Section A2.2.3.

Commercial

Commercial maritime vessels can harbor rodent populations that may be infected with zoonotic disease agents and can therefore cause the introduction of wildlife pathogens to novel areas or spread pathogens between mooring locations. Data pertaining to commercial shipping is summarized in Section A2.2.

Maritime vessel route durations are discussed in Section A2.2.1. Route times are important factors determining the likelihood of pathogen movement via ships because short-lived pathogens can "burn out" prior to a ship arriving at its next destination. Thus, pathogens associated with long-term persistence are more likely to move via ships. On the other hand, if a large host or vector population is on a vessel, shorter-lived pathogen infections can be maintained until a ship arrives at its next destination.

Maritime vessels are important contributors to the introduction and spread of wildlife pathogens and their vectors. Historic outbreaks of plague, cholera, and yellow fever have resulted from unintentional movement of pathogens via hosts or their vectors on ships (Tatem et al. 2006a; Tatem et al. 2006b). More than 100 disease outbreaks since 1970 have been associated with ships (WHO 2002) and rats on ships are considered to be responsible for the current global distribution of plague (Gubler 1998).

Rodent importation through international transport can cause serious problems. For example, an inspection in China found 266 rats arriving in a single ship, while a survey of ships arriving from 1990 to 1998 indicated that 270 of 1,093 ships arrived with rodents aboard (Song et al. 2003). In addition, aircraft, trains, and cargo containers arriving in China have been found to have rodent problems (Song et al. 2003). Very low percentages of international vessels inspected entering New Zealand and Australia had rats or rat sign during the 2006-2007 financial year (Russell et al. 2007). During 1981 to 1986, a study was conducted to assess the prevalence of antibodies reactive with Hantaan virus among *Rattus norvegicus* and *Rattus rattus* sera collected in the harbor area and anchored vessels of Port Shimizu, Japan (Suzuki et al. 1988). Seropositive rates were 12.8% (49/384) and 4.7% (3/64) of sera collected in the harbor area and 20% (1/5) and 4.8% (2/42) of sera collected from anchored ships from R. norvegicus and *R. rattus*, respectively (Suzuki et al. 1988).

Methods

Maritime cargo shipping containers may harbor rodent species or bat species infected with wildlife pathogens either inside the container or on the outside of the container. Infected vectors such as mosquitoes and ticks may also be present in shipping containers. In general, standard 20- and 40 foot metal containers are used in association with maritime vessels.

A5.1.2.1.3 *Air*

Military

Aircraft can harbor infected rodent species, bat species, or arthropod vectors such as ticks and mosquitoes infected with wildlife pathogens. Host species may be found in cargo areas or on the outside of aircraft such as in wheel wells. Air Force joint instruction 48–104, the Quarantine Regulations of the Armed Forces (DoD 1992), incorporate regulations to mitigate the risk for introduction and dissemination of arthropod vectors by movement of vessels, aircraft, and other transport of the Armed Forces arriving at or leaving installations in the United States and foreign countries, ports, or other facilities where arthropod vector-borne diseases are known to exist. The information on the materials and procedures for disinsectation can be found in the Military Entomology Operational Handbook (NAVFAC M0-310; Army TM 5-632; Air Force AFM 91-16) (U.S. Navy 1972; USAPHC 2010). The DoD outlines recommendations in their DoD customs and border clearance policies and procedures (DoD 2001).

Commercial

Commercial aircraft can harbor infected avian, mammalian, or arthropod species in cargo areas or on the outside of the aircraft. In particular, mosquitoes and their larvae are commonly transported via aircraft. In 1961, the U.S. Public Health Service published a comprehensive survey of insects found in aircraft over a thirteen year period. Among the more than 20,000 insects were 92 species of mosquito, 51 of which were not known to be present in the continental United States, Hawai'i, or Puerto Rico. Since then several similar reports have corroborated these findings (Gratz et al. 2000). Mosquito species commonly intercepted from flights of Asiatic origin include *Culex pipiens*, *Culex quinquefasciatus*, *Culex tritaeniorhynchus*, *Ochleratus japonicus*, *Aedes albopictus*, *Aedes aegypti*, *and Anopheles subpictus indefinitus* (Joyce 1961; Takahashi 1984; Goh et al. 1985).

Mosquitoes can survive air traffic under a variety of conditions (Laird 1947). The longest survival period recorded aboard aircraft was 6.5 days. Furthermore, adult and newly hatched mosquitoes can survive and go on to breed and lay eggs in other locations. Mosquitoes tend to remain aboard an airliner despite multiple stopovers. Flights from major Asian countries to Guam are on average less than 5 hours away such that high survival is likely.

Methods

Air cargo shipping containers may harbor rodent species or bat species infected with wildlife-associated pathogens. Infected arthropod vectors may also be present inside or outside of shipping containers. Air cargo shipping containers are generally smaller than maritime containers, but larger aircraft can transport standard 20- and 40 foot containers. Commercial air cargo may harbor rodent (Baker 1994) or bat species (Wiles and Hill 1986; Constantine 2003) that may be infected with zoonotic disease agents and can therefore cause the introduction of wildlife pathogens to novel areas or spread pathogens between landing locations.

A5.1.2.1.4 *Natural*

Wind and Natural Movements

Bird migration and dispersal can lead to the introduction and spread of wildlife pathogens. All islands in the Micronesia Region provide winter grounds for a large number of migrating birds which come from a myriad of locations within the Pacific Rim where a number of wildlife pathogens are endemic, but are not distributed in the Micronesia Region.

There is some evidence that Mariana fruit bats travel between Guam and Rota (Wiles and Jonhson 2004). In addition, the black drongo (*Dicrurus macrocercus*), introduced to Rota during the 1930s, is thought to have naturally moved to Guam and established a population during the late 1950s and is now found throughout the island (Guam DAWR 2010).

Rafting

Various animal species have the potential to raft (e.g., float on a piece of vegetation or other object) from island to island. If rafting species are infected with a wildlife disease agent or an infected vector is parasitizing them there is the opportunity for pathogen introduction or spread.

It has been suggested that reptiles may be more capable of rafting than mammals (Murphy and Wilcox 1986). In addition, various species may have different abilities. For example, at an island study site in Washington it was suggested that Microtus (voles) can easily swim distances up to 1 km (0.6 mile) while Peromyscus (mice) apparently must rely on rafting across water bodies at this site (note: neither of these rodent species occur in the Micronesia Region) (Aubry and West 1987).

Smuggling

Smuggling of wildlife species or products harboring wildlife species and/or disease vectors provides introduction pathways for the movement of wildlife-associated disease agents into novel regions as well as opportunities for the spread of pathogens. Large quantities of smuggled goods (e.g., agriculture and wildlife) are most likely to be moved by international shipping routes (Ferrier 2009). For wildlife and wildlife products, the average shipment refusal rate was approximately 2.5% annually during 2000 through 2004, although personal shipments were refused more frequently than commercial shipments (Ferrier 2009).

A5.1.2.1.5 *Foreign Trade Partners*

Commodities from multiple countries currently are imported into Guam. In addition, several countries in the Micronesia Region host tourists from several regions of the world. These data are discussed in Section A2. Multiple shipping lanes currently serve Guam. Waterways to the east/northeast connect with Hawai'i and the continental United States, while the waterways running north and west connect to CNMI and ports in Asia. In 2002, Guam imported agricultural commodities primarily from Australia, Asia (China, Korea, Hong Kong, Japan, Malaysia, the Philippines, Singapore, Taiwan, and Thailand), the rest of the Micronesia Region (Chuuk, CNMI, Palau, Pohnpei, and Yap), New Zealand, and the United States. Tourism is also a large industry in the Micronesia Region. In 2008 in Guam, most visitors (excluding transit arrivals and crew) arriving by air were from Japan or Korea (see Table A5-2). The bulk of arrivals to CNMI yielded a similar trend during 2002 (data from Table A5-5) and for Palau during 2007 (data from Table A5-8). The bulk of visitors arriving by air to FSM were from the United States, followed by Japan, and Europe (see Table A5-6). The bulk of visitors to Majuro were from the Americas, Japan, and other Pacific islands (see Table A5-10). In terms of the risk of introducing diseases associated with wildlife, movement of people and products from Asia poses the greatest risk, especially with respect to emerging zoonotic diseases (Mackenzie et al. 2001). Of particular concern is introduction of wildlife-associated diseases from China, Korea, Hong Kong, and Thailand (e.g., highly pathogenic AIVs), and Malaysia and the Philippines (e.g., henipaviruses).

A5.1.2.1.6 *Wildlife-associated Diseases in the Micronesia Region*

Several wildlife-associated diseases are known to occur in the Micronesia Region. Important wildlife-associated diseases presently found in the Micronesia Region are summarized in Table A5-1. Some of these include Aujesky's disease, avian chlamydiosis, avian infectious laryngotracheitis, avian leukosis, avian mycoplasmosis, avian tuberculosis, botulism, brucellosis, canine distemper, clostridial infections, fowl pox, infectious bursal disease, leptospirosis, Old World screwworm, Q fever, salmonellosis, scrub typhus, and toxoplasmosis (see citations in Table A5-1). Other disease-causing pathogens likely exist in the Micronesia Region, but have not yet been detected. Overall, much of the Micronesia Region appears to be presently free of many of the high-consequence pathogens that affect many other regions of the world, including many high-consequence pathogens from Asia.

Table A5-1: Wildlife-Associated Diseases and Their Pathogens That Have Been Found on one or More Islands in the Micronesia Region on at Least One Occasion

Disease[a]	Type[b]	Pathogen	Wildlife host(s)	Impact			Transmission	Distribution[c]	References[d]
				Humans	Agriculture	Wildlife			
Aujeszky's disease*	V	Pseudorabies virus	Feral swine		X	X	Contact, body fluids	Palau, FSM	1, 29
Avian chlamydiosis*	B	*Chlamydophila psittaci*	Doves, gulls, Anseriformes	X	X	X	Contact, fecal/oral	FSM	2
Avian infectious laryngotracheitis*	V	Herpesvirus	Pheasants, partridge, peafowl		X	X	Oral/nasal discharge	Guam	3, 29
Avian leukosis	V	Leukosis/sarcoma group viruses	Gamebirds, pigeons		X	X	Contact, vertical	Guam	2
Avian mycoplasmosis*	B	*Mycoplasma gallisepticum*	Finches		X	X	Contact, aerosol	Guam, CNMI	4, 5
Avian tuberculosis*	B	*Mycobacterium avium*	All birds, many mammals		X	X	Fecal/oral	Guam	4, 6
Botulism	B	*Clostridium botulinum*	Ruminants, birds	X	X	X	Food borne, wound infection	Guam, Palau	7
Brucellosis*	B	*Brucella* spp.	Cervids, swine, buffalo, rodents	X	X	X	Contact with birth tissue/fluids	Guam, FSM, CNMI	4, 5, 29
Canine distemper	V	Canine distemper virus	Canids, mustelids			X	Aerosol	Guam	8
Clostridial infections	B	*Clostridium perfringens*	Birds, mammals	X	X	X	Food borne, wound infection	Guam	9, 10
Fasciolosis	P	*Fasciola hepatica, F. gigantica*	Herbivores	X	X	X	Food contamination	Guam	13, 14
Fowl pox	V	Avipoxvirus	Passerines, Galliformes		X	X	Mosquito vector	Guam, Palau	6, 29
Infectious bursal disease	V	Infectious bursal disease virus	Ducks, gulls		X	X	Mealworm vector, fomites	Micronesia Region	4, 15, 29
Leptospirosis	B	*Leptospira* spp.	Vertebrates	X	X	X	Body fluid, bites	Micronesia Region	16, 17, 18, 19

Disease[a]	Type[b]	Pathogen	Wildlife host(s)	Impact: Humans	Impact: Agriculture	Impact: Wildlife	Transmission	Distribution[c]	References[d]
Old world screw-worm*	P	*Chrysomya bezziana* larvae	Mammals	X	X	X	Wound infection	Guam	5
Q fever*	B	*Coxiella burnetii*	Rodents, feral swine	X	X	X	Tick vector, body fluid, fomites	Guam, CNMI	20, 29
Salmonellosis	B	*Salmonella* spp.	Many species	X	X	X	Fecal/oral	Guam	6
Scrub typhus	B	*Orientia tsutsugamushi*	Rodents	X		X	Mite vector	Palau	21,22, 23
Toxoplasmosis	P	*Toxoplasma gondii*	Rodents, felines	X	X	X	Food contamination	Guam, Palau	7, 24, 29

[a] Diseases of importance to international trade based on World Organization for Animal Health (OIE) list (see Table A5-2) are marked with an asterisk (*).
[b] B = bacterial, P = parasitic, V= viral.
[c] FSM = Federated States of Micronesia, CNMI = Commonwealth of the Northern Mariana Islands.
[d] Reference codes: 1 = (CFSPH 2006b); 2 = (Thomas et al. 2007); 3 = (OIE 2008a); 4 = (Duguies et al. 2000); 5 = (CFSPH 2007b); 6 = (Friend and Franson 1999); 7 = (CFSPH 2005a); 8 = (Lobetti 2009); 9 = (Asaoka et al. 2004); 10 = (CFSPH 2004a); 11 = (WHO 2010g); 12 = (CDC 2010d); 13 = (Mas-Coma et al. 1999); 14 = (Stanford University 2001); 15 = (Intervet 2010); 16 = (Berlioz-Arthaud et al. 2007); 17 = (Haddock et al. 2002); 18 = (Pineda 2001); 19 = (WHO 2009d); 20 = (USACHPPM 2008); 21 = (Demma et al. 2006); 22 = (USACHPPM 2006); 23 = (WHO 2009a); 24 = (Wallace 1976); 25 = (Duffy et al. 2009); 26 = (Hayes 2009); 27 = (Lanciotti et al. 2008); 28 = (CDC 2007a); 29 = (Saville 1999).

Table A5-2: Some OIE-listed Diseases and Other Diseases Important to Animal Trade that could have a Wildlife Component

Species	Disease
Multiple species	Anthrax
	Aujeszky's disease
	Bluetongue
	Brucellosis
	Crimean Congo haemorrhagic fever
	Echinococcosis/hydatidosis
	Epizootic haemorrhagic disease
	Equine encephalomyelitis (Eastern)
	Foot and mouth disease
	Heartwater
	Japanese encephalitis
	Leptospirosis
	New world screwworm (*Cochliomyia hominivorax*)
	Old world screwworm (*Chrysomya bezziana*)
	Paratuberculosis
	Rabies
	Rift Valley fever
	Rinderpest
	Surra (*Trypanosoma evansi*)
	Trichinellosis (*Trichinella spiralis*)
	Tularemia
	Vesicular stomatitis
	West Nile fever
Birds	Avian chlamydiosis
	Avian infectious bronchitis
	Avian infectious laryngotracheitis (*rare in wildlife*)
	Avian influenza (high- and low pathogenic in poultry)
	Avian mycoplasmosis (*Mycoplasma gallisepticum* and *M. synoviae*)
	Avian tuberculosis
	Duck virus enteritis
	Duck virus hepatitis
	Fowl cholera
	Fowl typhoid and pullorum disease
	Infectious bursal disease (Gumboro disease)
	Marek's disease *(primarily galliformes*)
	Newcastle disease
Lagomorphs[a]	Myxomatosis
	Rabbit haemorrhagic disease
Suidae[b]	African swine fever
	Classical swine fever
	Nipah virus encephalitis
	Porcine cysticercosis
	Porcine reproductive and respiratory syndrome
	Swine vesicular disease
	Teschovirus encephalomyelitis
	Transmissible gastroenteritis

Source: Modified from OIE 2010e
[a] For example, pet rabbits released.
[b] For example, feral swine.

There is little information pertaining to the status of wildlife diseases in the Micronesia Region. The few and dated animal disease surveys that have been conducted were typically conducted on livestock. With the exception of wild bird surveillance for AIV, few systematic surveys have been conducted for wildlife diseases in the Micronesia Region. Because of this, several assumptions were made in this risk assessment. If, e.g., a pathogen is known to have occurred in the Micronesia Region in livestock and the pathogen in question has been detected in wildlife in some other region at some point in time, the pathogen is considered to be a wildlife pathogen in the Micronesia Region. In addition, due to the limited data on this subject in this region, published data were supplemented with personal communications, interviews, and other resources.

In March 2010, we conducted a brief survey of rodents, bats, feral swine, and wild birds on Guam and Saipan. We sampled 230 birds (30 on Guam, 119 on Saipan, and 81 on Palau; Table A5-3) and 297 mammals (21 on Guam, 48 on Saipan, 80 on Palau, and 148 interdicted), which were from *Rattus* spp., *Suncus murinus*, *Mus* sp., feral swine (*Sus scrofa*), and fruit bats (*Pteropus* spp.) (Table A5-4). Select results of this survey are included for some pathogens of concern elsewhere in this document.

Table A5-3: Avian Species and Numbers Sampled for Pathogens in 2010 on Guam, Saipan, and Palau

Common name	**Scientific name**	**Individuals**
	Guam	
Blue-breasted Quail	*Coturnix chinensis*	11
Eurasian Tree Sparrow	*Passer montanus*	12
Pacific Golden-Plover	*Pluvialis fulva*	2
Philippine Turtle Dove	*Streptopelia bitorquata*	3
Yellow Bittern	*Ixobrychus sinensis*	2
	Saipan	
Bridled White-eye	*Zosterops conspicillatu*	62
Collared Kingfisher	*Halcyon chloris*	3
Golden White-eye	*Cleptornis marchei*	17
Mariana Fruit-Dove	*Ptiliopus roseicapilla*	2
Orange-cheeked Waxbill	*Estrilda melpoda*	2
Rufous Fantail	*Rhipidura rufifrons*	32
White-throated Ground Dove	*Gallicolumba xanthonura*	1
Various	**Palau**	81

Table A5-4: Samples Collected from Mammals in the Micronesia Region

Species	Source	N	Tests pending
Rattus spp.	Guam	13	Antibody and viral RNA
	Saipan	46	Antibody and viral RNA
Suncus murinus	Guam	6	Antibody and viral RNA
	Saipan	1	
Mus sp.	Saipan	1	Antibody and viral RNA
Sus scrofa	Guam	2	Antibody and viral RNA
Pteropus spp.	Palau	80	Population genetics
	Micronesia Region (interdicted specimens)	148	Population genetics

Samples will be tested for various pathogens associated with human, livestock, or wildlife disease or population genetic analyses will be conducted on them. Results are pending.

A5.1.2.1.7 *Hosts for Wildlife-associated Diseases in the Micronesia Region*

There are a variety of species, mostly introduced, present on Guam and elsewhere in the Micronesia Region that could serve as potential hosts for introduced pathogens (Table A5-5, Table A5-6).

Table A5-5: Exotic Terrestrial Mammalian Vertebrate Species Known or Thought to Occur on Guam

Species	Species source	Potential pathogens[a]	Reference
Rattus exulans	GISIN[b]	An Arenavirus (generic)	Thailand (Nitatpattana et al. 2000)
Rattus rattus	GISIN	Seoul-like virus	Cambodia (Reynes et al. 2003)
		Various *Leptospira* serotypes	New Zealand (Carter and Cordes 1980)
		Hepatitis E virus	Nepal (He et al. 2002)
		Bartonella spp.	Multiple (Ellis et al. 1999)
		Francisella tularensis	Europe (Gundi et al. 2004) Bulgaria (Christova and Gladnishka 2005)
		Borrelia burgdorferi	Bulgaria (Christova and Gladnishka 2005)
		Anaplasma phagocytophilum	Bulgaria (Christova and Gladnishka 2005)
		An Arenavirus (generic)	Thailand (Nitatpattana et al. 2000)
Rattus norvegicus	GISIN	Unknown hantavirus	Thailand (Tantivanich et al. 1992)
		Seoul virus or Seoul-like virus	Indonesia (Plyusnina et al. 2004) United States (Easterbrook et al. 2007)
		Various *Leptospira* serotypes	Cambodia (Reynes et al. 2003) New Zealand (Carter and Cordes 1980)
		Leptospira interrogans	United States (Easterbrook et al. 2007)
		Bartonella spp.	Multiple (Ellis et al. 1999)
		Hepatitis E virus	United States (Easterbrook et al. 2007)
		Rickettsia typhi	United States (Easterbrook et al. 2007)
		Cryptosporidium parvum	United Kingdom (Webster and Macdonald 1995)
		Salmonella spp.	Canada (Harvey and MacNeill 1984)
		An Arenavirus (generic)	Thailand (Nitatpattana et al. 2000)
Suncus murinus	GISIN	Hepatitis E virus	Nepal (He et al. 2002)
Mus musculus	GISIN	*Francisella tularensis*	Bulgaria (Christova and Gladnishka 2005)
		Borrelia burgdorferi	Bulgaria (Christova and Gladnishka 2005)

The potentially important pathogens of these species to human or livestock health are listed, but their listing does not suggest that these pathogens are necessarily located on Guam.

[a] Indicates that evidence of the pathogen (e.g., the pathogen, a genetic signature, or antibodies to the pathogen of interest) has been detected in this species and the pathogen has the potential of being introduced into Guam.

[b] Global Invasive Species Information Network.

Table A5-6: Other Exotic Terrestrial Mammalian Vertebrate Species Known or Thought to Occur on Guam in Reasonable Numbers

Species	Species source	Potential pathogens	Reference
Feral house cat	GISIN	Feline leukemia virus	Longcore et al. 2009
		Influenza virus	Longcore et al. 2009
		Toxoplasma gondii	Longcore et al. 2009
		Rabies virus	Longcore et al. 2009
		Feline immunodeficiency virus	Longcore et al. 2009
Philippine deer	Guam DAWR[a]	Unknown but chronic wasting disease, bovine tuberculosis, epizootic hemorrhagic disease, and other ungulate diseases could affect this species	
Feral swine	Guam DAWR	Pseudorabies virus	United States (Campbell et al. 2008, Corn et al. 2009)
		Brucella suis	United States (Campbell et al. 2008, Corn et al. 2009)
		Porcine circovirus	United States (Campbell et al. 2008, Corn et al. 2009)
		Influenza A virus	United States (Hall et al. 2008)
		Giardia *Cryptosporidium* *Balantidium* *Entamoeba*	Australia (Hampton et al. 2006)
		Multiple pathogens (viral and bacterial)	Spain (Vicente et al. 2002)
		At least 30 viral and bacterial pathogens	Multiple (Witmer et al. 2003)
Asiatic water buffalo	Guam DAWR	Foot and mouth disease virus	(Pinto 2004)

Potentially important pathogens of these species are listed, but their listing does not suggest that these pathogens are necessarily located on Guam.

[a] GDOA, Division of Aquatic and Wildlife Resources.

A5.1.2.1.8 *Small Mammals*

The terrestrial small mammal fauna of Guam and CNMI typically comprises approximately five species (Wiewel et al. 2009) (see Table A5-5). The major species typically include *Rattus exulans*, *Rattus norvegicus*, *Mus musculus*, *Suncus murinus*, and a third Rattus species of uncertain taxonomic identity (i.e., *R. rattus*, *R. tanezumi*, or *R. diardii*) (Wiewel et al. 2009). Some species have been thought to occur in this region for great periods of time (e.g., *Rattus exulans*) (Steadman 1999), while other introductions are thought to have been more recent (e.g., *Suncus murinus*) (Peterson Jr. 1956). Rats of the genus *Rattus* are common on many islands of the Micronesia Region and can be found in most regions of the world. In a wildlife trade risk assessment for the United States, rats of this genus were listed as one of the top mammalian species for having the capacity to harbor a large number of zoonotic pathogens for risk of importation into the United States (Pavlin et al. 2009). Indeed, a large variety of pathogens can be harbored by a great diversity of rodent species. Because of this, many islands within the Micronesia Region, often with very abundant rat (i.e., host) populations, appear to have the elements needed to sustain select pathogens if they were to be introduced by related species. In addition, *Suncus murinus*, a shrew species known to occur on some islands within the Micronesia Region, is known to host Thottapalayam virus (a hantavirus not known to be a human pathogen) (Calisher et al. 2003). Overall, it is obvious that certain small mammal species are well established on many islands within this region. As such, their potential to perpetuate an introduction of many pathogens is of great concern. A good example of this scenario can be found in Seoul virus (an Old World hantavirus hosted by the genus *Rattus*). This virus, which has its origins in the Old World, can now be found in many port cities (e.g., Baltimore, Maryland, United States), likely originating from rats transported on cargo ships. In addition, the initial introduction of Suncus murinus onto Guam has been hypothesized to have occurred through cargo materials from ports in the Philippines (Peterson Jr. 1956).

A5.1.2.1.9 *Birds*

Most native land birds have been extirpated on Guam due to the invasive BTS. Currently native birds are restricted to the critically endangered Mariana crows (*Corvus kubaryi*), Mariana swiftlets (*Aerodramus vanikovensis*), and the endangered Micronesian starling (*Alplonis opaca guami*). Guam rails (*Rallus owstoni*), and Guam Micronesian kingfisher (*Halcyon cinnamonina cinnamomina*) are extinct in the wild, although some individuals are presently held in captivity. Each of these species is threatened by the potential introduction of avian disease agents. In particular, crows have been shown to be very susceptible to WNV such that its introduction to Guam has the potential to drive the Mariana Crow to extinction if an outbreak occurs. Some HPAIVs have been shown to be lethal to a number of wild bird species and thereforendangerd poses a serious threat to native bird species. Five species of introduced land birds are currently common on Guam–black drongo *(Dicurus macrocercus*), black francolin (*Francolinus francolinus*), Philippine turtle dove (*Streptopelia bitroquata*), rock dove (*Columba livia*), and Eurasian tree sparrow (*Passer montanus*). The presence of these species provides a pool of avian species that have the potential to maintain and spread introduced avian diseases to native birds. The yellow bittern (*Ixobrychus sinensis*) is the only common native aquatic bird on Guam although more than 150 migratory species have been known to visit Guam. The most common migratory species is the Pacific Golden-Plover (*Pluvialis fulva*). Migratory species on Guam visit many countries along the Pacific Rim and have the potential to carry a number of avian disease agents such as AIV and WNV.

The landbird fauna of the Northern Mariana Islands is more intact than that of Guam, but a number of species are endangered or critically endangered, including the Mariana crow, Mariana swiftlet, nightingale reed warbler (*Acrocephalus luscinia*), and the Micronesian megapode (*Megapodius laperouse laperouse*).

A serological survey of poultry on Guam indicated serological evidence of infectious bronchitis (multiple types), infectious laryngotracheitis, infectious bursal disease, Marek's disease, *Mycoplasma gallisepticum*, *Mycoplasma synoviae*, eggdrop syndrome, avian encephalomyelitis, and *Mycobacterium* sp. (Duguies et al. 2000). However, no evidence of antibodies to the etiologic agents associated with avian influenza and Newcastle disease were found during this survey (Duguies et al. 2000).

Savidge et al. (1992) tested 762 avian biological samples from Guam and conducted 112 necropsies on wild birds but did not find any significant pathogens. The authors tested for evidence of hematozoans (blood parasites of the Haemosporidia family), AIV, and NDV, but did not detect any evidence of the pathogens causing these diseases. More recently, U.S. surveillance efforts by the U.S. Department of Interior and USDA for HPAIV in wild birds from 2006 to 2010 have not detected the presence of highly pathogenic H5N1 AIV out of 5,827 samples tested that were collected in Guam, CNMI, Palau, and RMI and have detected only three cases of low pathogenic AIV (NBII 2010) (Table A5-7).

Table A5-7: AIV Surveillance Results for U.S. Department of Interior and USDA Testing for the Detection of HPAIV, 2006-Present

Location	Samples tested	H5N1 positives	LPAIV positives	Percent LPAIV positives
Guam	4,201	0	1	0.02
CNMI	611	0	1	0.16
Palau	824	0	1	0.12
RMI	191	0	0	0.00
TOTAL	5,827	0	3	0.05

A5.1.2.1.10 *Feral Swine*

Feral swine (*Sus scrofa*) are an invasive and destructive species found in many regions of the world. Foraging activities by feral swine can result in damage to crops and natural ecosystems (USDA-APHIS-WS 2008b). Although destructive, feral swine are often valued as a natural resource for hunting. Aside from their destructive tendencies, this species can also harbor a significant number of pathogens of agricultural and public health significance (Witmer et al. 2003) (see Table A5-6). Feral swine are known to occur on some islands within the Micronesia Region. It appears unlikely that feral swine will be smuggled or accidentally introduced onto islands in the present day. Therefore, there is a low likelihood of new feral swine associated pathogens being introduced into the Micronesia Region via this route. However, feral swine have been well documented to interact with domestic swine. This interface could be of key concern if a virulent swine pathogen were to be accidentally imported into Guam. Notably, the swine industry, although relatively small, is the largest livestock industry on Guam (Duguies et al. 2000). A serological survey of Guam swine during 1999 indicated evidence of only one pathogen, a parvovirus, among the swine tested (Duguies et al. 2000).

A5.1.2.1.11 *Philippine Deer*

As of 1999, Philippine deer (*Cervus mariannus*) were known to occur on four islands in the Micronesia Region: Guam, Rota, Saipan, and Pohnpei, with populations thought to be expanding on Guam and stable or declining on the other islands at that time (Wiles et al. 1999). The size of these animals makes them and similar sized animals unlikely to be accidentally introduced into most islands in the Micronesia Region. In addition, no significant diseases were found during literature reviews of this species. However, there are several wildlife diseases known to negatively affect various deer species, such as chronic wasting disease and others (see Table A5-6).

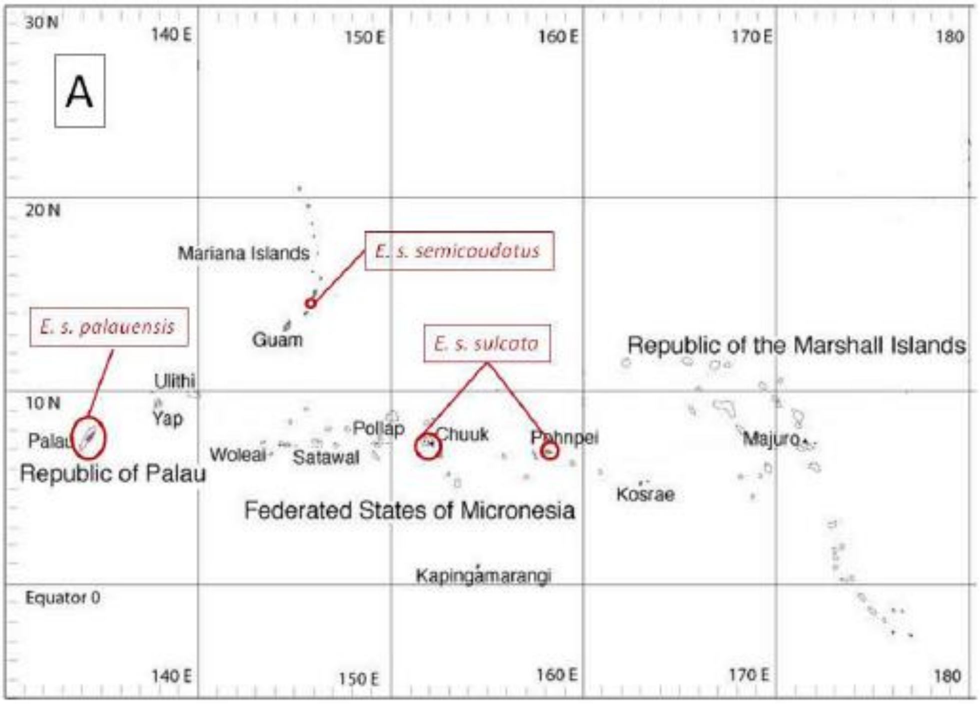
A5.1.2.1.12 *Asiatic Water Buffalo*

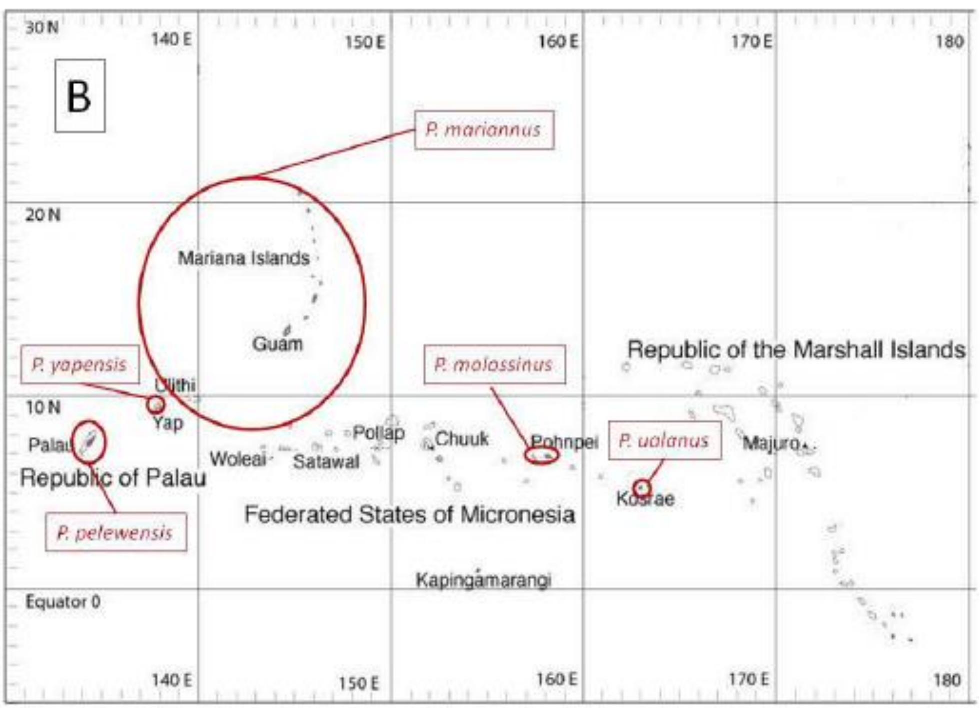
Likely originally introduced for farm use from the Philippines, a large feral herd of Asiatic water buffalo existed on Guam as of 1988 (Conry 1988b). Efforts to control this species on naval lands have been conducted since 1996 and the population is thought to have been reduced (personal communication cited in USFWS 2009b). It is highly unlikely that an animal of this size could be accidentally introduced into Guam or elsewhere in the Micronesia Region. No accounts of serious disease associated with this species on Guam were discovered. In a serosurvey of a small number of animals, only one animal tested positive for a single disease agent (*Anaplasma* sp.) of nine tested (Duguies et al. 2000). However, this species could be afflicted by bovine diseases of cattle. For example, workers have indicated that Indian water buffalo (*Bubalus bubalis*) are susceptible to infection with foot and mouse disease virus (Pinto 2004).

A5.1.2.1.13 *Bats*

There are one species of insectivorous bat and five extant species of frugivorous bats (flying foxes or fruit bats) in the Micronesia Region (Simmons 2005); two other species of frugivorous bats once occurred in the Micronesia Region but are now extinct. In the Micronesia Region, the single species of insectivorous bat (Pacific sheath-tailed bat, *Emballonura semicaudata*) is currently found as *E. s. palauensis* on Palau (Koror, Peleliu, Babeldaob, and Anguar), *E. s. sulcata* on Chuuk and Pohnpei, and *E. semicaudata rotensis* only on Aguiguan (Goat) Island in the Mariana archipelago, although this subspecies was historically found on Guam, Rota, Tinian, and Saipan (Lemke 1986; Simmons 2005; Bonaccorso and Allison 2008) (Figure A5-2). Outside of the Micronesia Region, this species is also found in Tonga and Fiji (Bonaccorso and Allison 2008). Historically, it was also found on American Samoa (Bonaccorso and Allison 2008), but it has not been detected there in recent surveys (Fraser et al. 2009). Pacific sheath-tailed bats are insectivorous and nocturnal and roost colonially in caves. They forage primarily in mature forest on Aguiguan (Esselstyn et al. 2004; Gorresen et al. 2009), although they have been observed in urban areas on Palau and Chuuk (Bruner and Pratt 1979; Wiles et al. 1997). Thus, in some areas in the Micronesia Region, such as Palau, Chuuk, and Pohnpei, this species may come into contact with humans. We found no evidence of pathogen surveys for Pacific sheath-tailed bats.

Figure A5-2: Distribution of Pacific Sheath-Tailed Bat (A) and Flying Foxes (B) in the Micronesia Region



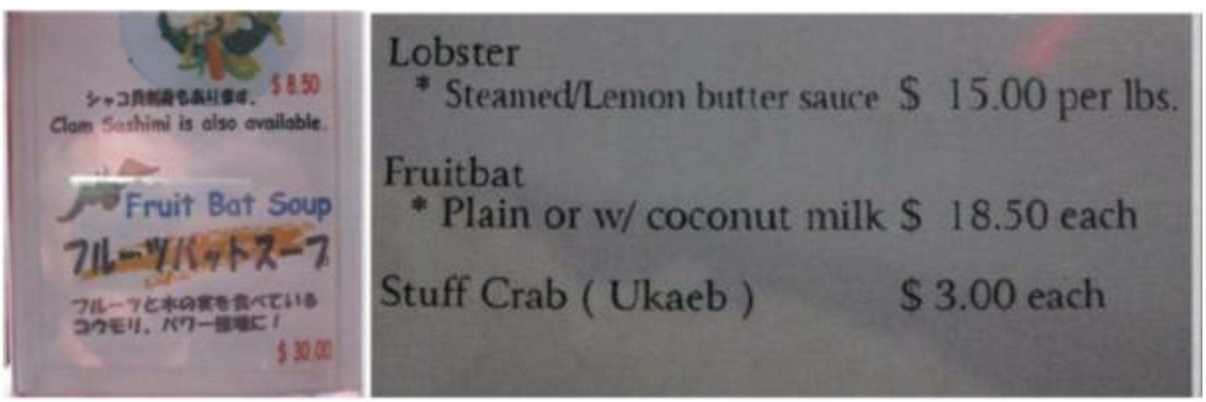


Source: Lemke 1986; Allison et al. 2008; Bonaccorso and Allison 2008; Bonaccorso et al. 2008a; Bonaccorso et al. 2008b; Buden et al. 2008; Wiles 2008; Wiles et al. 2008b, a

Historically, there were seven species of flying foxes (or fruit bats) in the Micronesia Region, all in the genus *Pteropus* (Simmons 2005). Two of these species are now extinct: the Guam flying fox (*P. tokudae*), which was endemic to Guam (Bonaccorso et al. 2008b) and the Large Pelew flying fox (*P. pilosus*), which was endemic to Palau (Bonaccorso et al. 2008a). The remaining extant five species (Simmons 2005) are the Mariana flying fox *(P. mariannus*) on Guam, the northern Mariana Islands, and Ulithi (Allison et al. 2008); the Caroline flying fox (*P. molossinus*) on Pohnpei and nearby atolls (Buden et al. 2008); the Pelew flying fox (*P. pelewensis*) on Palau (Wiles 2008); the Kosrae flying fox (*P. ualanus*) on Kosrae (Wiles et al. 2008a); and the Yap flying fox (*P. yapensis*) on the four main islands of Yap (Wiles et al. 2008b). Flying foxes (herein referred to generically as fruit bats) are phytophagous, feeding on plant flowers, leaves, and fruits (Marshall 1985).

In the Micronesia Region, fruit bats are a culturally significant food resource (Sheeline 1991). Fruit bats are considered a delicacy for many of the native population of the Micronesia Region and are still legally hunted and served in restaurants in Palau (Figure A5-3). Historically, there was considerable trade in fruit bats among the islands of the Micronesia Region. Prior to federal listing as endangered in 1984 and subsequent reclassification as threatened in Guam and CNMI (USFWS 2005), the Mariana flying fox was commonly hunted for food. Overharvesting of these fruit bats severely depleted numbers on Guam and fruit bats from other islands and countries were imported to supply demand (Wiles and Payne 1986; Wiles 1992).

Figure A5-3: Fruit Bat Offered on Restaurant Menus and Fruit Bat Soup in Restaurant In Palau, Where Fruit Bats are Served Whole, Including Entrails and Fur



Photos by Alan B. Franklin 2010

As of 1989, the trade in fruit bats had expanded from the Marianas to other islands in the Micronesia Region, the South Pacific, and Asia (Wiles and Payne 1986; Wiles 1992). While the trade from within the Marianas declined because of increased legal restrictions on hunting and declining fruit bat populations (USFWS 2005), commercial imports from outside the Micronesia Region increased (Wiles and Payne 1986). From 1975 through 1989, at least 220,437 fruit bats were imported into Guam (an average of 11,550 bats per year) with 21.5% of these imports coming from outside the Micronesia Region (Table A5-8). These were all legal imports and imported fruit bats were often sold commercially in stores, fetching prices from $17 to $30 per bat (Wiles and Payne 1986). After 1990, legal imports of bats to Guam were curtailed considerably with the implementation of regulations under CITES and the addition of USFWS inspectors on Guam (Wiles 1990; Mickleburgh et al. 2002).

Table A5-8: Imports of Fruit Bats (*Pteropus* Spp.) into Guam Before and After 1989

	1975 through 1989		After 1989			
Exporter	Total bats	Annual $\bar{X}$	Total bats	Annual $\bar{X}$	Period	No. years
Within the Micronesia Region						
CNMI						
Rota	7,145	476				
Saipan	7,813	521				
Tinian	1,366	91				
Pagan	190	13				
FSM						
Chuuk	5,795	386				
Kosrae	69	5				
Pohnpei	15,223	1,015				
Ulithi	50	3				
Yap	23,410	1,561				
Palau	112,184	7,479	38,936	7,787	1990-1994	5
Total	172,975	11,550				
Outside the Micronesia Region						
South Pacific islands						
Western Samoa	33,341	2,223				
American Samoa	4,155	277				
Fiji	6	<1				
Tonga	5,060	337				
Vanuatu	12	<1				
Indonesia	7	<1				
Papua New Guinea	1,789	119				
Philippines	3,092	206				
Total	47,462	3,165				

Source: Wiles and Hill 1986; Wiles 1992; Wiles et al. 1997

As of 1993, demand for fruit bats continued and they were still sold commercially (Wiles and Payne 1986) for up to $40 to $50 per bat at markets and in roadside stands (Hamm 1994). Culturally, 53% of Chamorro residents of Guam surveyed indicated that they enjoyed eating fruit bats and significantly more older Chamorros ate fruit bat than younger Chamorros, suggesting an eventual decrease in demand (Sheeline 1991). However, many Chamorros further interviewed during this survey indicated that their children and grandchildren ate fruit bat, which suggested that some level of demand would continue into the future. At this time, imports of fruit bats from Palau were still legal because Palau was still part of the United States and, therefore, not regulated by CITES. However, implementation of the U.S. Lacey Act finally curtailed these exports (Wiles 1990).

Because of current legal restrictions across the Micronesia Region, fruit bats can now only be legally hunted and sold within the Republic of Palau (USFWS 2005), where they are still hunted and sold in markets and restaurants (see Table A5-8). Legal exports from Palau to other parts of the Micronesia Region were discontinued under CITES when Palau became the Republic of Palau and no longer under U.S. jurisdiction (Wiles 1990). However, illegal shipments continued through smuggling, based on information on interdictions. For example, more than 200 fruit bats from 9 interdicted shipments were collected at the GDOA that had been confiscated by Guam and Saipan Customs during 1990 through 1994; these shipments were coming from Palau, Yap, Rota, Chuuk, and Pohnpei. It is unknown to what degree the demand for fruit bat continues today in the Micronesia Region, but the trade in fruit bats has likely shifted from the legal commercial trade in the past to illegal smuggling today. How this demand will shift in response to the military relocation on Guam depends largely on the nationality of the workers employed to assist in the relocation and whether their customs include the consumption of fruit bats. For example, fruit bats are widely used as a food resource in Indonesia, Malaysia, and the Philippines, and some species of fruit bats (e.g., *Pteropus vampyrus*) have been smuggled into Guam from the Philippines (Kunz and Jones 2000). In Malaysia and Indonesia, most of the trade in fruit bat meat is with Chinese and Manadonese customers, who believe bat meat can be used to treat asthma, kidney disease and malaise (Fujita 1988; Fujita and Tuttle 1991; Struebig et al. 2007). Bat hunting is legal in Malaysia, and as of 2001, bat hunters could obtain licenses to take up to 50 individuals (Mohd-Azlan et al. 2001). The estimated reported legal harvest from 1990 to 1996 on the Malaysian peninsula was 56,273 individuals; however, this was likely an underestimate of the total kill because of lack of enforcement of quotas (Mohd-Azlan et al. 2001). In Indonesia, up to 4,500 fruit bats per month have been harvested from a single location (Struebig et al. 2007). Hunted areas have become more remote as fruit bat populations dwindle but the epicenters of trade, even from remote areas, are still large cities and urban areas (Riley 2002). In the Philippines, fruit bats are also hunted heavily for food (Heaney and Heideman 1987), especially by people with lower incomes (Shively 1997). In addition, market vendors in Malaysia and Indonesia prefer live bats, which are then killed and prepared in front of the customer when sold (Fujita and Tuttle 1991; Struebig et al. 2007). The illegal smuggling of live bats from these countries (rather than dead, bats are now frozen) into the Micronesia Region could be disastrous in terms of pathogen introduction.

As far as we know, there are no known pathogens carried by either the insectivorous or fruit bats in the Micronesia Region that seriously affect human or agricultural health. The Chamorro people do suffer from a neurodegenerative disease similar to Alzheimer's and Parkinson's disease (Amyotrophic Lateral Sclerosis-Parkinsonism Dementia Complex), but this has been linked to consumption of fruit bats that have fed on and bioaccumulated neurotoxins from cycad seeds (Cox and Sacks 2002; Monson et al. 2003), rather than a pathogen. Globally, both insectivorous and frugivorous bats are of considerable concern because of the wide variety of pathogens they can carry, many of which can seriously affect both human and agricultural health. For example, fruit bats have been implicated as reservoirs for Zaire Ebola and Lake Victoria Marburg viruses (Leroy et al. 2005; Leroy et al. 2009; Kuzmin et al. 2010), SARS (Calisher et al. 2008), and Henipaviruses, such as Hendra and Nipah viruses (Mackenzie et al. 2003; Epstein et al. 2006). In addition, all species of bats in the Micronesia Region, including fruit bats, may have the ability to carry rabies and/or other lyssavirus (Constantine 2009). While insectivorous bats are often associated with rabies, fruit bats also serve as reservoirs for rabies-related lyssaviruses (Constantine 2009), which has been transmitted to humans with fatal consequences (Samaratunga et al. 1998). These pathogens are discussed in more detail elsewhere in this document.

A5.1.2.1.14 *Interdiction Procedures*

GDOA provides technical assistance to USDA-APHIS-PPQ, has assisted in identifying confiscated wildlife and wildlife products, placing wildlife in quarantine, and has assisted in multi-faceted efforts to prevent illegal wildlife imports from entering Guam (Beck 2000). In general, anyone engaging in the business as an importer of exporter of wildlife (living, dead, parts, or products) in the United States or its territories must obtain a license from the USFWS (USFWS OLE 2006). Information on pet importation into Guam is presented elsewhere in this document.

A5.1.2.1.15 *Wildlife Products*

During 2006 to 2008, USFWS inspected wildlife-derived products arriving in Guam from the following countries or undefined regions: Argentina, Australia, Bolivia, Cameroon, Canada, Chad, China, Columbia, Denmark, Fiji, Finland, French Polynesia, French Southern and Antarctic land, Germany, Greece, Hong Kong, India, Indonesia, Japan, South Korea, Macau, Madagascar, Malawi, Malaysia, Mali, FSM, Mozambique, Namibia, New Zealand, Norway, Palau, Papua New Guinea, Philippines, Russia, South Africa, Switzerland, Taiwan, Thailand, United States, Unspecified, Venezuela, Vietnam, Zimbabwe. During 1998 to 2003, there were 4,053 imported shipments and 696 exported shipments associated with wildlife trade in Agana, Guam (USFWS OLE 2004). During 2003, 5,752,168 amphibians, 1,594,515 reptiles, 449, 294 birds, and 63,716 mammals were imported into the United States from foreign countries (USFWS OLE 2004). From 1997 to 2003, the top 10 suppliers of wildlife shipments to the United States included Canada (102,227), Hong Kong (48,936) Philippines (40,294), Italy (38,404), Thailand (22,629), Indonesia (19,267), South Africa (18,844), Switzerland (14, 643), Mexico (13,701), and China (12,896) (USFWS OLE 2004). Although much of the trade in wildlife is legal, it is difficult to assess the risk from currently tabulated data if it is associated with illegally traded wildlife (Ferrier 2009). In terms of the risk of introducing diseases associated with wildlife into the Micronesia Region, movement of wildlife products from Asia, Africa, and South America pose the greatest risk, especially with respect to emerging zoonotic diseases (Mackenzie et al. 2001; Karesh and Cook 2005; Karesh et al. 2005; Karesh et al. 2007). Of particular concern to the Micronesia Region are the introduction of wildlife-associated diseases from China, Korea, Hong Kong, Indonesia, Malaysia, Philippines, Thailand, and Vietnam.

A5.1.3 Areas of Concern

A5.1.3.1 *Wildlife-associated Diseases Outside the Micronesia Region*

There are a large number of wildlife pathogens of potential concern for introduction into the Micronesia Region (Table A5-9). The World Organization for Animal Health (OIE) lists many animal diseases of importance to international trade, many of which are applicable to this section, such as those that can be found in wild or feral animals (see Table A5-2). For the sake of brevity, this section focuses on some pathogens of major concern (as determined by the authors) primarily associated with Asia and the United States, which will likely be two major regions for increased trade following the DoD relocation on

Guam. The biological and economic consequences of the introduction of a wildlife-associated disease could vary widely. For example, if a pathogen is introduced but no competent host is available the pathogen will likely go undetected and pose no biological or economic consequence to the region. This may occur regularly in many regions of the world. However, an alternative scenario in which a pathogen becomes established with significant host species could have enormous biological and economic consequences.

Table A5-9: Important Wildlife-Associated Diseases, Listed with their Pathogens, Hosts, and Distribution, that Could Be Introduced into the Micronesia Region

				Impact					
Disease[a]	Type[b]	Pathogen	Potential wildlife host(s) in the Micronesia Region	Humans	Agriculture	Wildlife	Transmission	Distribution in the Pacific Rim	References[c]
Anthrax*	B	*Bacillus anthracis*	**Most warm-blooded species (primarily grazing animals)**	X	X	X	Ingestion, skin contact, or inhalation of spores, insect bites	Asia, Australia, N. America	1, 4
HPAI A/H5N1*	V	Influenza virus A/H5N1	**Birds (particularly waterfowl)**	X	X	X	Close contact with secretions from infected animals, aerosol	Asia	2, 24
Low pathogenic avian influenza *	V	Influenza virus A	**Feral swine, birds (particularly waterfowl and shore birds)**	X	X	X	Close contact with secretions from infected animal, aerosol, environmental	Worldwide	2
Avian malaria	P	*Plasmodium* spp.	**Birds**		X	X	Mosquitoes	Worldwide	3
Bovine tuberculosis*	B	*Mycobacterium bovis*	**Most mammals (particularly introduced water buffalo and deer)**	X	X	X	Contact, aerosol, ingestion	N. America, Asia	5, 7
Chikungunya fever	V	Chikungunya virus	**Rodents, birds**	X		X	Mosquitoes	Asia	6, 30
Classical swine fever*	V	Classical swine fever virus	**Feral swine**		X	X	Contact between swine, ingestion of contaminated garbage, aerosol	Asia	7
Crimean Congo hemorrhagic fever	V	Crimean Congo hemorrhagic fever virus	**Rodents, feral swine, bats**	X			Ioxdid ticks	Asia	26
Duck viral enteritis	V	Duck herpesvirus 1	**Waterfowl**			X	Contact between infected birds,	N. America, Asia	8

Disease[a]	Type[b]	Pathogen	Potential wildlife host(s) in the Micronesia Region	Impact: Humans	Impact: Agriculture	Impact: Wildlife	Transmission	Distribution in the Pacific Rim	References[c]
							aerosol, vertical transmission		
Duck viral hepatitis*	V	Duck hepatitis A virus 1, Duck astrovirus I, Duck astrovirus II	**Waterfowl**		X	X	Contact with contaminated feces	Asia, N. America	9
Echinococcosis*	P	*Echinococcus* spp.	**Intermediate hosts–wild herbivores. Definitive hosts–wild carnivores**	X	X	X	Ingestion of eggs, or cyst-containing tissues	Worldwide	7, 10
Encephalomyocarditis	V	Encephalomyocarditis virus	**Rodents, feral swine**	X	X	X	Ingestion of contaminated fomites, close contact between swine	Australia. N. America	23
Equine encephalomyelitis*	V	Equine encephalomyelitis virus	**Birds, rodents**	X	X	X	Mosquitoes	N. America	12, 29
Erysipelothrix infections	B	*Erysipelothrix rhusiopathiae*	**Feral swine, birds**	X	X	X	Food contamination, wound infection	Worldwide	13, 25
Fowl cholera*	B	*Pasteurella multocida*	**Birds**		X	X	Contact with contaminated fomites or other infected birds	Worldwide	8
Fowl typhoid and pullorum disease*	B	*Salmonella enterica*	**Birds**		X	X	Respiratory, oral, contaminated environmental, vertical	Asia	7
Haemorrhagic septicaemia*	B	*Pasteurella multocida*	**Introduced water buffalo, feral swine**		X	X	Ingestion of contaminated feed, aerosol	Asia	11, 27

				Impact					
Disease[a]	Type[b]	Pathogen	Potential wildlife host(s) in the Micronesia Region	Humans	Agriculture	Wildlife	Transmission	Distribution in the Pacific Rim	References[c]
Hemorrhagic fever with renal syndrome and hantavirus pulmonary syndrome	V	Hantaviruses	**Rodents, shrews**	X			Aerosols from rodent excretions, bite of infected animal	N. America, Asia	12
Intestinal capillariasis	P	*Capilaria philippinensis*	**Fish; Fish-eating birds**	X		X	Consumption of raw freshwater fish	Philippines, Asia	14, 28
Japanese encephalitis*	V	JEV	**Feral swine, birds**	X	X	X	Mosquitoes	Asia, Pacific islands	15
Leishmaniasis	P	*Leishmania* spp.	**Rodents**	X		X	Sandflies	Asia, N. America	7, 31
Lyme disease/Borreliosis	B	*Borrelia* spp.	**Rodents**	X		X	Ixodid ticks	Worldwide	32
Lymphocytic choriomeningitis	V	Lymphocytic choriomeningitis virus	**House mice**	X		X	Exposure to mouse excretions	Worldwide	33
Melioidosis	B	*Burkholderia pseudomallei*	**Various birds, reptiles, fish, and mammals**	X	X	X	Ingestion, inhalation, direct contact with contaminated soil or water	Asia, Australia	4, 34
Menangle*	V	Menangle virus	**Fruit bats, feral swine**	X	X	X	Suspected fecal-oral	Australia	18, 35
Murine typhus	B	*Rickettsia typhi*	**Rodents**	X		X	Fleas	Worldwide	16
Murray Valley encephalitis	V	Murray Valley encephalitis virus	**Birds**	X		X	Mosquitoes	Australia	37
Newcastle disease*	V	NDV	**Birds**	X	X	X	Contact with contaminated secretions	Worldwide	17
Nipah virus encephalitis	V	Nipah virus	**Fruit bats, feral swine**	X	X	X	Contaminated swine products,	Asia	7, 36

				Impact					
Disease[a]	Type[b]	Pathogen	Potential wildlife host(s) in the Micronesia Region	Humans	Agriculture	Wildlife	Transmission	Distribution in the Pacific Rim	References[c]
							contaminated fruit, close contact with infected humans		
Paratuberculosis*	B	*Mycobacterium avium*	**Ruminants, other mammals, birds**		X	X	Contact with contaminated secretions or fomites	Worldwide	7
Plague	B	*Yersinia pestis*	**Rodents**	X		X	Fleas, aerosols	N. America, Asia	38, 39
Porcine brucellosis*	B	*Brucella suis*	**Feral swine**	X	X	X	Ingestion of contaminated feed or tissues, copulation	N. America, Asia, Australia	11
Psittacosis/avian chlamydiosis	B	*Chlamydophila psittaci*	**Birds**	X		X	Inhalation of infectious dust, biting insects, mites, lice	Worldwide	40
Queensland tick typhus	B	*Rickettsia australis*	**Rodents**	X		X	Ixodid ticks	Australia	41
Rabies and rabies related infections–Lyssaencephalitis*	V	Rabies virus, Duvenhage virus, Mokola virus, Ibadan shrew virus, Obodhiang virus	**Wild and feral carnivores, bats**	X	X	X	Bites from infected animals	N. America, Asia	7, 42
Rat bite fever	B	*Streptobacillus moniliformis, Spirillum minus*	**Rats**	X		X	Rat bites and scratches, exposure to contaminated urine or feces	Asia, N. America	18
Ross River fever	V	Ross River virus	**Small mammals,**	X			Mosquitoes	Australia,	43, 44

				Impact					
Disease[a]	**Type[b]**	**Pathogen**	**Potential wildlife host(s) in the Micronesia Region**	**Humans**	**Agriculture**	**Wildlife**	**Transmission**	**Distribution in the Pacific Rim**	**References[c]**
			Rodents					South Pacific Is.	
Sarcocytosis	P	*Sarcocystis* spp.	**Feral swine, rodents, carnivores, birds**	X	X	X	Ingestion of raw pork, ingestion of contaminated feces	Australia, N. America	19, 20
Sindbis virus diseases	V	Sindbis virus	**Birds**	X		X	Mosquitoes	Australia, Asia	45
Tick-borne relapsing fever	B	*Borrelia* spp.	**Rodents**	X		X	Ticks	Asia, N. America	46
Trichinellosis*	P	*Trichinella spiralis*	**Carnivores, feral swine**	X	X	X	Ingestion of meat containing cysts	Worldwide	21
Tularemia	B	*Francisella tularensis*	**Rodents, rabbits**	X		X	Insect bites, inhalation, handling infected carcasses	N. America, Asia, Australia	7
Vesicular stomatitis*	V	Vesicular stomatitis virus	**Feral swine**	X	X	X	Insects (especially flies), contaminated fomites	N. America	12
West Nile fever/West Nile neuroinvasive disease*	V	WNV	**Birds, some reptiles and mammals**	X	X	X	Mosquitoes, ingestion of infected carcass	N. America	15
Yersiniosis	B	*Yersinia* spp.	**Rodents, feral swine**	X	X	X	Ingestion of infected pork products, contact with contaminated feces	N. America	22

Note: This table is not intended to be an inclusive list of all potential pathogens that could be introduced into the Micronesia Region.

[a] Diseases of importance to international trade based on OIE list (see Table A5-2) are marked with an asterisk (*).

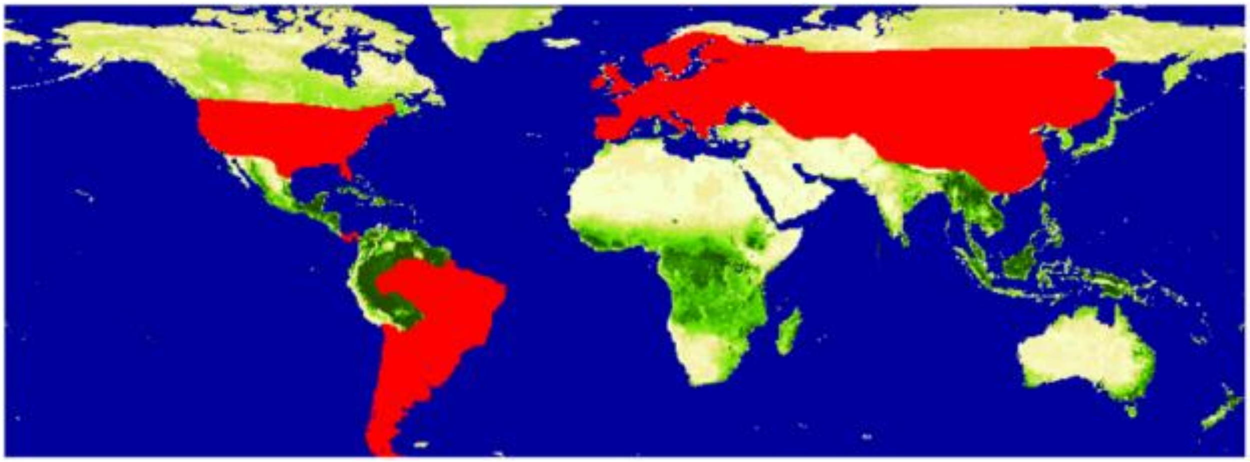
[n] B = bacterial, P = parasitic, V= viral.

[c] Reference Codes: 1 = (Dragon and Rennie 1995); 2 = (Stallknecht et al. 2007); 3 = (Atkinson 2008); 4 = (CFSPH 2007a); 5 = (State of Michigan 2007); 6 = (CDC 2008b); 7 = (CFSPH 2009c); 8 = (Friend and Franson 1999); 9 = (OIE 2008d); 10 = (Bennett Undated); 11 = (OIE 2008m); 12 = (CFSPH 2008a); 13 = (Wolcott 2007); 14 = (Cross 1992); 15 = (McLean and Ubico 2007); 16 = (Texas Department of State Health Services 2010); 17 = (Leighton and Heckert 2007); 18 = (CFSPH 2006c); 19 = (CFSPH 2005c); 20 = (Friend and Franson 1999); 21 = (Despommier and Chen 2007); 22 = (Mair 1973); 23 = (Kahn and Line 2008); 24 = (CFSPH 2010b); 25 = (Wood and Steele 1994); 26 = (Ergönül 2007); 27 = (De Alwis 1999); 28 = (Cross 1992); 29 = (Mackenzie et al. 2004); 30 = (Pardigon 2009); 31 = (Desjeux 2004); 32 = (CDC 2007b); 33 = (CFSPH 2010c); 34 = (White 2003); 35 = (USDA-APHIS-VS CEAH CEI 1998); 36 = (Epstein et al. 2006); 37 = (Cordova et al. 2000); 38 = (CDC 2010f); 39 = (Gage and Kosoy 2005); 40 = (CFSPH 2004b); 41 = (McBride et al. 2007); 42 = (CDC 2010g); 43 = (Boyd and Kay 2002); 44 = (Carver et al. 2008); 45 = (Kurkela et al. 2008); 46 = (Hall et al. 2008).

A5.1.3.1.1 *Hantaviruses*

Hantaviruses are members of the genus *Hantavirus* and the viral family Bunyaviridae. They are etiologic agents of human diseases called hantavirus pulmonary syndrome in the New World and hemorrhagic fever with renal syndrome (HFRS) in the Old World and these diseases range from mild to severe. Even in mild cases, these diseases should not be taken lightly. HFRS, e.g., has been thought to cause a large number of human illnesses in Asia and Europe (e.g., as many as 50,000 to 100,000 per year) (Johnson 1999) (Figure A5-4). In addition, in China alone, 1,557,622 cases of HFRS were reported between 1950 and 2007, resulting in 46,427 deaths (Zhang et al. 2010). Even following the recent implementation of preventive measures, the numbers of HFRS cases and deaths caused by this disease in China remain amongst the highest reported in the world (Zhang et al. 2010). The viruses causing these diseases are thought to be frequently transmitted to humans through the inhalation of rodent excreta (e.g., via aerosolized virus (Padula et al. 2004). These viruses are hosted primarily by rodent hosts, but some insectivore (e.g., shrew) associations with these viruses have been documented as well. Hantaviruses are thought to cause persistent (i.e., the virus is not rapidly cleared from the host) infections in rodents, which is often initiated by a short acute phase (high infectious virus levels) followed by a chronic stage (typically lower virus levels) (Padula et al. 2004). Hantaviruses are generally thought to be transmitted among rodents through interspecific interactions among animals. Although some of these viruses could pose a great threat to human health, they appear to pose little threat to wildlife and livestock health. The primary means of introduction of these viruses into the Micronesia Region are through rodent hosts in cargo on ships and airplanes. Because one *Rattus* spp. could potentially transmit a hantavirus to naïve individuals within this genus, and many islands within the Micronesia Region have large rat populations, select viruses (e.g., Seoul virus) within this genus could become established following their introduction. Because hantaviruses can be found in many different environmental conditions, the climate in much of the Micronesia Region is likely suitable for their introduction. Hantaviruses are examples of wildlife-associated diseases that could have both biological and economic consequences. Although these viruses are unlikely to negatively affect native wildlife or livestock, they could cause human disease such as hemorrhagic fever with renal syndrome. Thus, the economic consequences of this group of viruses could entail increased hospitalizations, decreased work and productivity, increased need for laboratory networks, and increased surveillance.

Figure A5-4: Global Distribution of Hantaviruses

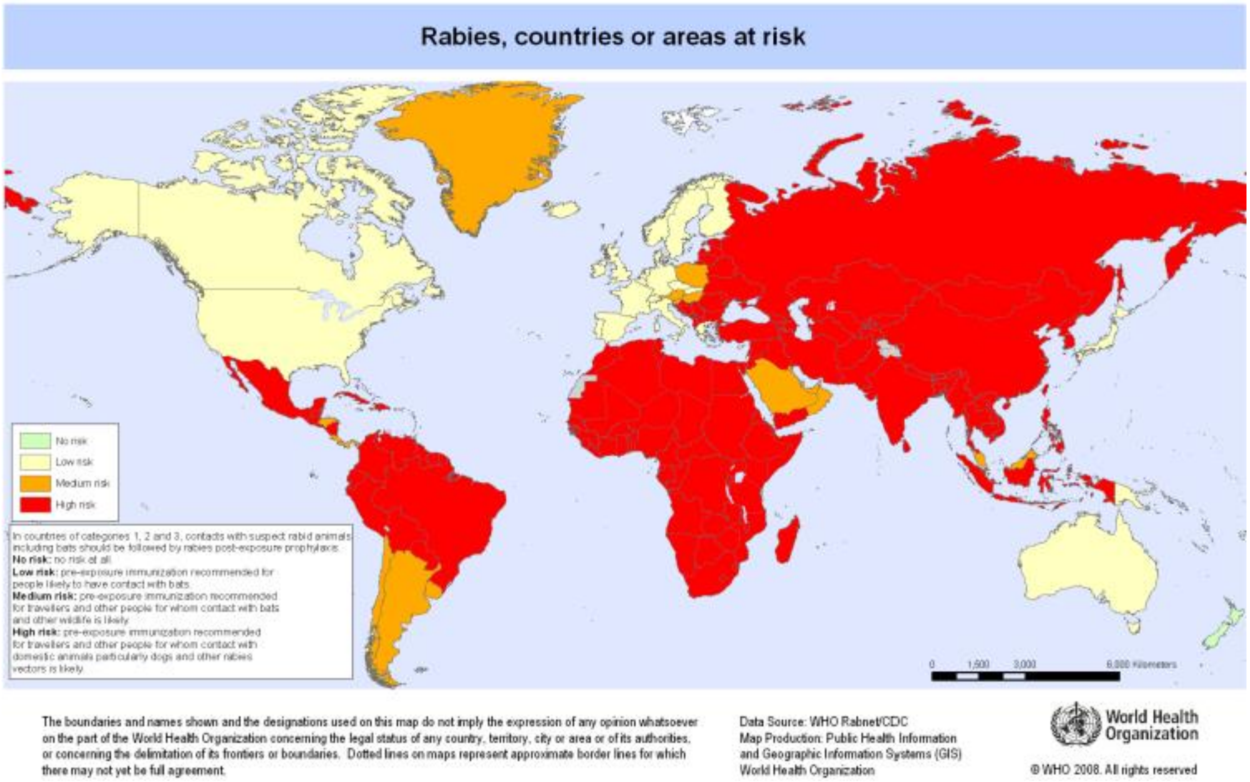


Source: CHAART 1999

A5.1.3.1.2 *Rabies Virus*

Rabies virus is a member of the viral family Rhadoviridae and the genus *Lyssavirus*. It can cause severe human disease (typically resulting death) and is known to cause thousands of deaths each year, especially in developing countries (Figure A5-5). The natural hosts of rabies virus are mammals, primarily carnivores and bats. Rabies is primarily transmitted among susceptible individuals through bite wounds. Guam is known to be free of rabies, as is Hawai'i. Wildlife poses a potential threat to the introduction of rabies to Guam through the importation of wildlife (deliberate or not), especially through bats and carnivores. Further, this virus poses a serious threat to human, agricultural, and wildlife health. Of interest, in a recent risk assessment of wildlife importation into the United States, rabies viruses, including zoonotic lyssaviruses, were listed as being able to potentially affect 155 of 190 genera analyzed (Pavlin et al. 2009). Due to the lack of carnivores in much of the Micronesia Region, the primary wildlife threat of rabies virus spread would appear to be associated with bat and feral carnivores on these islands. However, the small Indian mongoose, *Herpestes javanicus*, is well-established in parts of Hawai'i (Baldwin et al. 1952); although Hawai'i is rabies free, this species is known to be a major reservoir and vector of rabies on other islands such as Puerto Rico (Everard and Everard 1988).

Figure A5-5: Global Distribution of Rabies, Based on Risk to Travelers

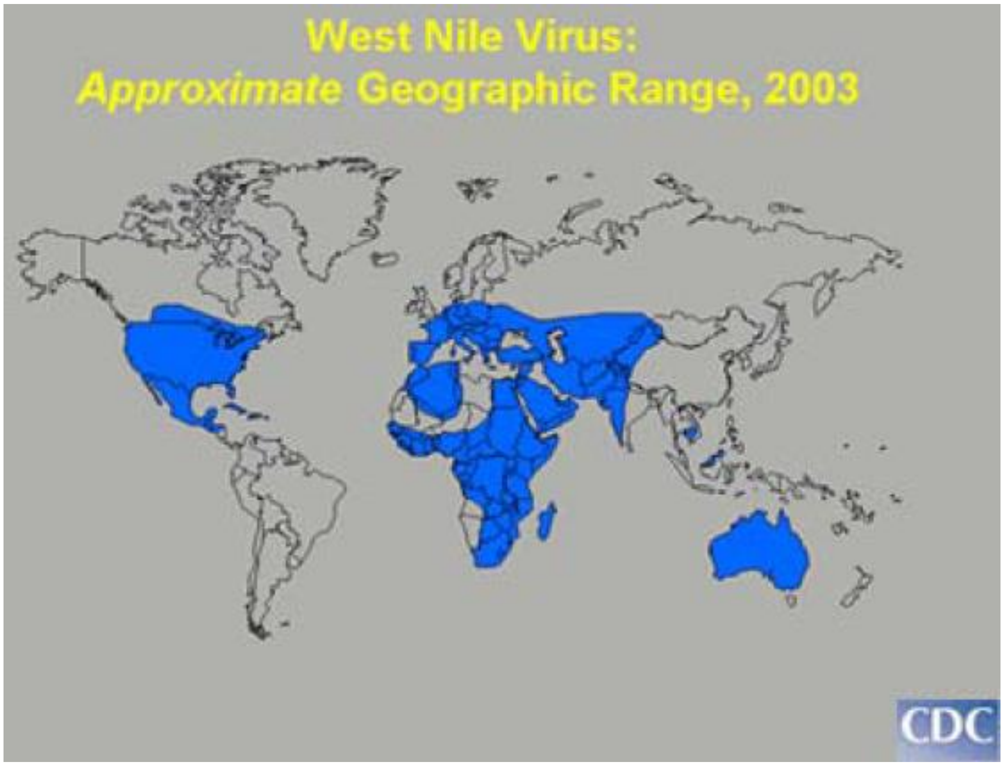


Source: WHO 2010b

A5.1.3.1.3 *West Nile Virus*

WNV is an arthropod-borne virus (i.e., an arbovirus) of the viral family Flaviviridae that is now common in many regions of the world (Figures A5-6 and A5-7). The normal transmission of WNV is thought to be associated with transmission of the virus from mosquito vectors to certain bird species (McLean et al. 2002). The virus is known to be able to cause severe disease in humans, some bird species, and some mammals. The mosquito *Aedes albopictus*, which is known to have occurred on Guam since 1944 (Rozeboom and Bridges 1972), is thought to be an efficient vector of WNV in a laboratory setting (Turell et al. 2005) (see Table A5-10). Although Guam does not have a rich avian fauna, some islands in the Micronesia Region still possess many avian species. Thus, this virus could pose a threat for some of these species if it were to be introduced into an area with competent vectors through the introduction of mosquitoes or viremic birds. For example, workers have estimated that a small number of WNV infected mosquitoes could reach Hawai'i by airplane each year following the expansion of this virus to the western United States and that U.S. exemptions of quarantine regulations (at the time of publication or earlier) could lead to the inadvertent importation of a small number of viremic birds each year (Kilpatrick et al. 2004). If introduced, WNV could have a severe biological impact on some bird populations in the Micronesia Region, such as the limited native bird populations on Guam which have already had severe population declines and extinctions due to the introduction of invasive species. In addition, a severe biological consequence exists in terms of human health and safety from this virus if the appropriate mosquito vectors are present on the island in question. Testing of 108 avian serum samples and 2 pig serum samples collected in early 2010 by our group on Guam and Saipan were all negative for generic flaviviruses (Franklin et al. unpublished data), which suggested that WNV was not present in the samples we tested.

Figure A5-6: Global Distributions of WNV



Source: CDC 2010a

Figure A5-7: Global Distributions of JEV

Source: CDC 2010a

1 **Table A5-10: Native and Introduced Mosquito Species in Guam and CNMI**

Species	Distribution	Potential diseasethrough pathogen transmission	Global distribution	References[b]
ENDEMIC				
Aedes oakleyi	Anatahan Island Saipan and Guam	None found	Belongs to a group found throughout Australian, Papuan, Oriental, Indomalayan, South and West Pacific regions	1,3,4
Aedes pandani	Guam, CNMI	None found	Micronesia Region	1,4
Aedes rotanus	Guam, CNMI	None found	Micronesia Region	1,4
Aedes saipanensis	Guam, CNMI	None found	Micronesia Region	1,3,4
Aedes guamensis	Guam, Rota, Saipan, and Tinian	None found	Guam, Rota, Saipan, Tinian	1,4
Culex litoralis	Guam, CNMI	None found	Guam, CNMI	1,4
Culex annulirostris marianae	Guam, CNMI	Japanese encephalitis	*C. annulirostris* has a broad distribution in Pacific	1,3,4
COSMOTROPICAL INTRODUCTIONS				
Aedes vexans	Guam, Saipan	Japanese encephalitis, Dirofilariasis	Cosmotropical	1,2,3,4
Culex quinquefasciatus	Guam, Saipan	St. Louis encephalitis, Japanese encephalitis, Chikungunya fever, Avian malaria	Cosmotropical	1,2,3,4
ORIENTAL INTRODUCTIONS				
Anopheles indefinitus	Guam, Saipan	Malaria	Species extends from Malaya and Java to Taiwan and Philippines	1,3,4
Culex fuscocephalus	Guam	Japanese encephalitis	Widespread in Asia and found to be naturally infected with two strains of JEV in Thailand	1,2,4
Anopheles barbirostris	Guam	Japanese encephalitis	Widespread in Asia	1,2,4
Anopheles litoralis	Guam	Malaria vector in Philippines	Philippines	1,4
MICRONESIA INTRODUCTIONS				
Aedes neopandani	Guam, Rota, Saipan and Tinian	None found	Endemic to Saipan and Tinian. Introduced onto Guam and Rota	1,3,4
GLOBAL INTRODUCTIONS				

Species	Distribution	Potential diseasethrough pathogen transmission	Global distribution	References[b]
Aedes albopictus[a]	Guam, Saipan	Dengue fever, Chikungunya fever, select hemorrhagic fevers, Japanese encephalitis, yellow fever, West Nile fever, western equine encephalitis	Abundant on many Pacific islands and responsible for Dengue epidemics on Guam	1,2,3,4
Culex sitiens	Guam, Saipan	Japanese encephalitis	Wide distribution through S. Pacific islands, Oriental, Papuan, Australian, Afrotropical and Palearctic areas	1,2,3,4
Aedeomyia catastica	Guam	None found	Distributed from India and Philippines to Fiji and North Australia	1,4
Culex tritaeniorhynchus	Guam, Saipan	Japanese encephalitis, Chikungunya fever, Sindbis fever	Widely distributed in Oriental, Afrotropical and Asian areas. Most important vector of Japanese encephalitis in Oriental region. Potentially involved in Japanese encephalitis outbreak in Saipan in 1990	1,2,3,4
Mansonia uniformis	Guam	Chikungunya fever	Old World tropics	1,2,4
Armigeres subalbatus	Guam	None found	Widely distributed through Oriental region	1,4
Culex fuscanus	Guam, Saipan	Japanese encephalitis	Records of occurrence on Saipan/Rota. Widely distributed through Oriental region, Asian Palearctic, and Pacific islands	1,3,4
Anopheles vagus	Guam	Malaria	India, China, Indonesia, Borneo, and Philippines	1,2,4
Anopheles subpictus	Guam	Malaria	Middle East to India, Indonesia, New Guinea, Philippines	1,2,4

[a] Since the eradication of Aedes aegypti in 1945, A. albopictus has filled the A. aegypti niche and could be responsible for future Dengue outbreaks on Guam.

[b] Reference codes: 1 = (Ward 1984); 2 = (Knechtges 1989); 3 = (Mitchell et al. 1993); 4 = (Nowell 1977).

A5.1.3.1.4 *Highly Pathogenic Avian Influenza*

Avian influenza is a highly contagious disease of birds caused by influenza viruses from the family Orthomyxoviridae, genus *Influenzavirus* A. AIVs are found worldwide and are closely related to human and swine influenza viruses. While there are three influenza types–influenza A, influenza B, and influenza C–all avian influenzas are type A. AIVs are a threat to humans, poultry, and wild birds. Humans can be directly infected with AIVs and these viruses have the potential to recombine with mammalian influenza virus strains to form novel strains that readily transmit between humans and have pandemic potential. Poultry may experience reduced productivity or mass die-offs in response to different AIV strains. Moreover, wild birds can suffer severe disease from some AIV strains.

The primary reservoirs for AIVs are wild birds, especially waterfowl, seabirds, and shorebird species. AIVs have been isolated from more than 90 species and 13 orders of birds (CIDRAP 2010). Wild birds have been associated with all known subtypes of Influenza A viruses. While wild birds are the natural hosts for Influenza A viruses, many mammals such as humans, cats, dogs, pigs, horses, marine mammals, mice, and rats are spillover species that can become infected with the low pathogenic strains of the virus.

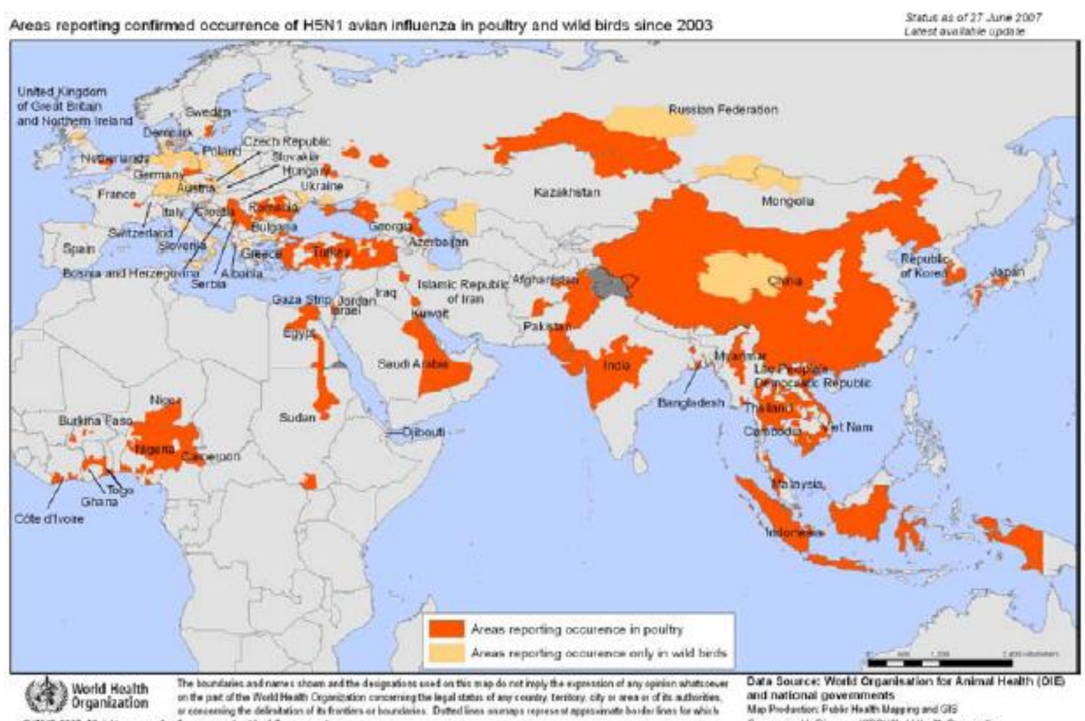
AIVs generally cause little or no disease in wild birds, but may cause significant disease in poultry. The pathogenicity of an AIV is based on its ability to cause severe morbidity or mortality to poultry. Low pathogenic AIVs (LPAIV) cause mild disease in poultry whereas AIVs (HPAIV) cause significant disease and/or death in poultry. HPAIV that cause significant disease in poultry species may cause little or no disease in wild birds which can be asymptomatic spreaders of the virus. Alternatively, HPAIV may cause severe illness and death in wild species.

Influenza viruses are very dynamic and have a high capacity to evolve. Viral evolution generally occurs via small genetic changes over time or via abrupt changes in response to novel environments. HPAIV are thought to develop when poultry species are exposed to LPAIV from wild birds and the virus undergoes a major change in response to a different host species. Alternatively, novel influenza viruses can also evolve via genetic reassortment which occurs when a host species is infected with more than one strain of influenza virus and the two viruses recombine into a new strain. Although wild birds may become infected and transmit HPAIV, they are not associated with the development of HPAIV strains. To date, all HPAIV have been subtypes including an H5 or H7 hemagglutinin surface protein.

While AIVs are closely related to human influenza A viruses, human and avian virus strains exhibit significant genetic differences. Currently only subtypes H1N1, H1N2, and H3N2 are readily transmitted between humans. Nonetheless, some AIVs, including H5N1, H7N2, H7N3, H7N7, H9N2, and H10N7, have been known to cause human infections. Serological testing has shown human exposures to H3, H4, and H6 subtypes. HPAIV do not readily transmit to humans, but humans can become infected with these viruses. HPAIV infections in humans can cause disease symptoms that range from mild to severe. Similarly, LPAIV do not generally infect humans and the infections that do occur are usually limited to people that have extended and direct contact with birds. Most humans infected with LPAIV are asymptomatic or develop conjunctivitis. However, in some cases, LPAIV infections have been known to cause influenza-like symptoms. An influenza pandemic occurs when a novel subtype is introduced into the human population, the novel virus causes serious illness, and the virus spreads easily from person to person.

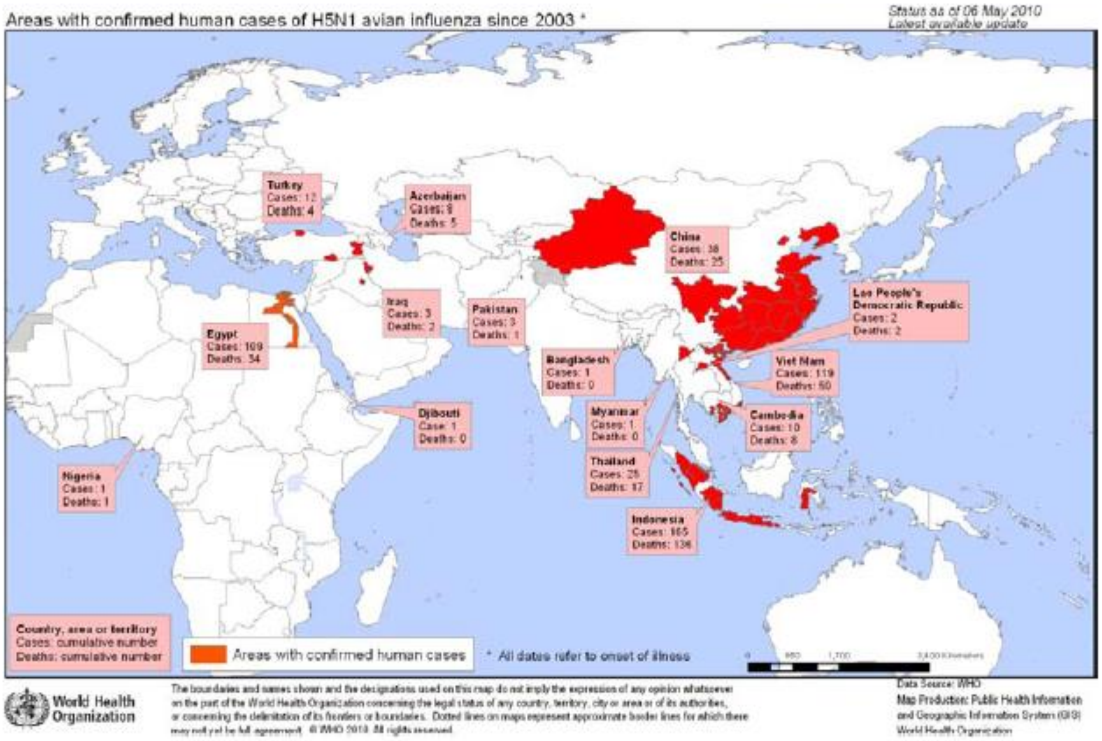
While a novel influenza virus can evolve at any time, currently the major avian influenza threat is from highly pathogenic Asian-strain H5N1. This virus was originally detected in Hong Kong in 1997 and re-emerged as an outbreak that began in poultry in Southeast Asia in 2003. The virus has spread to domesticated and wild birds in Asia, Europe, the Pacific, the Middle East, and Africa and is now considered endemic in Southeast Asia (Figure A5-8 and A5-9). To date, highly pathogenic Asian-strain H5N1 has been associated with the death or depopulation of tens of millions of poultry, severe disease in some wild birds, and more than 500 human cases (including nearly 300 deaths). As of July 2010, human cases have occurred in Indonesia (166), Vietnam (119), Egypt (109), China (39), Thailand (25), Turkey (12), Cambodia (10), Azerbaijan (8), Iraq (3), Pakistan (3), Bangladesh (1), Djibouti (1), Myanmar (1), and Nigeria (1) (WHO 2010a). For obvious reasons, the introduction of this virus into the Micronesia Region could have devastating economic effects due to loss of tourism revenue.

Figure A5-8: Global Distribution of Asian-Strain H5N1 AIV Detected In Poultry and Wild Birds, Including Fatalities



Source: WHO 2006

Figure A5-9: Global Distribution of Asian-Strain H5N1 AIV Detected In Human Cases, Including Fatalities



Source: WHO 2006

The primary shedding pathway in wild birds is fecal excretion of the virus accompanied by some respiratory shedding. Shedding in feces versus respiratory tissues can vary by strain. For example, the highly pathogenic Asian-strain H5N1 virus has been found to exhibit higher shedding rates in oropharyngeal swabs compared to cloacal swabs. Feces deposited in water (ponds, lakes, reservoirs, and streams) by wild birds are most hazardous when the virus does not become diluted due to large water volume and/or movement. The virus can be transmitted to suitable hosts by ingestion of contaminated water, eye contact with contaminated water, or possibly by inhalation of aerosols.

Avian influenza infection occurs by direct contact with infected individuals via their feces or respiratory secretions or contact with contaminated materials (vehicles, clothing, shoes, food, water, crates, and cages). Transmission can also occur from contact with tissues from an infected animal. Virus can be moved by wild bird movement or transportation of infected birds, or it can be transported on humans and their machines. Aerosol transmission is unlikely, but may occur in enclosed, high density poultry operations. Vertical transmission is unlikely because virus causes egg death such that exposed eggs do not hatch. However, transmission can occur if chicks are exposed to broken infected eggs. Currently it is unknown whether HPAIV can become endemic in wild birds or if infections are a result of spillover from infected poultry.

Cool temperatures and the presence of organic material favor long term AIV survival in the environment. Different subtypes and conditions lead to differential virus survival. Virus can persist for long periods in water. Webster et al. (1978) were able to detect virus for up to 32 days at 4° C and for 4 days at 22° C. More recently, Stallknecht et al. (1990) found that AIV could persist for 207 days in distilled water at 17°C and 102 days at 28°C. Brown et al. (2009) found that pH, temperature, and salinity affect the survival of AIVs. Virus is viable in liquid feces for 30 to 35 days at 4° C and for 7 days at 20° C (Webster et al. 1978). LPAIV H7N2 persists for up to 2 weeks in feces and on cages, and composting kills most strains of AIV within 10 days (OIE 2009m).

Capua and Alexander (2004) summarized global avian influenza outbreaks and showed that the number of outbreaks has been increasing over the last decade (Table A5-11).

Table A5-11: Major HPAI Outbreaks in Poultry

Year	Subtype	Location	Impact	Comments
1983	H5	United States	17 million birds depopulated	Similar LPAIV had been detected in the previous 6 months (Swayne 2008)
1994-2003	H5N2	Mexico	Nearly 1 billion birds sick or culled	
1995-2003	H7N3	Pakistan	3.2 million birds died in 1995	Outbreak controlled via vaccination
1997	H5N1	Hong Kong	1.5 million birds depopulated/died in 3 days	18 human cases with 6 deaths; first human case of H5N1 infection
2002	H7N3	Chile	618,00 birds depopulated on one farm	First report of HPAIV in South America
2003	H7N7	Netherlands	30 million birds depopulated/died; 255 infected flocks	Spread to Belgium; outbreak rapidly controlled
2003-2010	H5N1	Asia, Europe, Africa	Panzootic; Nearly 300 million birds depopulated/died	Now considered endemic in Southeast Asia, more than 500 human cases and nearly 300 deaths
2004	H5N2	United States		
2004	H7N3	British Columbia	More than 19 million birds depopulated/died	Two human cases (conjunctivitis)
2005	H7	North Korea	Approximately 200,000 birds depopulated/died	

Source: Capua and Alexander 2004

A5.1.3.1.5 *Japanese Encephalitis*

Japanese encephalitis is a disease caused by the arthropod-borne Japanese encephalitis virus (JEV) which is a member of the genus *Flavivirus* in the family Flaviviridae. Japanese encephalitis is a significant public health concern in Asia. While the majority of infections cause subclinical disease, acute encephalitis may occur and can result in permanent neurologic damage and mortality rates up to 60% (CDC 2010a). JEV is widespread in eastern, southeastern and southern Asia with 30,000 to 50,000 cases reported annually (Umenai et al. 1985). Major epidemics have occurred in China, Korea, Japan, Taiwan, and Thailand and minor epidemics have occurred in Vietnam, Cambodia, Myanmar, India, Nepal, and Malaysia (see Figure A5-9). Epidemics are typically controlled by vaccination which can result in significant economic impacts due to the high cost of the vaccine. JEV has been spreading both eastward and westward (Mackenzie 2007). Currently Japanese encephalitis has spread to Indonesia, New Guinea, and Northern Australia. While not currently established in the Micronesia Region, an outbreak occurred in Guam in 1947/1948 (Hammon et al. 1958) and in Saipan in 1990 (Mitchell et al. 1993; Paul et al. 1993).

Wild birds, especially members of the family Ardeidae (herons and egrets) are the primary enzootic host species for JEV and mosquitoes are the primary vector. Wild birds do not generally exhibit clinical disease associated with JEV infection, but infected birds develop high viremias. Pigs are considered to be a primary amplifying host for the virus and an important host species associated with Japanese encephalitis outbreaks in humans.

In endemic areas in the tropics JEV is continuously transmitted between birds, pigs, and mosquitoes. Humans become infected as a result of being bitten by an infected mosquito. One of the main mosquito vectors is *Culex tritaeniorhynchus*, which is currently established in Guam and Saipan (Nowell 1977; Ward 1984; Knechtges 1989; Mitchell et al. 1993). The virus is maintained by mosquitoes becoming infected by taking a blood meal from wild birds and pigs infected with JEV. Infected mosquitoes can then transmit the virus to susceptible wild birds and pigs where the virus replicates.

Definitive introduction pathways for the previous Japanese encephalitis outbreaks in Guam and Saipan were not determined. Possible routes (Paul et al. 1993) are viremic mammals or birds, introduction of infected mosquitoes or their eggs, or the movement of a viremic human. Some workers (Paul et al. 1993) also note that CNMI hosts several migratory bird species that migrate from Japanese encephalitis-endemic countries to CNMI, such as the black-crowned night heron, the plumed egret, and the cattle egret–all of which have the potential to develop adequate viremias for infecting mosquitoes (Buescher et al. 1959). Likely routes of JEV introduction or re-introduction include migratory birds (Van Den Hurk et al. 2009), migratory bats (Nga et al. 2004), especially fruit bats (Sulkin and Allen 1974), windblown mosquitoes (Ming 1993; Ritchie and Rochester 2001), and incidental transport of infected mosquitoes on aircraft (Haseyama et al. 2007).

A5.1.3.1.6 *Avian Malaria*

Avian malaria is a parasitic disease caused by protozoans in the genus *Plasmodium* that can infect birds. *Plasmodium* parasites belong to the Haemosporidia family. The parasites reproduce in avian red blood cells and if parasite loads becomes high enough red blood cells are lost and anemia may occur. The parasites are not transmitted directly between birds, but are moved between hosts by mosquito vectors (see Table A5-10), such as *Culex quiquefasciatus*. More than 40 *Plasmodium* species have been described, but the primary species of concern in the Micronesia Region is *P. relictum*, which was introduced into the Hawai'ian Islands and has been associated with significant population declines in endemic Hawai'ian birds. While *Plasmodium* species are common in many continental areas, the mosquitoes that transmit the parasite were traditionally absent in most island archipelagos such that many endemic island bird species evolved in the absence of the parasites and are currently assumed to be highly susceptible to morbidity and mortality associated with avian malaria infection.

The distribution of *P. relictum* on the Pacific islands has not been well characterized. Jarvi et al. (2003) found a high prevalence of *P. relictum* in American Samoa along with stable bird populations. Due to the presence of endemic mosquito vectors, the authors suggest *Plasmodium* is endemic in American Samoa. Steadman et al. (1990) did not detect *Plasmodium* species in the Cook Islands and Savidge (1984) did not find *Plasmodium* on Guam. Tompkins and Gleeson (2006) recently showed that *P. relictum* is common in New Zealand, but additional study is needed to determine whether it is endemic or introduced.

The pathogen (*Plasmodium relictum*) causing avian malaria is considered one of the 100 worst invasive species on the globe (Lowe et al. 2000). While many birds are susceptible to *Plasmodium* infection, perching birds (Passeriformes) are primarily affected. *Plasmodium* may be a serious threat to endemic Micronesian birds if those species have not evolved in the presence of this parasite.

Haemoproteus is another protozoan avian blood parasite genus in the Haemosporidia family. These parasites are represented by more than 140 species, many of which are host specific. Haemoproteus species are transmitted primarily by mosquitoes, but also by some midges and louses. Haemoproteus infections are generally associated with subclinical infections and are considered less of a threat than *Plasmodium* species. Nonetheless, Haemoproteus infections may cause significant disease in some species and have been known to cause significant declines in poultry productivity and in some cases mortality rates can be as high as 20%. Infections with Haemoproteus are sometimes referred to as pseudomalaria.

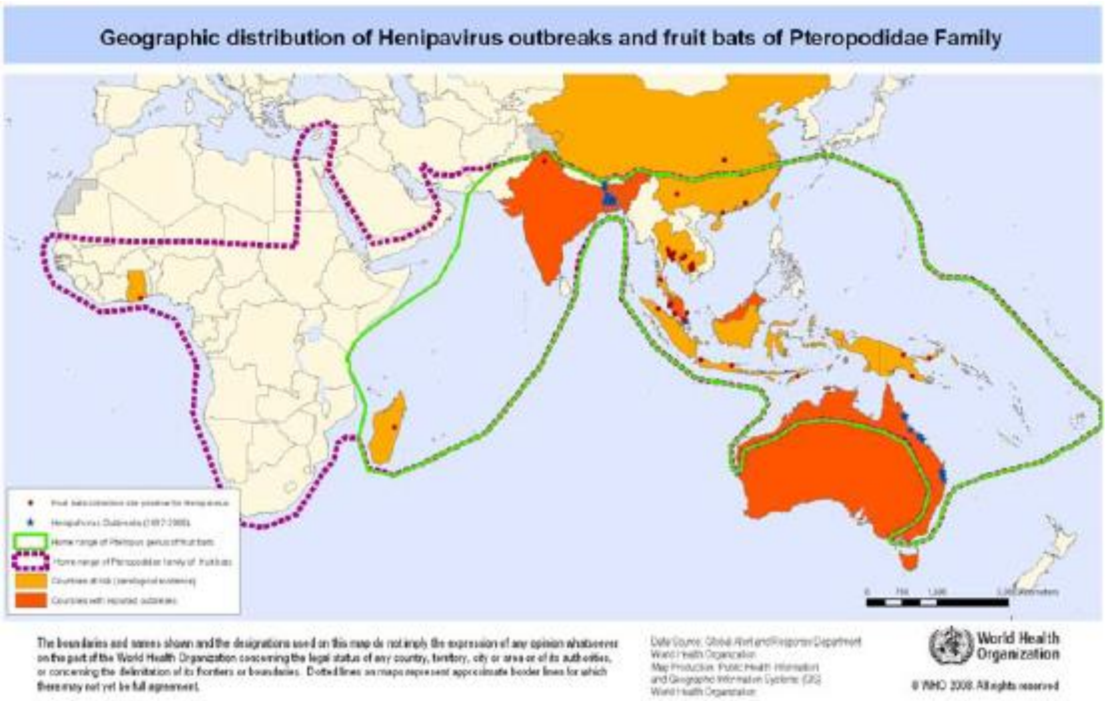
Preliminary screening of more than 100 avian serum samples collected by our group in early 2010 on Guam and Saipan is currently ongoing for avian blood parasites (Franklin et al. unpublished data). The blood samples (n=138) were screened for infection based on the presence of blood parasite DNA. The proportion of samples provisionally positive in this initial screen was between 46.4%and 85.5%. Suspected positives from Guam include several introduced species including the Philippine turtle-dove, Eurasian tree sparrow, and bobwhite quail. Two yellow bittern, a common species on Guam, were also suspected blood parasite positives. Subsequent testing on 30 samples from Saipan confirmed 53.3% to be infected with *Plasmodium* species. These confirmed samples include several bridled white-eyes which are endemic and currently listed as endangered. Confirmatory results for all samples are still pending.

A5.1.3.1.7 *Henipaviruses*

Henipaviruses are zoonotic paramyxoviruses (family Paramyxoviridae) of the genus *Henipavirus* (Halpin et al. 2000; Harcourt et al. 2000). The genus *Henipavirus* was first described based on the emergence of two new viruses, Hendra virus, which first emerged in Australia in 1994, and Nipah virus, which first emerged in Malaysia in 1998/1999. Although Hendra virus has remained confined to northeast Australia, Nipah virus was subsequently detected in other Asian countries, including India and

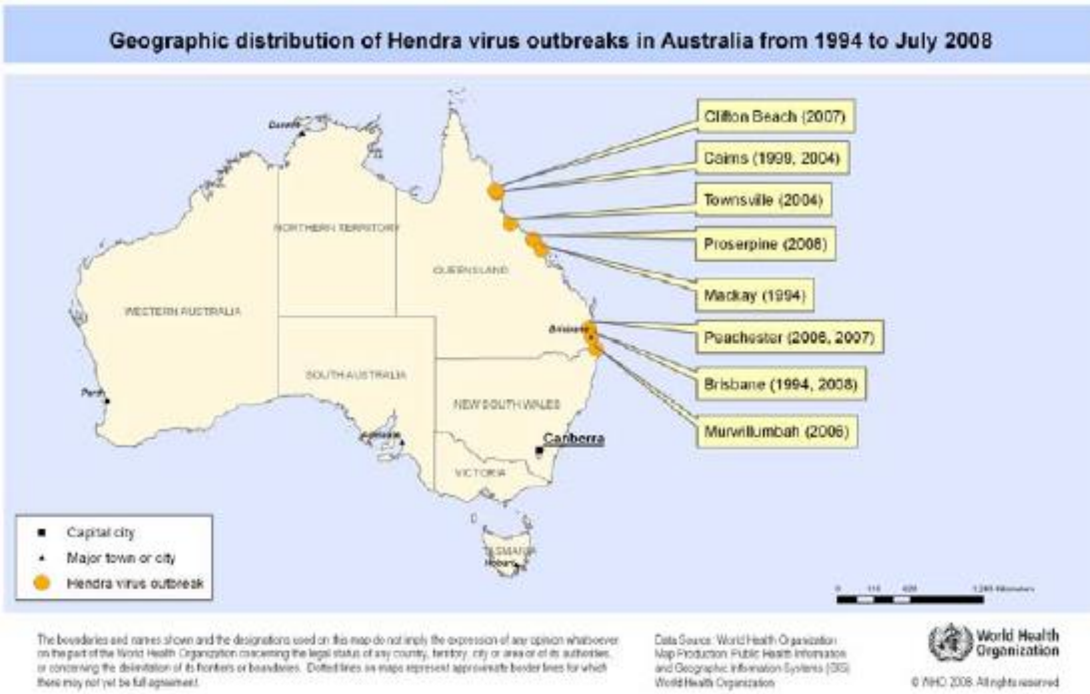
Bangladesh (Figures A5-10 and A5-11). The two viruses are similar in that they first emerged in domestic animals (which served as amplifier hosts), were subsequently transmitted to humans, and have fruit bats of the genus *Pteropus* as natural reservoirs (Epstein et al. 2006).

Figure A5-10: Known Distribution of Henipavirus Outbreaks, Mostly Nipah Virus and Hendra Virus



Source: WHO 2010f

Figure A5-11: Geographic Distribution of Henipavirus Outbreaks Currently Confined to Northeast Australia



Source: WHO 2010d

Both Hendra and Nipah viruses appear to be relatively stable in the environment. These viruses can survive for days in fruit bat urine and contaminated fruit juice, have a wide pH tolerance (4.0 to 10.0), and are inactivated only at high temperatures for relatively long periods (60°C for 60 minutes) (OIE 2010f). Fruit bats are the natural reservoirs for both Hendra and Nipah viruses and generally show no signs of infection (i.e., are asymptomatic) from either virus.

Hendra virus was first discovered in 1994 when it caused an outbreak of severe, acute respiratory disease in domestic horses on two farms in Queensland, Australia (Murray et al. 1995, Mackenzie et al. 2003). During these initial outbreaks, three humans in contact with the horses contracted the disease and two died from it (Field et al. 2007). Since then, eight more outbreaks have occurred in horses, all in northeast Australia (see Figure A5-11; Field et al. (2007)). Three of these outbreaks involved six human cases, with a case fatality rate of 50% (WHO 2009c). Thus far, horses have been the only domestic animals that have been naturally infected, with a case fatality rate of about 75% (WHO 2009c). The incubation period is 8 to 16 days for horses and 5 to 14 days for humans; there are no drugs or vaccines available to treat Hendra virus infection in either horses or humans (WHO 2009c).

Nipah virus was first discovered in pigs in Ipoh, Malaysia in 1998/1999 and was subsequently transmitted to humans. It was first identified as a swine respiratory and neurological disease, which spread throughout the Malaysian peninsula (Epstein et al. 2006). In the initial outbreak, 1.1 million pigs were destroyed and 105 (39.6%) of the 265 humans infected with this virus died (mostly adult male

Chinese farmers in contact with pigs) (Mackenzie et al. 2001; Field et al. 2007). Another outbreak occurred during 1999 among slaughterhouse workers in Singapore, where 80% of the pigs slaughtered came from Malaysia (Ling 1999; Chan et al. 2002). Nipah virus has since been detected in five outbreaks in Bangladesh and one outbreak in India between 2001 and 2005 (Wang et al. 2008b). These outbreaks involved 168 human cases with a case fatality rate of 67 to 92% (Wang et al. 2008b). Infections during these outbreaks were also reported in domestic dogs, cats, horses, and goats (OIE 2010f). Average incubation period in humans is 4 to 20 days (WHO 2009e).

Fruit bats of the genus *Pteropus* have been implicated as the likely reservoir in the outbreaks of Nipah virus in both pigs and humans. The virus has been detected in urine collected under fruit bat roosts and in fruits partially eaten by free-ranging fruit bats, suggesting two modes of transmission to pigs and humans (Tee et al. 2009). Nipah virus and antibodies have been detected in fruit bats from Thailand, Cambodia, Indonesia, Malaysia, Bangladesh, and India, suggesting widespread dissemination of the virus in fruit bat populations (especially Pteropus) in Southeast and South Asia (Reynes et al. 2005; Field et al. 2007; Tee et al. 2009). Nipah virus has been classified as a potential agent of bioterrorism because it is an extremely pathogenic organism, with no vaccines or drugs to treat infections (Lam 2003).

Hendra and Nipah virus infections can result in extremely high mortality rates in both domestic livestock and humans but generally do not cause clinical signs in fruit bats of the genus *Pteropus*, which appear to be the natural reservoirs for these viruses. The linkage of these viruses with fruit bats is cause for concern when viewed in terms of the Micronesian fruit bat trade.

A5.1.3.1.8 *Newcastle Disease Virus*

Newcastle disease is caused by viruses in the genus *Avulavirus* in the family Paramyxoviridae. This is a complex of viruses with nine serotypes and five pathotypes (Alexander 2009). Generically, the virus causing Newcastle disease is referred to as NDV (used here) or avian paramyxovirus. Natural or experimental infection of NDV has been demonstrated in 241 avian species from 27 (54%) of the 50 taxonomic orders of birds.

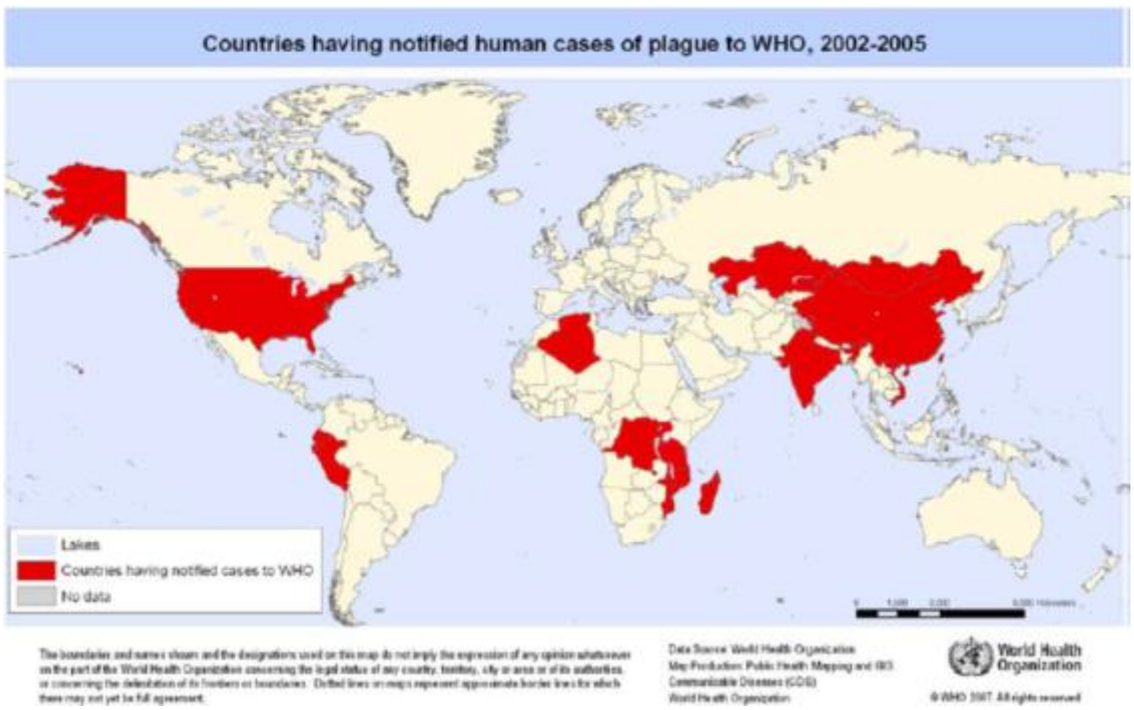
Domestic poultry and wild birds are infected by NDV, with the effects of infection dependent on the serotype and pathotype. Although a wide variety of wild birds can remain asymptomatic when infected (Alexander 2009; Coffee et al. 2010), poultry and some wild birds, such as certain passerine species, Galliformes, crows and ravens, pigeons, and parrots, may exhibit severe mortality, depending on the NDV strain (OIE 2010f). Humans are rarely infected and, when infected, show mild symptoms. Thus, NDV is primarily of concern in the Micronesia Region because of effects on poultry and native wild birds, especially pigeons (order Columbiformes).

Transmission occurs via direct contact with the secretions of infected birds which can be ingested (most likely) or inhaled; transmission may also occur by way of fomites from feed, water, or equipment. Virus survival is enhanced by the presence of feces (Alexander 2009).

A5.1.3.1.9 *Plague*

The effect of plague on humanity has had a long history. It has been estimated that this disease may have caused more than 200 million deaths (WHO 2005a). Significant plague foci are currently recognized in Africa, Asia, North America, and South America (WHO 2005a; Meerburg et al. 2009) (Figure A5-12). Notably, the observation of human cases of plague following decades of inactivity does not always mean that plague foci are re-emerging, as Yersinia pestis bacteria have been thought to be naturally maintained and circulated at low levels with no obvious indication of disease in the rodent populations (Duplantier et al. 2005).

Figure A5-12: Global Distribution of Human Cases of Plague, 2002–2005



Source: WHO 2006

Plague is a rodent-associated, flea-borne infectious disease caused by the bacterium Yersinia pestis (CDC 2010f). Overall, this organism is found in rodents and their fleas in many regions of the world (WHO 2005a). Human plague infections are typically associated with being bitten by a rodent flea infected with Yersinia pestis or by handling an infected rodent or other animal (WHO 2005a; CDC 2010f). Over 200 species of mammals (typically rodents and lagomorphs) are known to have been naturally infected with Yersinia pestis (Gage and Kosoy 2005; WHO 2005a), although only a small number of these species that have been exposed to the bacterium are considered significant hosts (Gage and Kosoy 2005). Untreated plague has high case fatality rates (WHO 2005a). Globally, there are typically 1,000 to 3,000 human cases of plague reported annually (CDC 2010f).

A5.1.3.1.10 *Tick-borne Encephalitis*

Tick-borne encephalitis is a zoonotic disease caused by the tick-borne encephalitis virus (TBEV). TBEV is a member of the genus *Flavivirus*, family Flaviviridae and is endemic throughout much of Europe and far-eastern Asia. Three main subtypes of TBEV have been identified: European, Siberian, and far-eastern (reviewed by Gritsun et al. 2003). While a majority of infections are asymptomatic, the reported case mortality rates for tick-borne encephalitis are approximately 1 to 2% for European subtype infections, 2 to 3% following Siberian subtype infections, and as high as 20 to 40% in far-eastern subtype infections (Gritsun et al. 2003; Mandl 2005). In terms of morbidity, TBEV is second only to JEV among neurotropic flavivirus infections (reviewed by Lindquist and Vapalahti 2008). Safe and effective TBEV vaccines are available but, with the exception of Austria, vaccination campaigns have had limited success due to cost and necessary booster vaccinations (Gritsun et al. 2003).

TBEV is transmitted primarily through the bite of an ixodid tick. *Ixodes ricinus* is responsible for most TBEV transmission in western Europe, while *I. persulcatus* is the primary vector in Siberia and the far-east (Lindquist and Vapalahti 2008). The maintenance cycle for TBEV primarily involves ixodid ticks feeding on small rodents. Rodents appear to act as both an amplifying host and a reservoir host for the virus because they can maintain chronic infections throughout the year (Süss 2003; Bakhvalova et al. 2006). Humans, large mammals, and birds are also hosts for these same ticks, but are not primary contributors to the TBEV maintenance cycle.

Tick-borne encephalitis may be considered an emerging disease as the geographic distribution of TBEV and list of competent Ixodes vectors seem to be expanding (Kim et al. 2008; Lu et al. 2008). Generally TBEV is isolated from areas with temperature ranges from 6°C to 25°C, humidity >85%, and a high density of rodent hosts. However, even within areas where Ixodes vectors and rodent hosts are abundant, TBEV is found only in small foci indicating that other environmental factors may be key in predicting the risk of TBEV in an area (Lindquist and Vapalahti 2008). It is hypothesized that climate change, social, political, ecological, economic, and demographic factors including changes in land use are also factors that may contribute to increased incidence and risk of TBEV infection (reviewed by Mansfield et al. 2009). Thus far Ixodes species have not been isolated from Guam, but *I. mindanensis* has been reported on the island of Palau (Kohls 1957) suggesting that these vectors could thrive in the Micronesia Region if introduced. The presence of rodent hosts, tick vectors, and suitable climate could present a risk of TBEV introduction into Guam.

A5.1.3.2 *Novel Hosts*

Some of the vertebrate species in the Micronesia Region are found only on certain islands at this point in time. The musk shrew, *Suncus murinus*, provides a good example. The initial introduction of *Suncus murinus* into Guam has been hypothesized to have occurred through cargo materials from ports in the Philippines (Peterson Jr. 1956). Considering its relatively recent introduction into Guam, this species may be of considerable risk for introduction into additional islands in the Micronesia Region, although it does occur on more islands than Guam at present. Further, this species is known to play a role in plague cycles in select locations (Duplantier et al. 2005) and is known to host a hantavirus (Calisher et al. 2003).

As of 1999, Philippine deer (*Cervus mariannus*) were known to occur on four islands in the Micronesia Region: Guam, Rota, Saipan, and Pohnpei, with populations thought to be increasing on Guam and stable or declining on the other islands at that time (Wiles et al. 1999). The introduction of pathogens affecting this species is unlikely through wildlife-related means. However, this species could potentially be a host of various pathogens affecting deer and related species in other regions of the world, dependent on the introduction of the pathogen and, in some cases, the appropriate vector. Some examples include chronic wasting disease, epizootic hemorrhagic disease, and bovine tuberculosis.

There are many avian species on some islands in the Micronesia Region. Some of these are endemic to certain islands. As such, many of the avian species on some these islands have never been exposed to some of the pathogens that have affected birds in other regions of the world (i.e., highly pathogenic H5N1 AIV and WNV).

A5.1.3.3 *Potential Trade Partners*

During the past decade, Guam imported commodities from several countries, many of which were from Asia. Tourism is a large industry in the Micronesia Region, with the majority of tourists originating from Asian countries for several islands. In terms of the risk of introducing diseases associated with wildlife into the Micronesia Region, movements between Asia and the Micronesia Region are of particular concern because of the number and rate of emerging zoonotic diseases originating from wildlife species in that region (Mackenzie et al. 2001; Jones et al. 2008). It is anticipated that trade and tourism will continue with many of the countries that Guam currently trades with during and after the DoD relocation. In addition, the relatively close proximity of many Asian countries to several islands in the Micronesia Region may facilitate future trade among these countries.

The anticipated military relocation on Guam will likely increase construction on this island via increased residences and support facilities. It is anticipated that this may result in a large influx of temporary workers, possibly from Asian countries. Along with these foreign workers, wildlife products may be imported (legally and illegally), which are culturally significant to some of these temporary workers.

A5.2 RISK ASSESSMENT

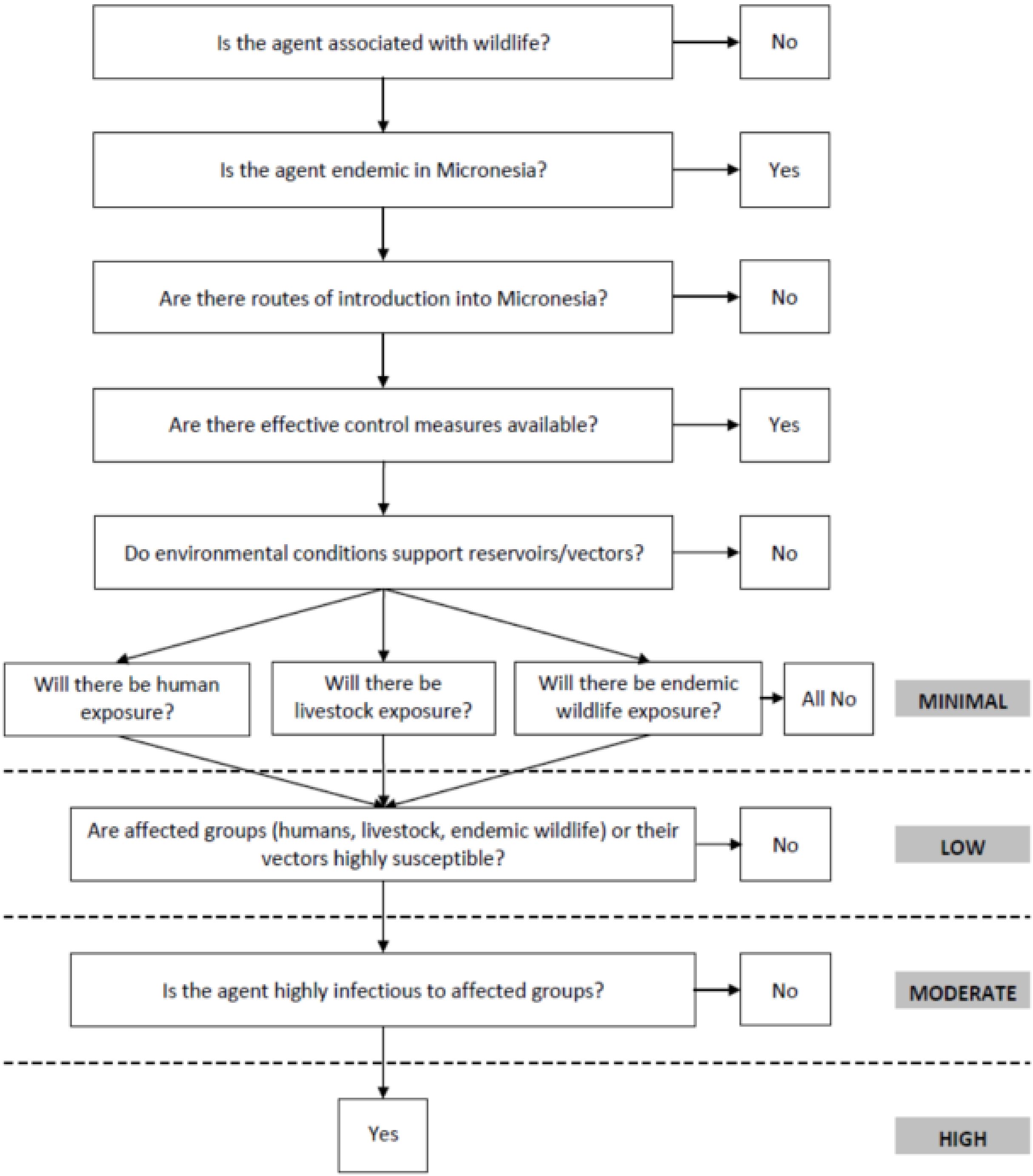
A5.2.1 General Approach

The risk associated with the 10 wildlife-associated pathogens outlined in Section A5.1.3 was assessed following the general procedures outlined by Morgan et al. (2009) for estimating risk for emerging infectious diseases. We focused on these 10 pathogens as they are all associated with Pacific Rim countries that are the most likely trade partners with the Micronesia Region. These pathogens do not represent a comprehensive list of possible pathogens that may enter the Micronesia Region as a result of the military relocation. Rather, they represent the pathogens that we identified as representing potential threats based on the properties of the pathogen in question and the ecology of its host(s). Other potential pathogens are described in Table A5-9. Moreover, emerging pathogens that may become important in the future are not addressed in the following analyses.

We adapted the Morgan et al. (2009) approach from a focus on human disease potential to disease potential in humans, livestock, and endemic wildlife species from wildlife-associated diseases. In general, Morgan et al. define risk as the product of the probability that a new infection occurs in the area of interest and the potential impact of the infection. The method uses a series of decision questions in a flow chart format to determine a qualitative estimate of risk for 1) the probability that an agent will cause an infection in the area of interest and 2) the potential impact of the agent.

The risk assessment tool comprises two flow charts (Figure A5-13 and Figure A5-14) thqt characterize the pathogen of interest and assign a level of risk (minimal, low, moderate, high, or very high) based on the answers to the series of questions associated with each chart. The first flow chart addresses the Probability of Infection as a function of a series of eight questions aimed at assessing the likelihood that a pathogen will be introduced and the probability that the agent could be maintained based on environmental conditions, host availability, and host infectiousness. In this risk assessment, the probability of infection refers to the probability of an infectious agent causing infection in the Micronesia Region in human populations, livestock populations, or endemic wildlife populations. The specific questions in the Probability of Infection flow chart aimed at assessing risk are as follows (Figure A5-13):

Figure A5-13: General Procedure Used for Assessing the Probability of Infection from an Infectious Pathogen Associated with Wildlife into the Micronesia Region



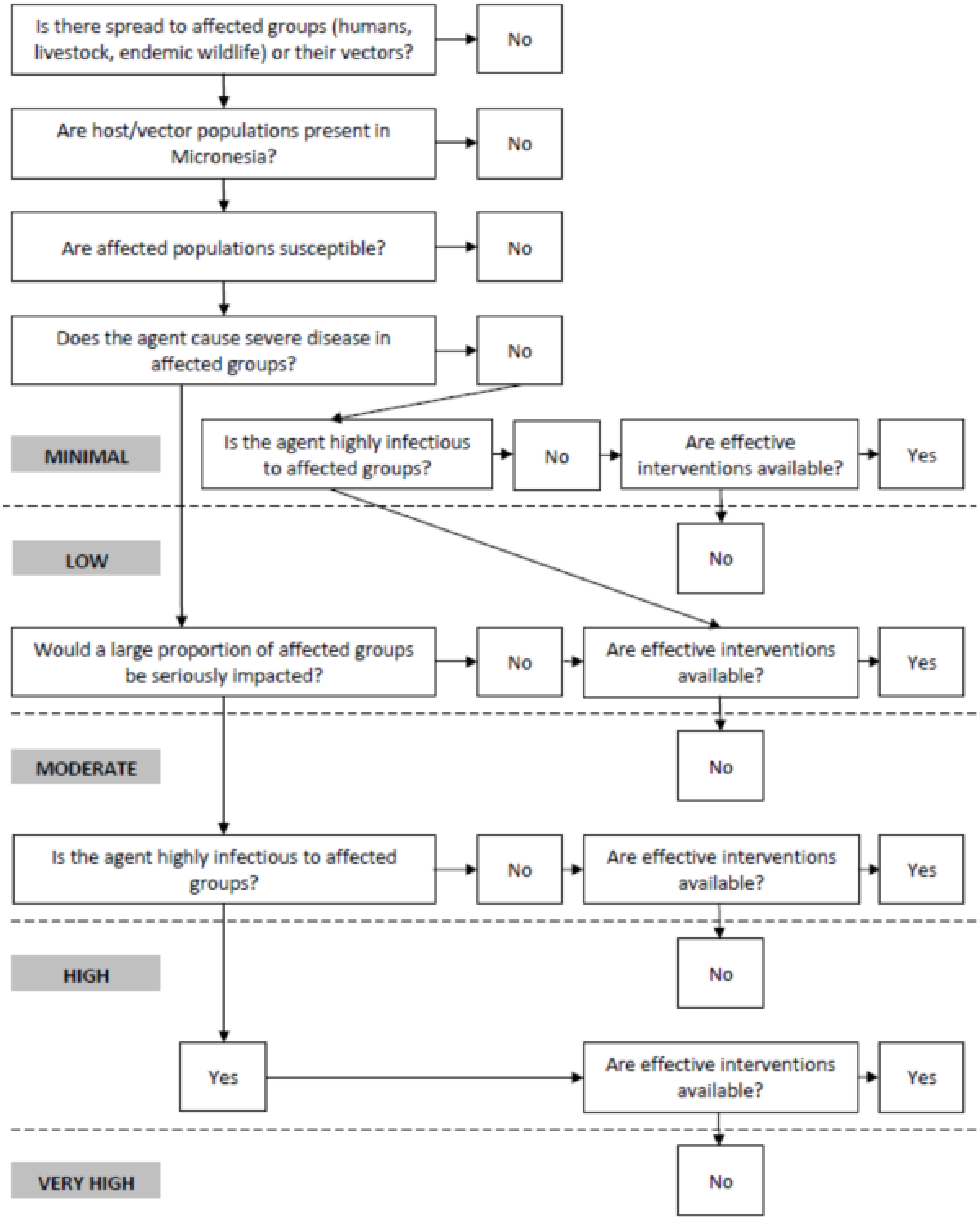
Note: See text for explanation.

The second flow chart assesses the potential Impact of Infection, or the level of potential harm that could be caused by the wildlife-associated pathogen in terms of morbidity and mortality. Impact is a function of the mode of transmission, infectiousness, severity of illness, and whether or not effective interventions are available. The specific questions in the Impact of Infection flow chart are as follows (Figure A5-14):

1. Is there spread to affected populations (humans, livestock, or endemic wildlife) or their vectors? Spread should be considered as the potential for both spatial and temporal movement of the pathogen. Factors that affect spread are the infective dose, the virulence of the pathogen, whether or not routes of spread are available, and the susceptibility of affected populations.
2. Are wildlife hosts and/or vector populations present in the Micronesia Region?
3. Are affected populations susceptible?
4. Does the agent cause severe disease in affected populations? Severity refers to the level of harm that can be inflicted on affected populations with respect to morbidity and mortality.
5. Is the agent highly infectious to affected populations?
6. Are effective interventions available? Factors to consider for assessing interventions are whether or not it is feasible to change the potential impact of the introduction and spread of the pathogen by containing or eliminating the pathogen via treatment or prophylaxis.
7. Would a large proportion of affected populations be seriously impacted?
8. Is the agent highly infectious to affected populations?

The risk assessment for each agent is based on current knowledge and should be updated and revised as additional information becomes available.

Figure A5-14: General Procedure Used for Assessing the Impact of Infection from an Infectious Pathogen Associated with Wildlife into the Micronesia Region



A5.2.2 Assumptions

This risk assessment assumes that:

1. Current knowledge of pathogen, host, and vector distributions and characteristics is relatively accurate. Knowledge gaps create uncertainty in the analyses and are generally represented by alternative risk assignments to account for unknown information.

2. Major trade partners for the Micronesia Region are Pacific Rim countries: the United States (especially Hawai'i), Russia, China, Singapore, Hong Kong, Taiwan, Japan, Indonesia, the Philippines, Korea, Vietnam, Australia, and New Zealand.

A5.2.3 Pathways of Introduction and Spread Associated With the Military Relocation

A5.2.3.1 *People*

A5.2.3.1.1 *Military*

It is anticipated that the proposed DoD relocation on Guam will bring more than 30,000 people to Guam through permanent military personnel, dependents, transient military personnel, and the DoD civilian workforce (U.S. Navy 2009h) by 2014.[8] Individual military members and their family members are required to follow rules and laws of the host country in question and the laws and regulations associated with imports to the United States (DoD 2001).

A5.2.3.1.2 *Civilian*

In addition to the increase in population associated directly with the proposed military relocation, the DoD currently estimates that thousands (up to 18,373) of off-island temporary workers will be needed for construction projects during certain years (U.S. Navy 2009h). There is an insufficient labor force for the construction work associated with this upcoming relocation (U.S. Navy 2009h). During past construction projects, much of the labor force came from China and the Philippines, but some skilled labor came from other locations of the United States (U.S. Navy 2009h). It is anticipated that most off-island construction workers will originate from the Philippines (U.S. Navy 2009h).

A5.2.3.1.3 *Methods*

Increases in human populations, both military and civilian, are expected to significantly increase the likelihood of wildlife pathogen introductions and spread via humans.

A5.2.3.2 *Shipping*

A5.2.3.2.1 *Military*

The military relocation is expected to significantly increase maritime vessel traffic to accommodate increased commodities to support military personnel and their dependents. Increased maritime traffic will increase the likelihood of pathogen introduction.

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[8] Ibid.

It is anticipated that the relocation of the 3rd Marine Expeditionary Unit from Okinawa to Guam will increase the amount of containerized cargo shipped into Guam to support the relocation and the provisioning of increased military personnel stationed there.

Naval ships can carry up to 5,000 crewmen, of which up to 43% have been shown to be infected with bacterial and viral pathogens (WHO 2002). Military transportation was the second highest reason for insect invasion behind importation of plant material in Japan (Kiritani and Yamamura 2003).

A5.2.3.2.2 *Commercial*

Maritime vessel traffic to Guam is expected to increase through more container and break-bulk vessels per year (U.S. Navy 2009f; PAG 2010b). These estimated increases in maritime traffic are expected to significantly increase the likelihood of pathogen introduction.

A5.2.3.3 *Air*

A5.2.3.3.1 *Military*

The military relocation is expected to significantly increase military aircraft traffic to accommodate increased commodities to support military personnel and their dependents. Increased military air traffic will increase the likelihood of pathogen introduction.

A5.2.3.3.2 *Commercial*

The military relocation is expected to significantly increase commercial aircraft traffic due to expected increases in commodities to support the population increase on the island and increased movement of humans. Increased commercial air traffic will increase the likelihood of pathogen introduction.

A5.2.3.4 *Natural Movements*

The military relocation is not expected to have a significant impact on the introduction of wildlife pathogens via wind, rafting, and natural movements. However, the military relocation may be associated with increased probabilities of establishment and spread of pathogens that are introduced naturally. For example, a zoonotic disease agent is more likely to become established if increased human population densities enhance the likelihood that the pathogen will move into a human host. Similarly, increased human population densities may enhance the likelihood of zoonotic pathogen spread due to higher numbers of susceptible individuals to act as hosts, so long as humans are not dead-end hosts for the pathogen in question.

A5.2.3.5 *Smuggling and Legal Wildlife Trade*

The military relocation is expected to significantly increase the probability of introduction and spread of wildlife pathogens due to increased demand for illegal and legal wildlife goods associated with the anticipated increase in human population density. Up to 2,722 kg (6,000 pounds) of meat are intercepted annually from travelers and shipments into Guam and Saipan (Figure A5-15 and A5-16), as much as 15% which is from undetermined species. With an increase of foreign workers, there is concern that illegal importation of bushmeat (the meat of wild animals) will increase, depending on the origin of workers. Bushmeat is an important component of diet and culture in many parts of the world, especially Asia and Africa (Milner-Gulland et al. 2003; Chaber et al. 2010). The illegal importation of bushmeat has become a global problem related to immigration of different cultures. For example, more than 4,990 metric tons (11 million pounds) of bushmeat and wildlife parts were smuggled into the United States between 2000 and 2004 from 14 species of monkeys, rodents, bats, and apes seized in mail and luggage (Viegas 2010). Projections indicate that 247,661 kg (273 tons) of bushmeat enter Paris annually via airline flights from Africa (Chaber et al. 2010) and 4,536 kg (5 tons) annually through Heathrow Airport in London (Milmo and Garman 2006).

Figure A5-15: Meat Intercepted during Customs Inspections on Saipan from 2003 to 2009

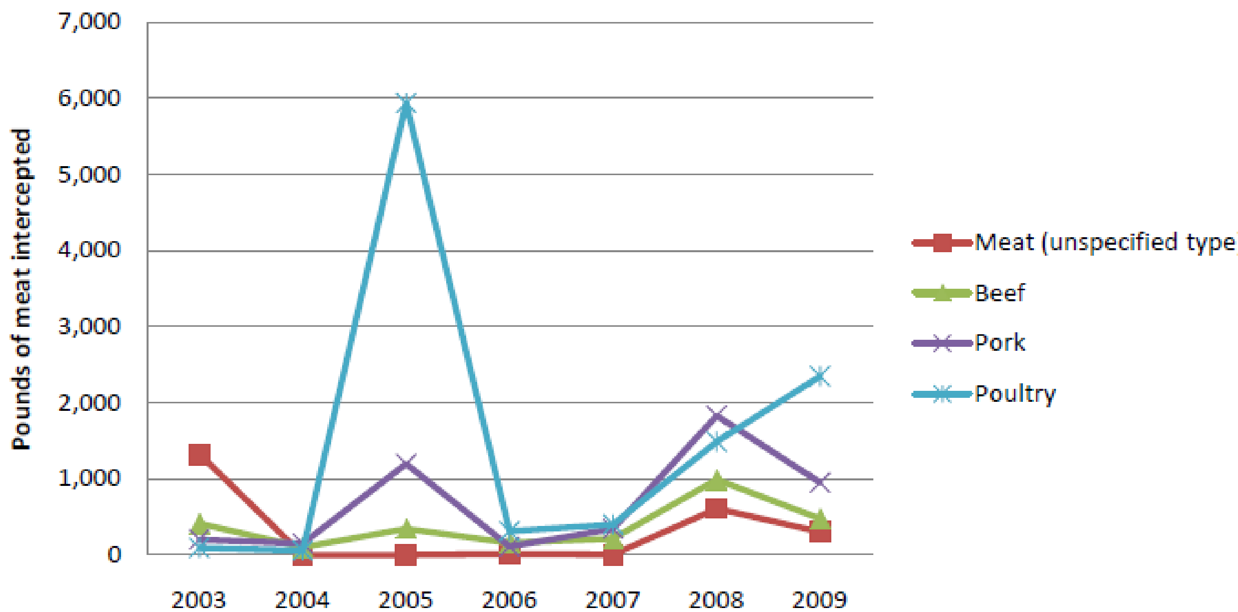
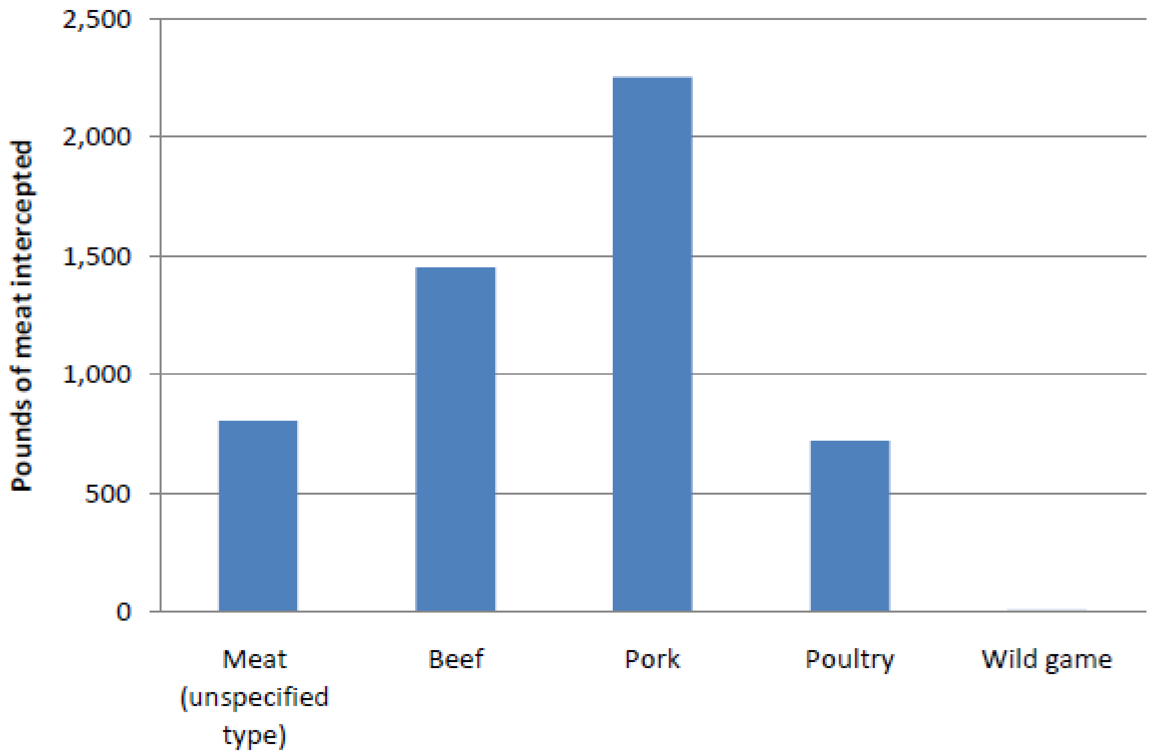


Figure A5-16: Meat Intercepted during Customs Inspections on Guam in 2009



Of particular concern in the Micronesia Region is the potential importation of fruit bats, which are culturally important in the Micronesia Region and are regularly eaten in Asia (Cambodia, China, India, Indonesia, Lao, Malaysia, Myanmar, the Philippines, Thailand, and Vietnam) and other Pacific islands (American Samoa, Fiji, and New Caledonia) (Mickleburgh et al. 2002). Fruit bats illegally smuggled into the Micronesia Region have the potential of introducing a wide variety of diseases, some of which cause considerable morbidity and mortality in livestock and humans.

A5.2.4 Risk Assessment Steps

A5.2.4.1 *Release*

The biological pathways needed for an importation event to release (i.e., introduce) a pathogen are complex with regard to many factors (OIE 2009d). We suggest that small mammals may be key species of risk. In Guam, e.g., unlike domestic carnivores (e.g., cats and dogs, which are required to remain in quarantine and arrive pre-vaccinated against some pathogenic agents; small mammals could arrive undetected via various modes of transportation. Further, these small mammals could arrive from various ports around the world. Although previous deratting procedures and modern recommended ship sanitation procedures have likely led to a less frequent incidence of small mammal stowaways, it likely still happens on occasion.

In addition to small mammals, bird species represent a risk pathway for the importation of wildlife-associated disease agents. Infected birds could arrive via natural migration, excessive wind events, smuggling, or intentional importation. Bats are another taxon of concern as they can host a number of important pathogens such as rabies virus, other lyssaviruses, and henipaviruses. While importation of bats is currently illegal outside of Palau, smuggling of bats is considered to occur such that the introduction of a bat-hosted infectious agent into Palau is likely to be disseminated throughout the Micronesia Region via smuggling.

A5.2.4.2 *Exposure*

A5.2.4.2.1 *Pathogen Properties*

The properties of a pathogen certainly influence the probability of it being introduced into a new environment. An important characteristic that can affect the probability that a pathogen is introduced into a novel region is the length of the typical infectious period. Many viruses infect a host but are subsequently cleared by the host through immunological processes. On the other hand, some pathogens cause persistent infections within hosts. In many instances, pathogens causing persistent infections will have a higher probability of introduction when compared to pathogens which are cleared from the host in a short amount of time.

Infectivity is another important pathogen attribute in terms of probability of introduction. For example, some viruses are only efficiently transmitted through vector-competent arthropods, while others are easily transmitted from host to host. The latter scenario suggests that multiple hosts may be needed on a long-term movement (e.g., shipping containers) to maintain pathogen viability for pathogens that are quickly cleared by susceptible hosts. Infectivity is also affected by the infectious dose required for an active infection to develop for a particular pathogen. Exposure to agents with a low infectious dose is more likely to result in an infection.

A5.2.4.2.2 *Vector and Host Presence*

A large number of mosquito species are known to occur on Guam (see Table A5-10). Some are endemic and others have been introduced. Some of these species are known vectors of pathogens in many regions of the world. For example, *Culex quinquefasciatus* is associated with a number of potential diseases (e.g., St. Louis encephalitis, Japanese encephalitis, Chikungunya fever, and avian malaria) and filarial infections (e.g., Bancroftian filariasis and Dirofilariasis). In addition, *Aedes albopictus*, which was first recognized in Guam in 1944 (see Table A5-10) and is abundant on many Pacific islands, is associated with many vector-borne diseases (e.g., Dengue fever, Chikungunya fever, Japanese encephalitis, Dirofilariasis, yellow fever, and West Nile fever) some of which could pose a threat through the introduction of their pathogens into the Micronesia Region. The large-scale global expansion of this mosquito species during the last three decades has increased public health concerns because it is a potential vector of a number of medically important arthropod-borne viruses (Lambrechts et al. 2010).

A5.2.4.2.3 *Human and Host Populations*

As of 2009, the population of the Micronesia Region was relatively small, estimated to be less than 500,000 individuals. The proportions of visitors to Guam are expected to change, with visitors from Japan declining from 80to 68% of total visitors, visitors from Korea increasing from 10to 19% of total visitors, visitors from the continental United States and Hawai'i increasing from 4to 5% of total visitors, and visitors from East Asia increasing from 4to 6% of total visitors (PB International 2008).

Wildlife host populations are limited in much of the Micronesia Region. In some instances, this may be primarily due to past introductions of invasive species (i.e., BTS). Guam, e.g., has low population levels of most bird species and many of the mammal species (e.g., small mammals) that are found there. When compared to the three major islands of CNMI, the densities of several small mammal species were often notably lower on Guam (Wiewel et al. 2009). Overall, several small mammal species (especially *Rattus* spp.) can be found on many islands in the Micronesia Region. Very few mammals are endemic to these islands. However, many mammalian introductions have occurred in this region, often leading to viable populations. For example, feral swine and Philippine deer are known to occur on multiple islands in the Micronesia Region. In many instances, densities of potential wildlife host populations are limited or non-existent.

A5.2.4.2.4 ***Human Culture***

Human culture in the Micronesia Region directly affects the probability of exposure to wildlife-associated pathogens. Historically many wildlife species, including fruit bats and most avian species, were eaten and hunted by native humans. This legacy increases the probability of close interaction between humans and wildlife and increases the likelihood of human exposure in the event of pathogen importation. In addition, relatively high population densities on Guam increase the likelihood of human-wildlife interactions and consequently the likelihood of pathogen exposure. Increased population densities associated with the military relocation will only exacerbate human-wildlife interactions in the region.

A5.2.4.2.5 ***Environment***

Micronesian countries have tropical climates that offer excellent environmental conditions for a wide variety of wildlife-associated pathogens, wildlife hosts, and vectors. Human environmental exposure to wildlife-associated pathogens is likely to result from contact with vectors (e.g., mosquitoes) while outdoors (for recreation, work, cooling off) as well as disease agents that are able to survive in the environment (e.g., AIVs).

A5.2.4.2.6 ***Trade***

Legal and illegal wildlife trade provides a pathway for exposure/introduction of wildlife pathogens. While few animal hosts are imported legally, disease exposure/introduction may occur from animals with subclinical disease. In addition, illegal importation of wildlife is more likely to cause wildlife-associated pathogen exposure as animals are not checked for signs of disease.

A5.2.4.2.7 ***Consequences***

The consequences of exotic pathogen introductions can be enormous. WNV provides a good example. There is little doubt that the introduction of this virus caused tens of millions of dollars in costs associated with animal infections, disease, and/or human health. For example, an outbreak of WNV in Louisiana during 2002 was estimated to cost more than $20 million to treat illnesses and for public health responses (e.g., mosquito control) (The Associated Press 2004). During 2002, this virus was thought to cost the equine industry hundreds of thousands of dollars in Colorado and Nebraska (USDA-APHIS-VS 2003b). During 2005, a WNV outbreak in Sacramento County, California was estimated to have cost nearly $3 dollars (Barber et al. 2010).

Emerging infectious diseases of wildlife pose a substantial threat not only to human health but also to wildlife conservation (Daszak et al. 2000). For example, the introduction of WNV has affected wildlife conservation issues, as has been the case with sage grouse (Naugle et al. 2004). Further, several extinctions and near extinctions of local animal populations that have been thought to have been directly caused by disease have been noted (Woodroffe 1999).

A5.2.4.2.8 *Estimation*

Because information is often lacking for specific pathogens, alternative answers to the risk assessment questions listed elsewhere in this document were considered in cases where a definitive answer could not be confidently drawn. In such cases the most likely qualitative risk level is assigned, but the alternative outcome is also reported. In order to visualize the assignments of risk and potential alternatives, for each wildlife-associated pathogen considered, the flow charts for Probability of Infection and Impact of Infection are filled in to represent the answers to the series of questions. The more likely path is filled in as gray and if an alternative path and risk assignment is considered, it is represented with cross-hatching in the flow chart (FigureA5-17 through Figure A5-36). As noted previously, in addition to considering multiple risk categories for pathogens lacking complete information, risk assessments should be updated in response to new information or developments. The following section describes our estimates of risk of introduction for specific wildlife-associated pathogens. The categorization of risk for each of these pathogens is summarized in Table A5-12.

HANTAVIRUSES (described in Section A5.1.3.1)

PROBABILITY OF INFECTION (Figure A5-17)

Is the agent associated with wildlife? Yes, the reservoir hosts are small mammals (rodents, most often mice and rats, also insectivores, such as shrews).

Is the agent endemic in the Micronesia Region? No, but host species are known to occur. No detections have been reported, but Seoul virus (an old world hantavirus) is known to have been imported into ports in the New World.

Alternative answer: Yes. No screening has been conducted in the Micronesia Region so it is possible that the agent is present, but has not been detected.

Are there routes of introduction into the Micronesia Region? Yes, infected mammals may be introduced via shipping and cargo planes. The agent often causes persistent infections in rodents. Therefore, rodents introduced via shipping cargo can easily be infectious upon arrival in the Micronesia Region.

Are there effective control measures available? No.

Do environmental conditions support reservoirs/vectors? Yes.

Will there be human, livestock, or endemic wildlife exposure? Yes, human exposure is possible for high risk populations living in close association with commensal rodents.

Are affected populations highly susceptible? Yes, for humans that have a high rate of exposure to commensal rodents or their excreta, especially in enclosed environments.

Is the agent highly infectious to affected populations via hosts or vectors? No, humans are considered dead-end hosts for most hantaviruses. However, hantaviruses are readily transmissible between select non-endemic wildlife species (introduced small mammals).

Risk category: Moderate

Alternative risk category: Minimal

IMPACT OF INFECTION (Figure A5- 18)

Is there spread to affected populations? Yes.

Are wildlife hosts and/or vector populations present in the Micronesia Region? Yes, rodent densities are very high on some islands, especially in CNMI.

Are affected populations susceptible? Yes.

Does the agent cause severe disease in affected populations? Yes, humans can develop severe disease with high rates of mortality. On the other hand, rodent populations infected with the virus do not exhibit severe disease.

Is the agent highly infectious to affected populations? No; the agent is primarily infectious to humans that come in frequent contact with commensal rodents in enclosed spaces where urine and feces may become aerosolized due to disturbance.

Are effective interventions available? No.

Risk category: Low

Figure A5-17: Probability of Infection with Hantaviruses

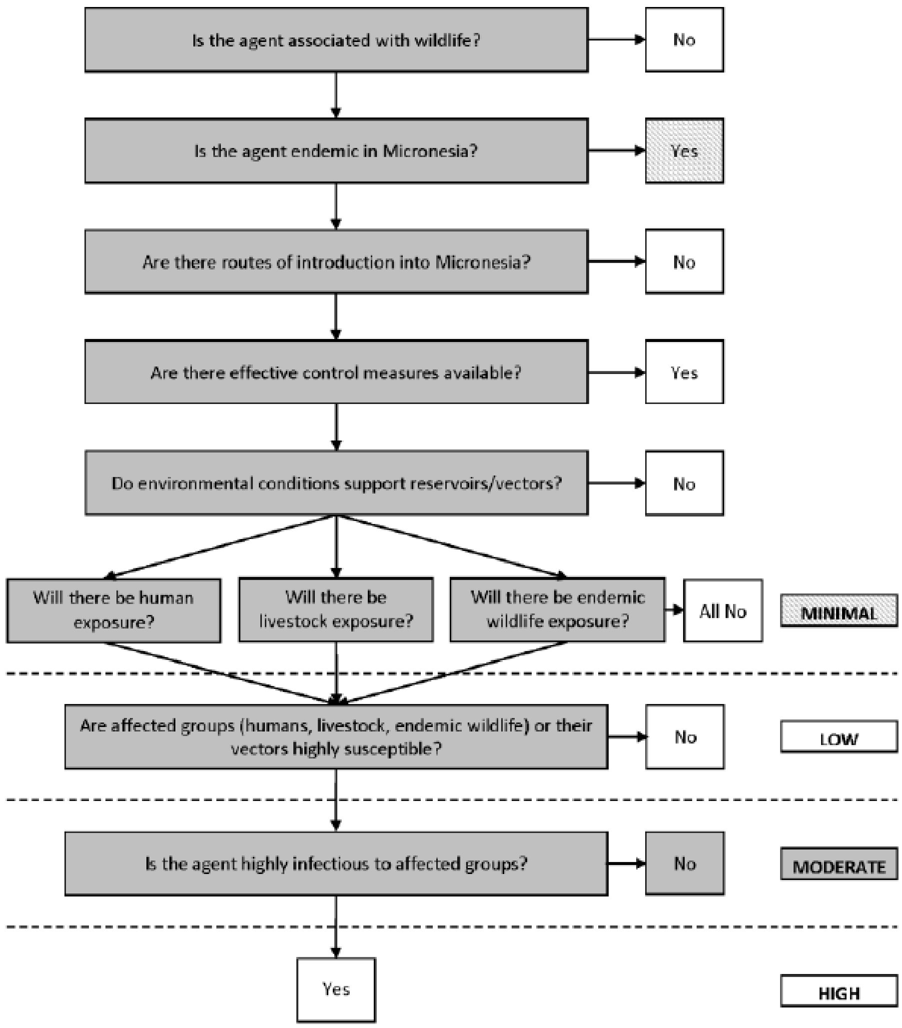
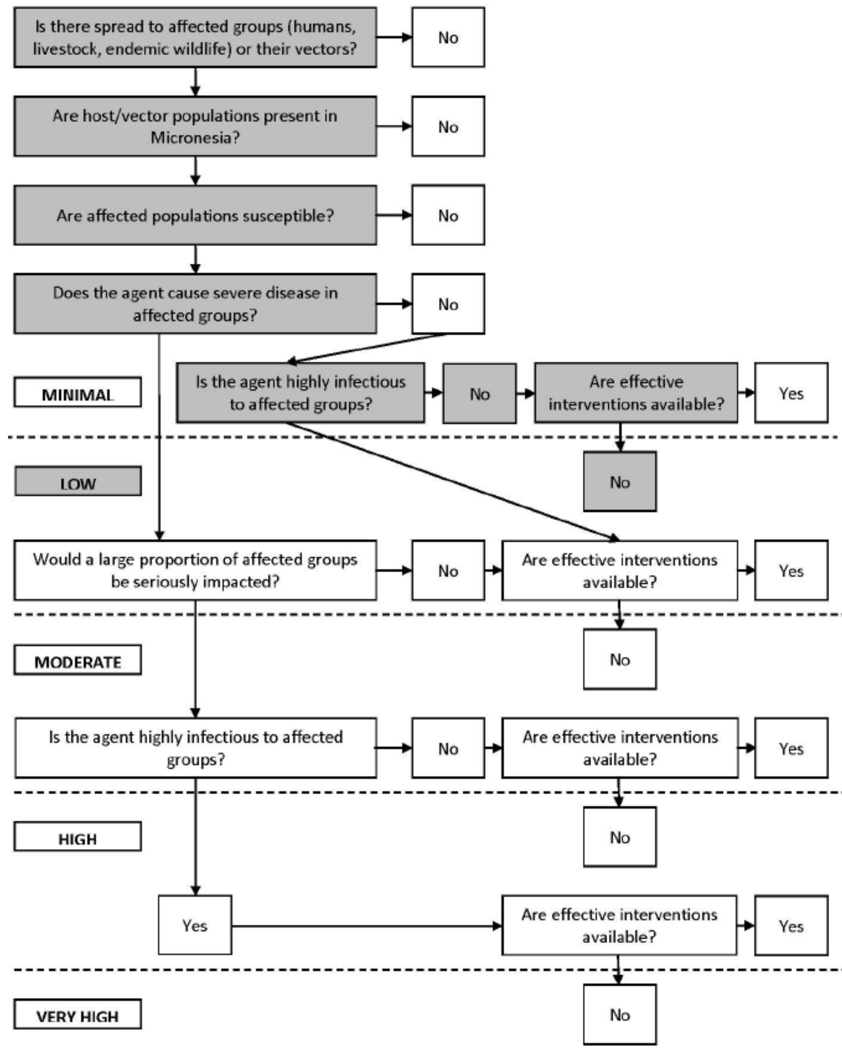


Figure A5-18: Impact of Infection with Hantaviruses in the Micronesia Region



The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk assignment is considered, it is represented as light gray in the flow chart.

RABIES VIRUS (described in SectionA5.2.3.1)

PROBABILITY OF INFECTION (Figure A5-19)

Is the agent associated with wildlife? Yes, the reservoir hosts are typically carnivores and bats.

Is the agent endemic in the Micronesia Region? No, Guam is considered to be free of rabies. Little testing has been conducted outside of Guam. However, despite limited testing it is unlikely that the agent is present elsewhere, but has not been identified since the symptoms of the disease are well known.

Are there routes of introduction into the Micronesia Region? No, Guam has strict quarantine procedures to prevent the introduction of rabies from cats, dogs, and other carnivores. However, illegally smuggled live bats may be a potential route of introduction.

Are there effective control measures available? Yes, vaccination programs would likely limit the spread of rabies among feral carnivores.

Risk category: Minimal

IMPACT OF INFECTION (Figure A5-20)

Is there spread to affected populations? Yes, if the agent was introduced via wildlife, it would likely spread to pets and then to humans.

Are wildlife hosts and/or vector populations present in the Micronesia Region? Yes.

Are affected populations susceptible? Yes.

Does the agent cause severe disease in affected populations? Yes.

Is the agent highly infectious to affected populations? Yes.

Would a large proportion of affected groups be seriously impacted? No.

Are effective interventions available? Yes.

Risk category: Low

Figure A5-19: Probability of Infection with Rabies Virus

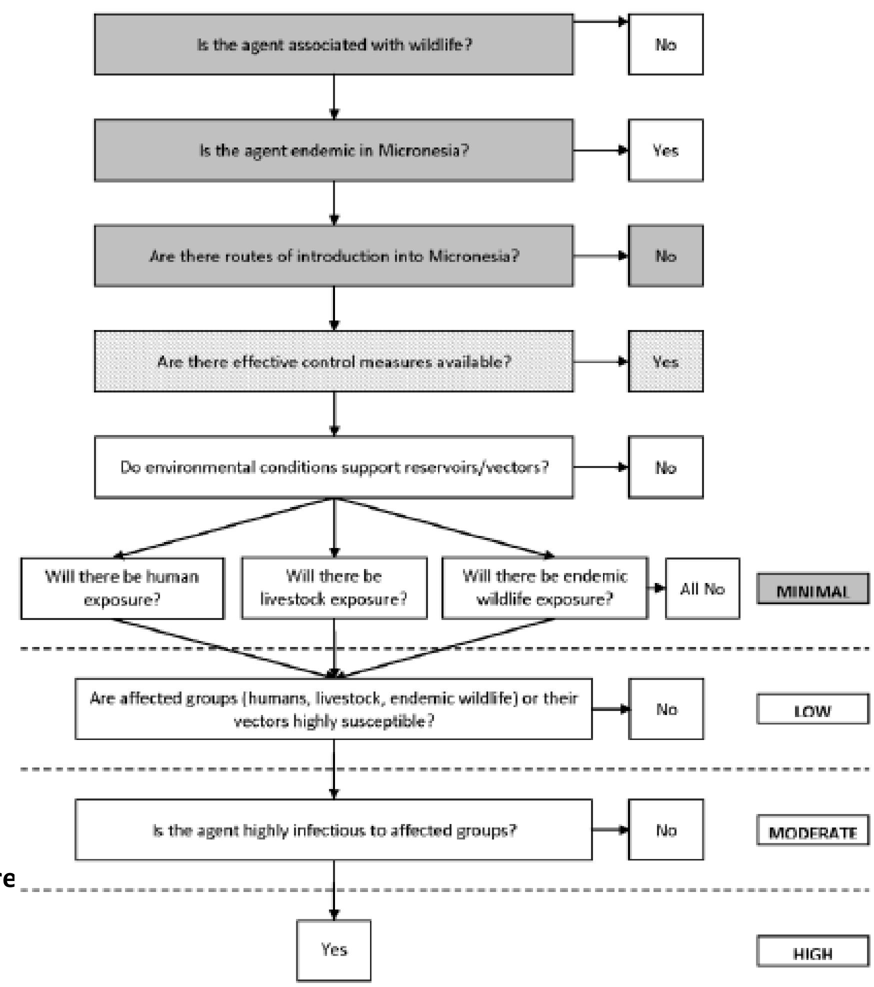
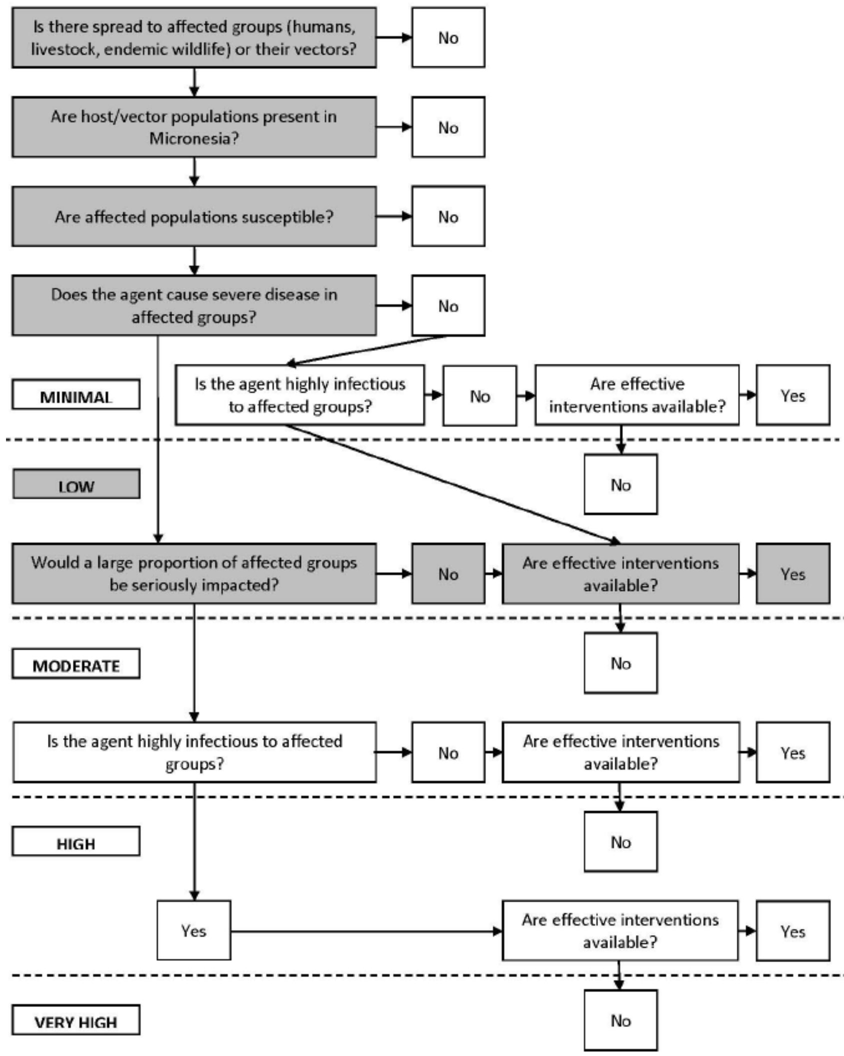


Figure A5-20: Impact of Infection with Rabies Virus in the Micronesia Region



The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk assignment is considered, it is represented as light gray in the flow chart.

WNV (described in Section A5.2.3.1)

PROBABILITY OF INFECTION (Figure A5-21)

Is the agent associated with wildlife? Yes, wild birds are reservoir competent. Most mammals are not involved in natural WNV cycles; however, some mammal species have recently been shown to develop viremias sufficient for infecting some mosquito species.

Is the agent endemic in the Micronesia Region? No.

Are there routes of introduction into the Micronesia Region? No, the likelihood of introduction is low.

Alternative answer: Yes, if WNV becomes established in Hawai'i or Alaska in which case WNV would have the potential to enter Micronesian countries via infected mosquitoes or migratory birds arriving from Alaska or Hawai'i. Introduction via the import of poultry and fighting cocks is negligible. A lesser probability of introduction via an infected mammal (including humans) is possible.

Are there effective control measures available? No.

Do environmental conditions support reservoirs/vectors? Yes.

Will there be human, livestock, or endemic wildlife exposure? Yes, human, livestock, and endemic wildlife exposures are possible.

Are affected populations highly susceptible? Yes.

Is the agent highly infectious to affected populations via hosts or vectors? Yes.

Risk category: Minimal

Alternative risk category: High (if WNV becomes established in Hawai'i or Alaska)

IMPACT OF INFECTION (Figure A5-22)

Is there spread to affected populations? Yes.

Are wildlife hosts and/or vector populations present in the Micronesia Region? Yes, both host and vector species are present in the Micronesia Region.

Are affected populations susceptible? Yes.

Does the agent cause severe disease in affected populations? Yes, WNV can cause serious disease in wild bird populations, especially corvids. In addition, a small proportion of humans can suffer severe morbidity and mortality.

Is the agent highly infectious to affected populations? Yes, WNV is highly infectious to wild birds.

Would a large proportion of affected populations be seriously impacted? Yes.

Is the agent highly infectious to affected populations? Yes.

Are effective interventions available? Yes, mosquito control and education can reduce vector populations.

Risk category: High

Figure A5-21: Probability of Infection with WNV

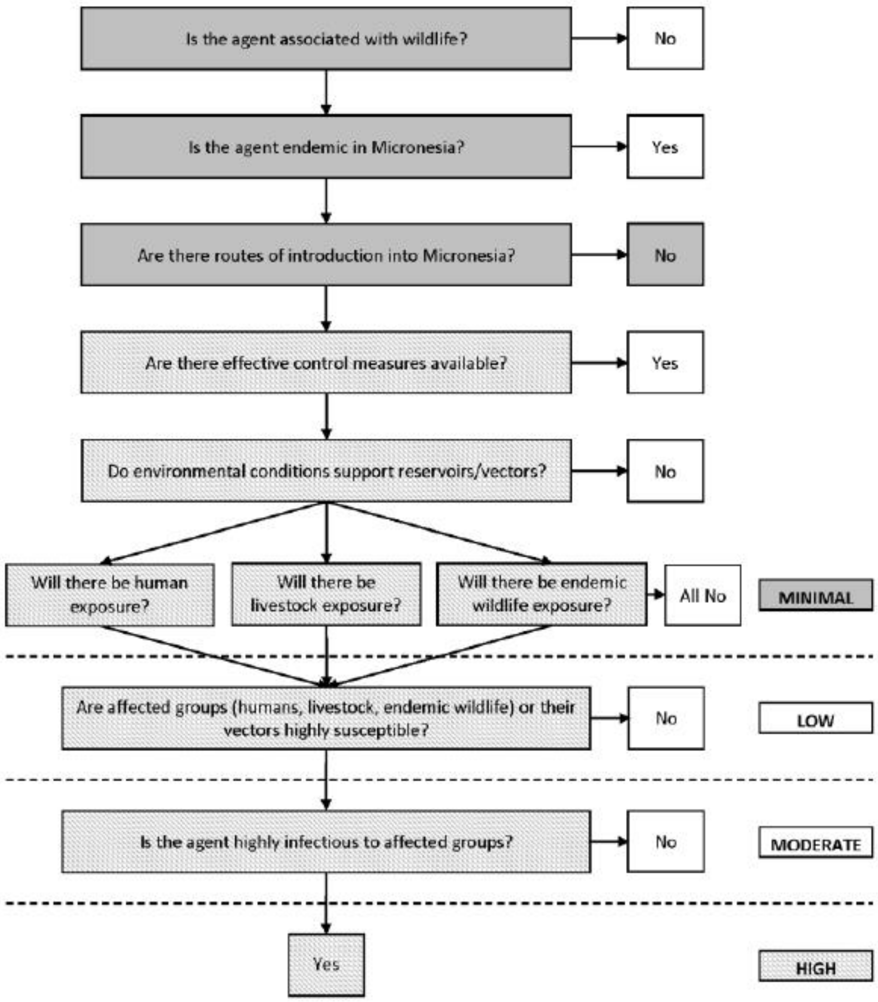
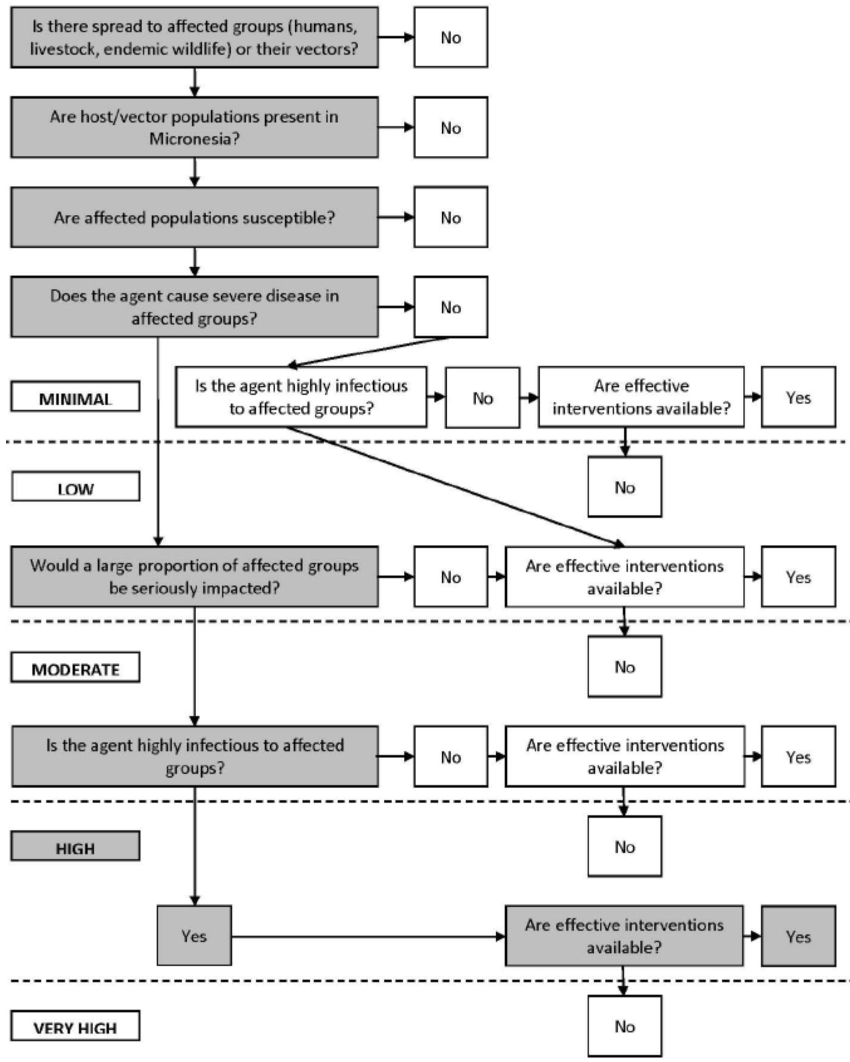


Figure A5-22: Impact of Infection with WNV



The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk assignment is considered, it is represented as light gray in the flow chart.

HIGHLY PATHOGENIC AVIAN INFLUENZA VIRUS (described in Section A5.2.3.1)

PROBABILITY OF INFECTION (Figure A5-23)

Is the agent associated with wildlife? Yes, the reservoir host is wild birds, particularly waterfowl, shorebirds, and seabirds. In addition, select wild mammals have been infected.

Is the agent endemic in the Micronesia Region? No, but low pathogenic AIVs have been detected in 3 wild birds (out of more than 5,000 sampled).

Are there routes of introduction into the Micronesia Region? Yes, AIVs have the potential to enter Micronesian countries via infected migratory birds. Introduction via the import of poultry and fighting cocks is negligible. AIVs may also enter Micronesian countries via spillover into mammals. However, because the course of infection is approximately a week, this type of release is likely to be limited to air cargo because infections would be expected to resolve prior to shipping for sea cargo.

Are there effective control measures available? No, control measures (depopulation and quarantine) are generally effective if implemented quickly, but the high densities of feral chickens on Guam and Saipan render effective control unlikely.

Do environmental conditions support reservoirs/vectors? Yes.

Will there be human, livestock, or endemic wildlife exposure? Yes.

Are affected populations highly susceptible? Yes (for livestock and endemic wildlife).

Is the agent highly infectious to affected populations via hosts or vectors? Yes.

Risk category: High

IMPACT OF INFECTION (Figure A5-24)

Is there spread to affected populations? Yes.

Are wildlife hosts and/or vector populations present in the Micronesia Region? Yes.

Are affected populations susceptible? Yes.

Does the agent cause severe disease in affected populations? No, highly pathogenic subtypes do not generally cause severe morbidity and mortality in wild birds.

Alternative answer: Yes, while uncommon, some strains of HPAIV have been associated with severe disease and mortality in wild birds.

Is the agent highly infectious to affected populations? Yes, especially in wild birds; moreover, humans in close contact with infected birds can also become infected.

Are effective interventions available? No, vaccines are available for domestic birds, but control of the virus in wild populations is not feasible.

Would a large proportion of affected groups be seriously impacted? No, most wild bird populations do not exhibit severe morbidity or mortality.

Risk category: Moderate

Alternative risk category: Moderate

Figure A5-23: Probability of Infection with Highly Pathogenic Avian Influenza Virus in the Micronesia Region

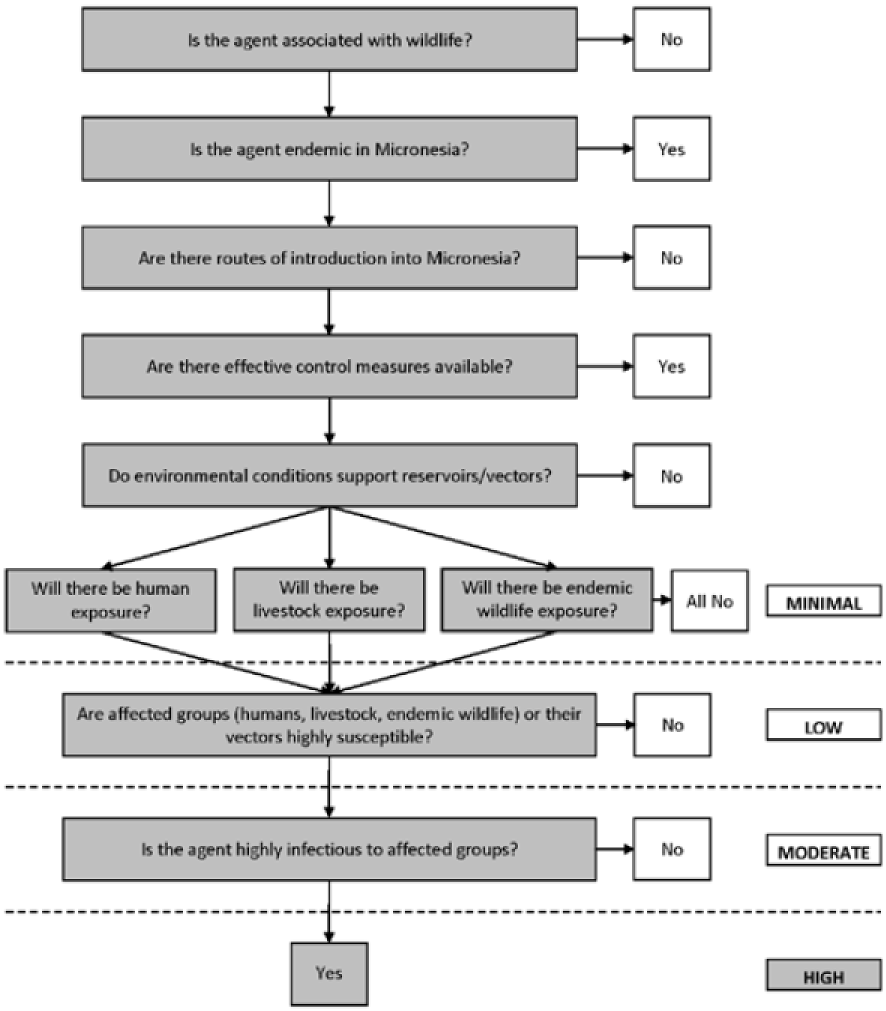
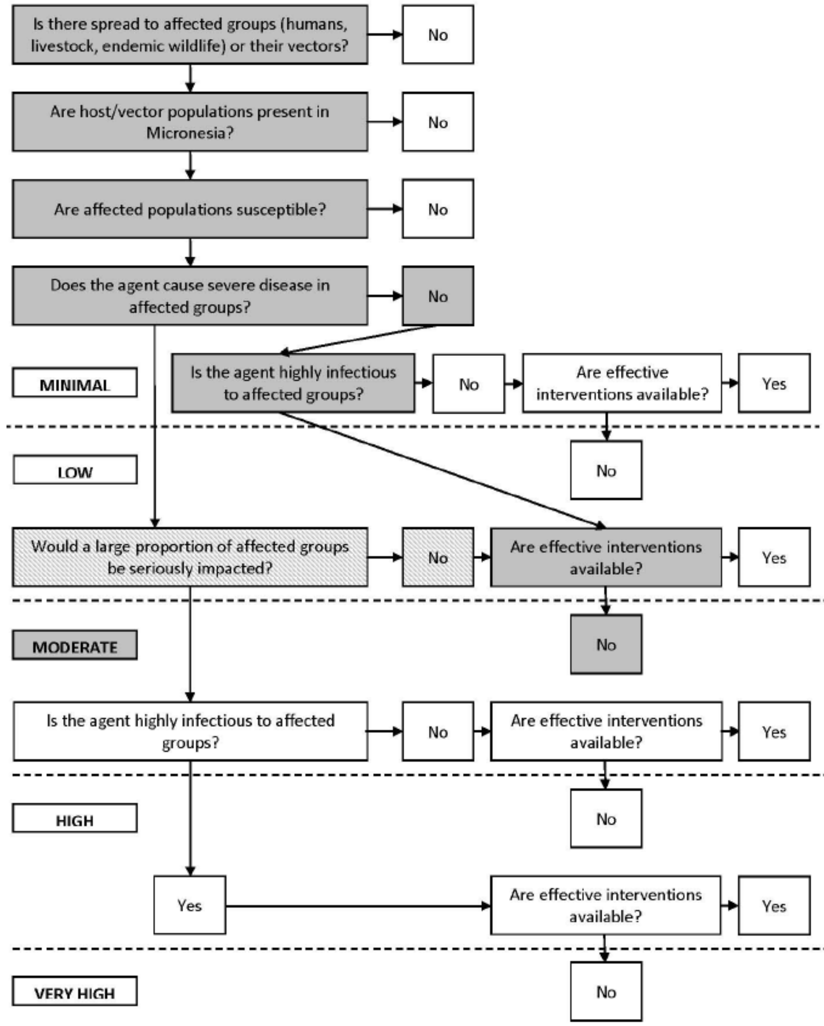


Figure A5-24: Impact of Infection with HPAIV in the Micronesia Region



The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk assignment is considered, it is represented as light gray in the flow chart.

JAPANESE ENCEPHALITIS VIRUS (described in Section A5.2.3.1)

PROBABILITY OF INFECTION (Figure A5-25)

Is the agent associated with wildlife? Yes, wild birds are reservoir competent and pigs can act as amplifying hosts.

Is the agent endemic in the Micronesia Region? No, but an outbreak occurred in Guam in 1947 and in Saipan in 1990.

Are there routes of introduction into the Micronesia Region? Yes, infected mosquitoes, migratory birds, or humans could move the virus into the Micronesia Region

Are there effective control measures available? Yes for mitigation of human and swine infections, but if the virus becomes established in wild birds, control is unlikely. However, JEV does not cause clinical illness in wild birds.

Do environmental conditions support reservoirs/vectors? Yes.

Will there be human, livestock, or endemic wildlife exposure? Yes, human, livestock, and endemic wildlife exposures are possible.

Are affected populations highly susceptible? Yes.

Is the agent highly infectious to affected populations via hosts or vectors? Yes, wild birds as well as humans and livestock are readily infected.

Risk category: High

IMPACT OF INFECTION (Figure A5-26)

Is there spread to affected populations? Yes, JEV is easily spread among wild birds which represent the primary natural reservoir. Humans and livestock can act as spillover hosts.

Are wildlife hosts and/or vector populations present in the Micronesia Region? Yes, both host (birds and mammals) and vector populations are currently present.

Are affected populations susceptible? Yes, wild birds, livestock, and humans are susceptible.

Does the agent cause severe disease in affected populations? No, JEV does not cause severe disease in wild bird populations.

Alternative answer: Yes, JEV may cause severe disease in a small proportion of humans that may become infected.

Is the agent highly infectious to affected populations? No; while JEV is highly infectious to wild birds, it is less infectious to humans which are most likely to be impacted.

Are effective interventions available? Yes, vaccinations are available for humans.

Would a large proportion of affected populations be seriously impacted? No.

Risk category: Minimal

Alternative risk category: Low

Figure A5-25: Probability of Infection with Japanese Encephalitis Virus in the Micronesia Region

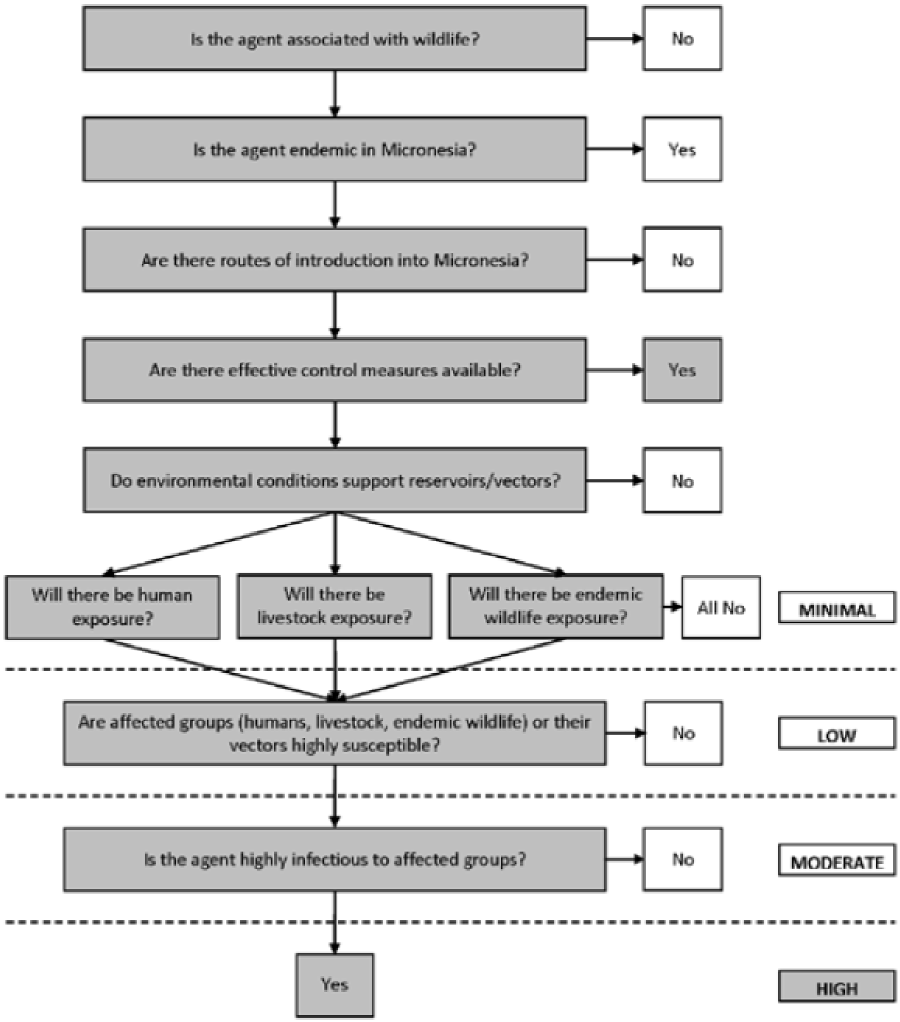
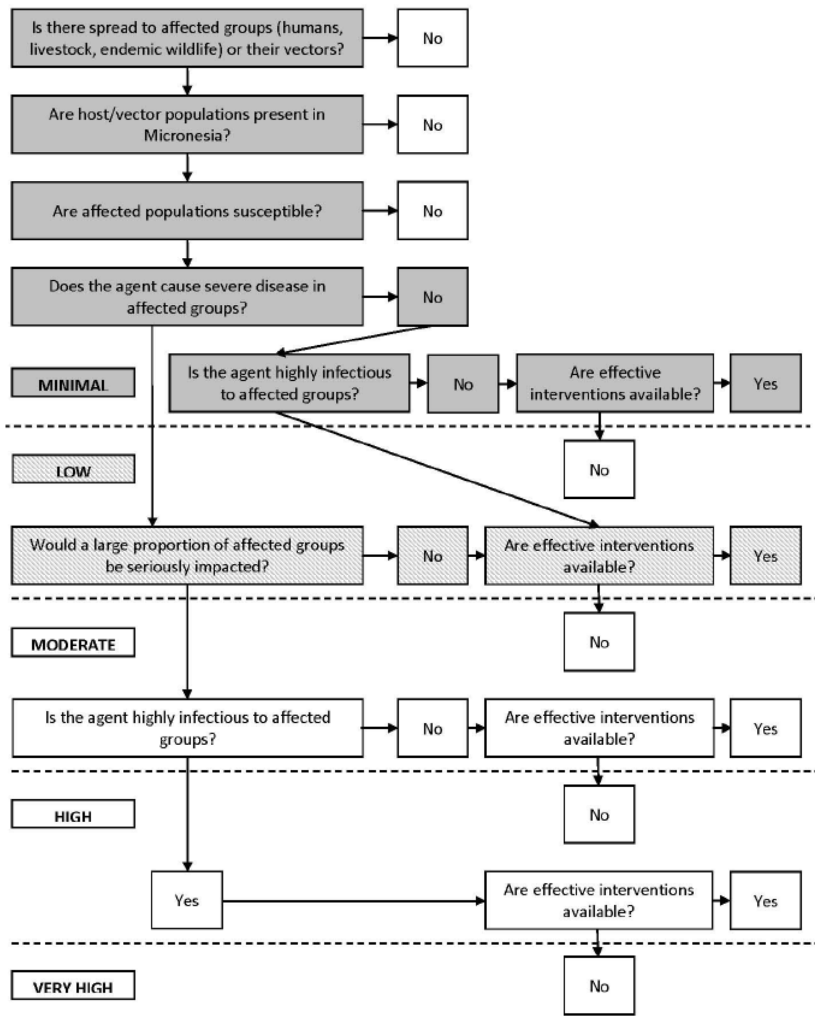


Figure A5-26: Impact of Infection with JEV in the Micronesia Region



The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk assignment is considered, it is represented as light gray in the flow chart.

AVIAN MALARIA PARASITES (*Plasmodium* spp.) (described in Section A5.2.3.1)

PROBABILITY OF INFECTION (Figure A5-27)

Is the agent associated with wildlife? Yes, wild birds are reservoir competent.

Is the agent endemic in the Micronesia Region? No (not likely), screening for blood parasites in Guam has not yet identified any *Plasmodium* spp.

Alternative answer: Yes, testing in Saipan more than 50 years ago revealed the possible presence of *Plasmodium* sp. in birds; however, modern detection methods were not available.

Are there routes of introduction into the Micronesia Region? Yes, infected mosquitoes or migratory birds could move the virus into the Micronesia Region. Movement of infected mosquitoes or their larvae from Hawai'i is possible via air cargo.

Are there effective control measures available? No.

Do environmental conditions support reservoirs/vectors? Yes.

Will there be human, livestock, or endemic wildlife exposure? Yes, endemic wild bird exposures are possible.

Are affected populations highly susceptible? Yes, wild birds are highly susceptible.

Is the agent highly infectious to affected populations via hosts or vectors? Yes, *Plasmodium* spp. are highly infectious to wild birds.

Risk category: High

Alternative risk category: Minimal

IMPACT OF INFECTION (Figure A5-28)

Is there spread to affected populations? Yes, *Plasmodium* spp. would spread easily between wild bird hosts via mosquito vectors.

Are wildlife hosts and/or vector populations present in the Micronesia Region? Yes, both wild bird hosts and mosquito vectors are present.

Are affected populations susceptible? Yes, wild bird populations are highly susceptible to *Plasmodium* spp.

Does the agent cause severe disease in affected populations? No, *Plasmodium* spp. do not cause severe disease in most bird species.

Alternative answer: Yes, *Plasmodium* spp. are associated with severe disease in some Hawai'ian bird species that did not evolve with the agent. If bird species in the Micronesia Region did not evolve in the presence of *Plasmodium* spp. it is possible that severe population impacts may be felt in some wild bird species as has happened in Hawai'i.

Is the agent highly infectious to affected populations? Yes.

Are effective interventions available? No.

Would a large proportion of affected populations be seriously impacted? No, not all wild bird species would be likely to suffer serious impacts.

Risk category: Moderate

Alternative risk category: Moderate

Figure A5-27: Probability of Infection with Avian malaria Parasites in the Micronesia Region

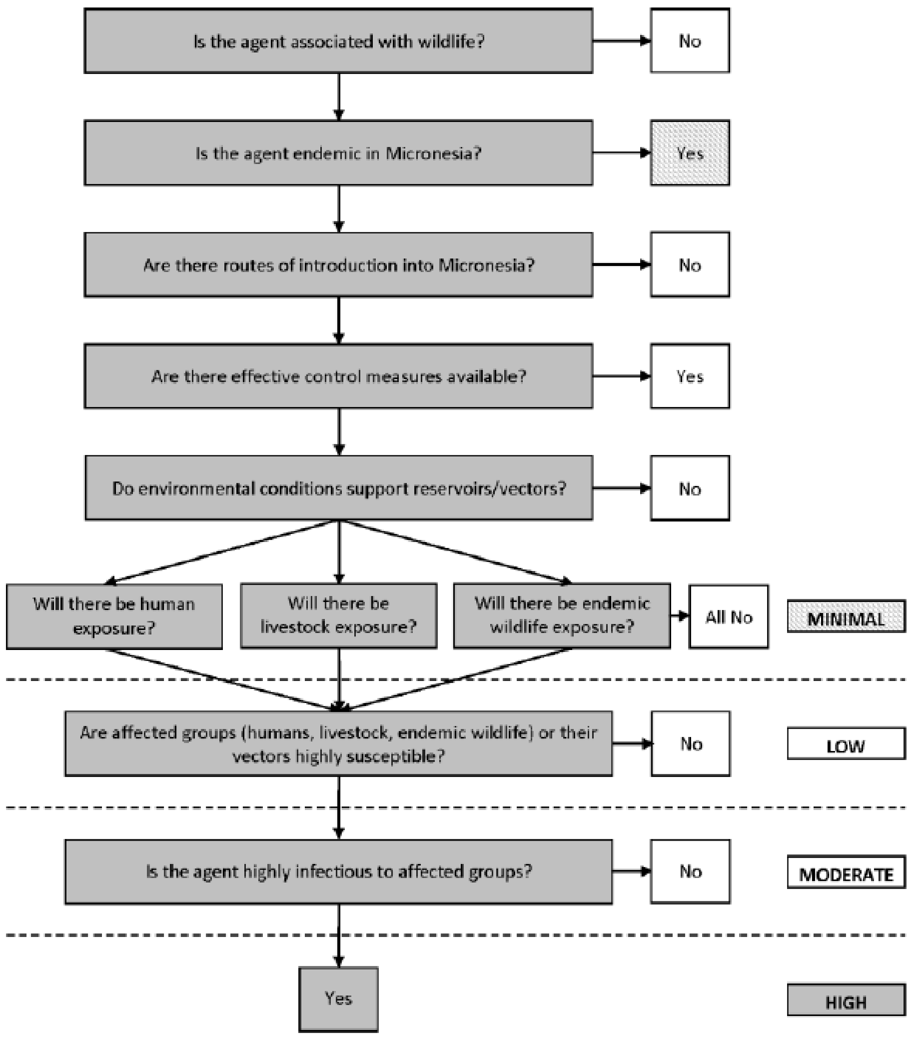
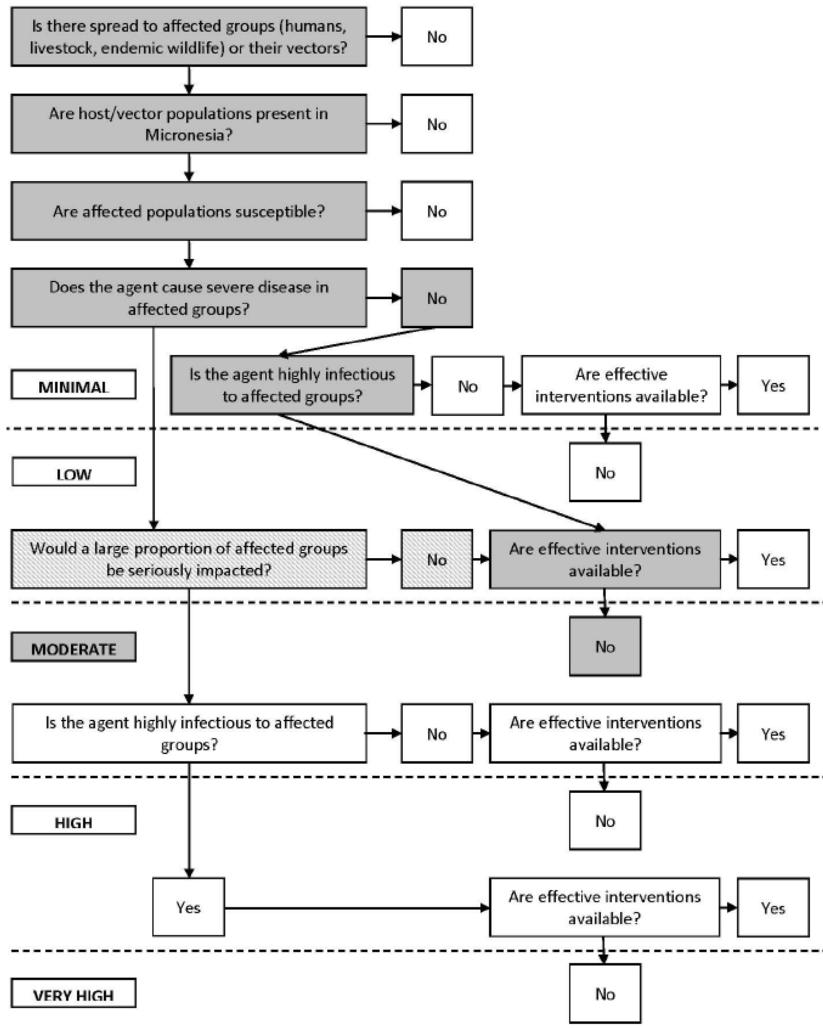


Figure A5-28: Impact of Infection with Avian Malaria Parasites in the Micronesia Region



The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk assignment is considered, it is represented as light gray in the flow chart.

HENIPAVIRUSES (described in Section A5.2.3.1)

PROBABILITY OF INFECTION (Figure A5-29)

Is the agent associated with wildlife? Yes, bats are considered the reservoir species and livestock can act as amplifying hosts.

Is the agent endemic in the Micronesia Region? No.

Are there routes of introduction into the Micronesia Region? No, the likelihood of introduction is low.

Alternative answer: Yes, henipaviruses could move into the Micronesia Region via smuggling of infected bats or introduction via shipping or air cargo.

Are there effective control measures available? No.

Do environmental conditions support reservoirs/vectors? Yes.

Will there be human, livestock, or endemic wildlife exposure? Yes, if introduced, human, livestock, and endemic wildlife exposures are possible.

Are affected populations highly susceptible? Yes.

Is the agent highly infectious to affected populations via hosts or vectors? Yes.

Risk category: Minimal

Alternative risk category: High

IMPACT OF INFECTION (Figure A5-30)

Is there spread to affected populations? Yes, the virus spreads easily between bats and spillover hosts such as pigs and humans.

Are wildlife hosts and/or vector populations present in the Micronesia Region? Yes, in parts of the Micronesia Region (e.g., Palau), bat populations are still relatively large.

Are affected populations susceptible? Yes, bats, humans, and pigs are susceptible.

Does the agent cause severe disease in affected populations? No, henipaviruses do not cause severe illness in reservoir bat populations.

Alternative answer: Yes, henipaviruses can cause severe disease in pigs and humans.

Is the agent highly infectious to affected populations? Yes.

Are effective interventions available? No.

Would a large proportion of affected populations be seriously impacted? No; while the agent can cause severe morbidity and mortality in humans and pigs, only individuals in close contact with bats are likely to be impacted.

Risk category: Moderate

Alternative risk category: Moderate

Figure A5-29: Probability of Infection with Henipaviruses in the Micronesia Region

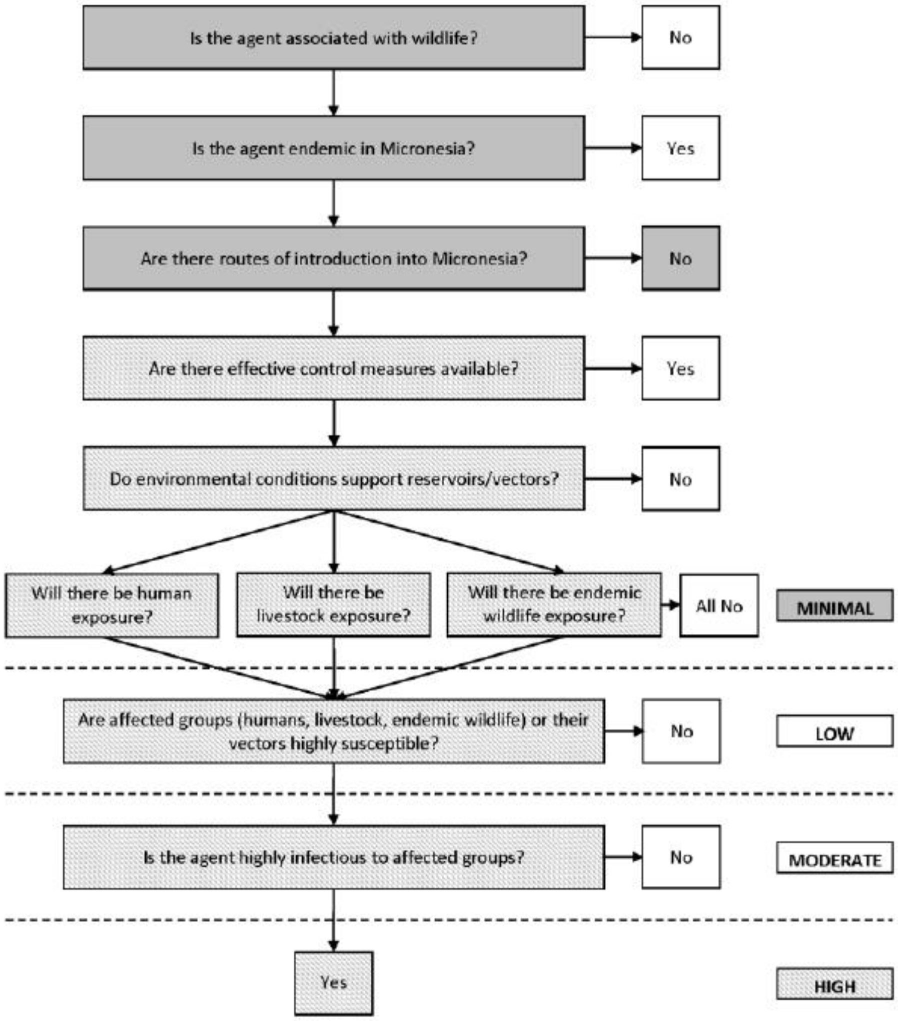
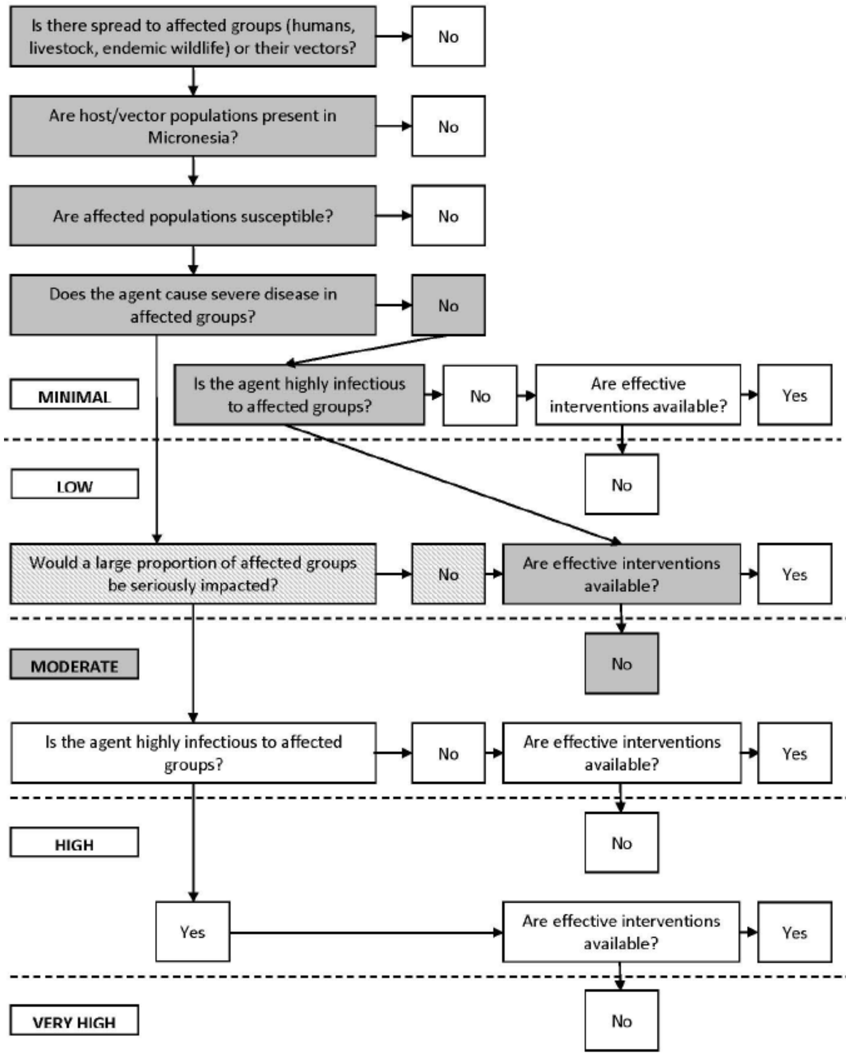


Figure A5-30: Impact of Infection with Henipaviruses in the Micronesia Region



The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk assignment is considered, it is represented as light gray in the flow chart.

NEWCASTLE DISEASE VIRUS (described in Section A5.2.3.1)

PROBABILITY OF INFECTION (Figure A5-31)

Is the agent associated with wildlife? Yes, more than 240 wild bird and poultry species are known to become infected.

Is the agent endemic in the Micronesia Region? No.

Are there routes of introduction into the Micronesia Region? No, NDV has been endemic throughout Southeast Asia for a long period of time without any known introductions into the Micronesia Region.

Alternative answer: Yes, infected migratory birds from Southeast Asia are a potential route of introduction. Introduction via the import of poultry or fighting cocks is negligible.

Are there effective control measures available? Yes, vaccination and quarantine are effective for poultry species, but are not a viable option for wild birds.

Do environmental conditions support reservoirs/vectors? Yes.

Will there be human, livestock, or endemic wildlife exposure? Yes, livestock and endemic wildlife exposures are possible. NDV can be particularly harmful to columbid species and therefore pose a risk to the endangered fruit doves.

Are affected populations highly susceptible? Yes.

Is the agent highly infectious to affected populations via hosts or vectors? Yes, wild bird populations are highly susceptible to NDV.

Risk category: Minimal

Alternative risk category: High

IMPACT OF INFECTION (Figure A5-32)

Is there spread to affected populations? Yes, NDV spreads readily among wild birds.

Are wildlife hosts and/or vector populations present in the Micronesia Region? Yes, wild bird species expected to be susceptible to the agent are present.

Are affected populations susceptible? Yes.

Does the agent cause severe disease in affected populations? No, many bird species remain asymptomatic.

Alternative answer: Yes, certain pathotypes of the agent are capable of causing severe morbidity and high mortality certain of wild bird species (e.g., columbids).

Is the agent highly infectious to affected populations? Yes.

Are effective interventions available? No, there are no feasible interventions for wild bird populations.

Would a large proportion of affected populations be seriously impacted? No, only select species are expected to be seriously impacted.

Risk category: Moderate

Alternative risk category: Moderate

Figure A5-31: Probability of Infection with Newcastle Disease Virus in the Micronesia Region

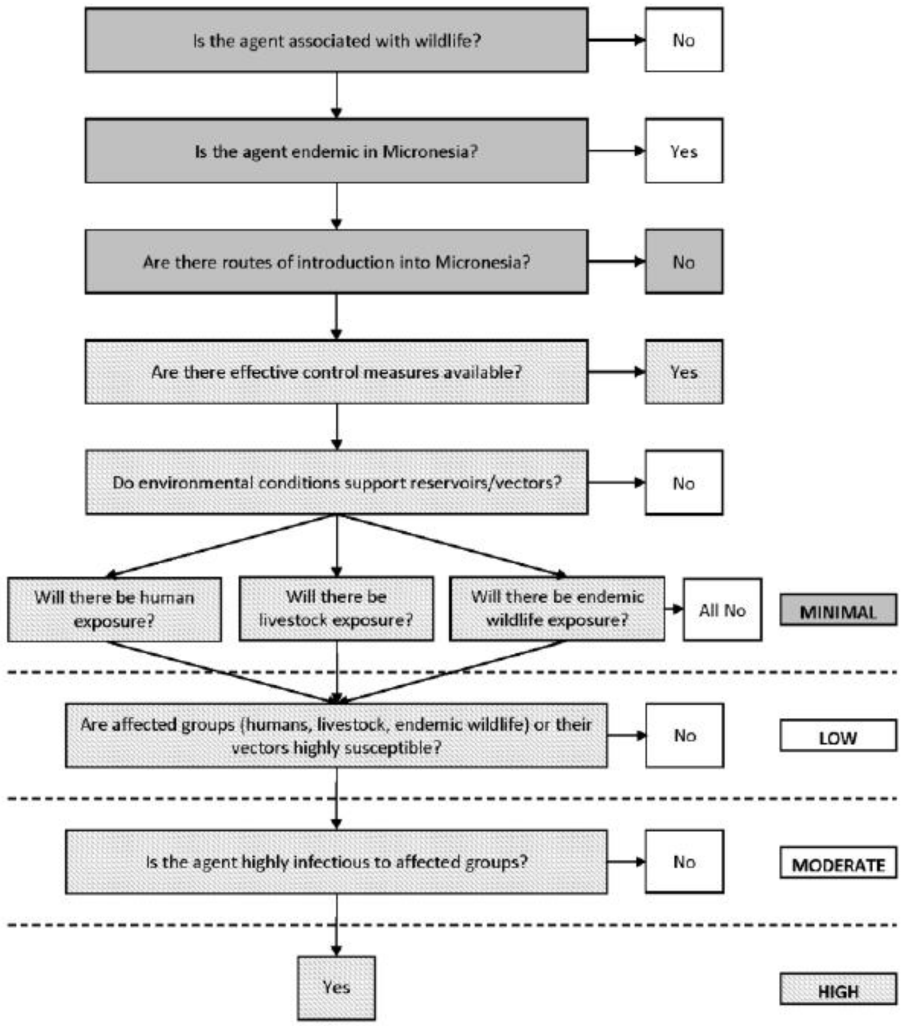
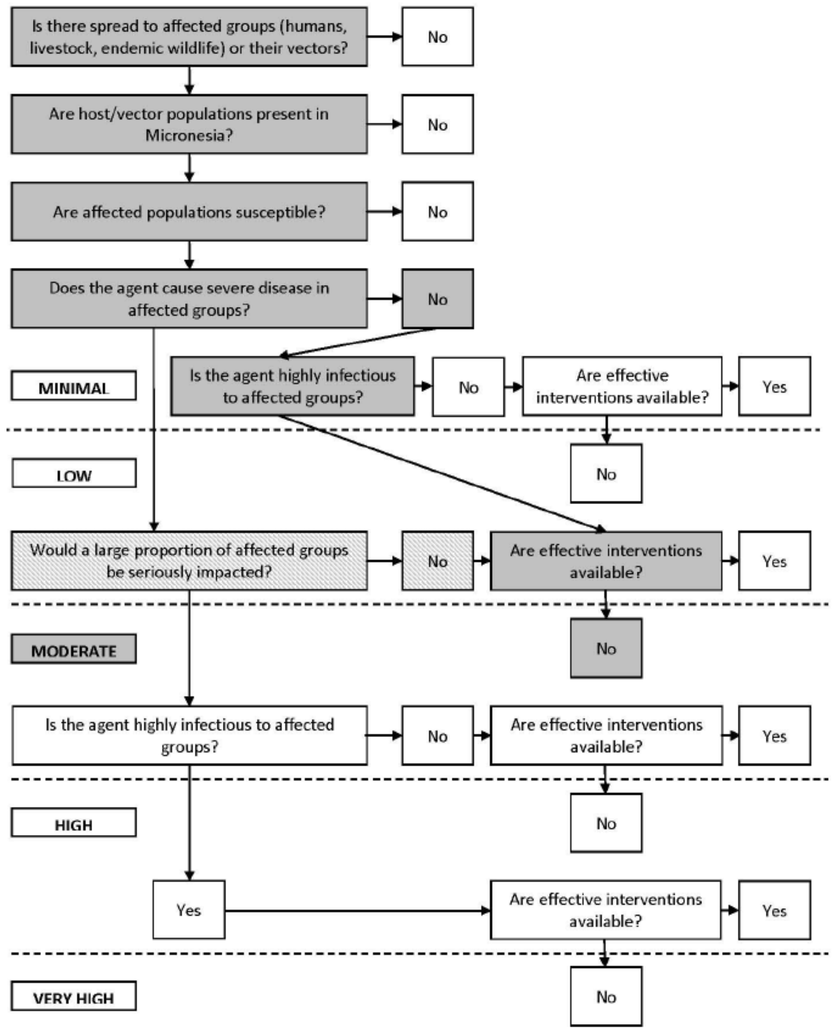


Figure A5-32: Impact of Infection with NDV in the Micronesia Region



The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk assignment is considered, it is represented as light gray in the flow chart.

YERSINIA PESTIS (PLAGUE) (described in Section A5.2.3.1)

PROBABILITY OF INFECTION (Figure A5-33)

Is the agent associated with wildlife? Yes, rodents and their associated fleas.

Is the agent endemic in the Micronesia Region? No.

Are there routes of introduction into the Micronesia Region? Yes, introduction of infected rodents and their fleas is possible via shipping and air cargo originating from Southeast Asia or the West Coast of North America.

Are there effective control measures available? Yes, environmental management (e.g. use of appropriate insecticides in response to plague outbreaks), public health education, and preventive drug therapy are effective control measures for reducing the impact of plague on humans.

Risk category: Minimal

IMPACT OF INFECTION (Figure A5-34)

Is there spread to affected populations? Yes, if introduced, *Yersinia pestis* would likely spread to reservoir rodent species and could subsequently spread to humans as a spillover species.

Are wildlife hosts and/or vector populations present in the Micronesia Region? Yes.

Are affected populations susceptible? Yes.

Does the agent cause severe disease in affected populations? Yes, plague has the potential to cause severe disease in humans.

Would a large proportion of affected populations be seriously impacted? No, only humans in close contact with infected rodents would be impacted.

Are effective interventions available? Yes.

Risk category: Low

Figure A5-33: Probability of Infection of *Yersinia pestis* (Plague) in the Micronesia Region

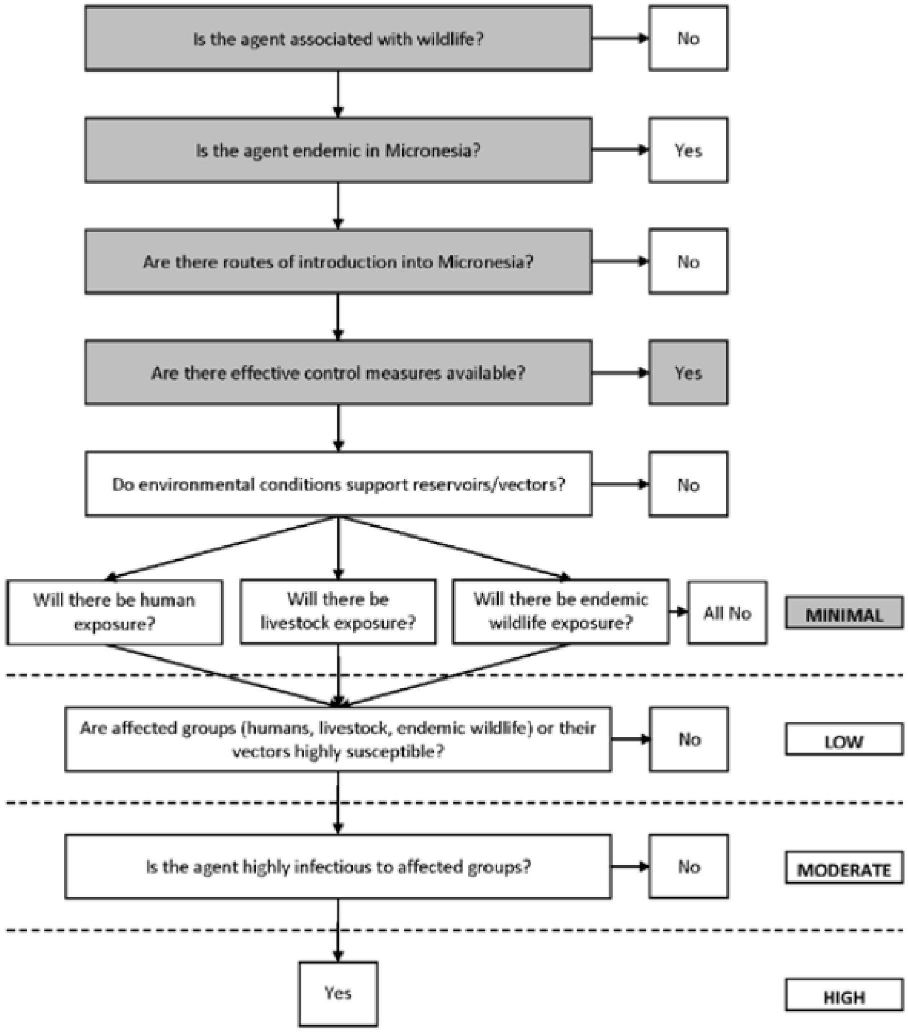
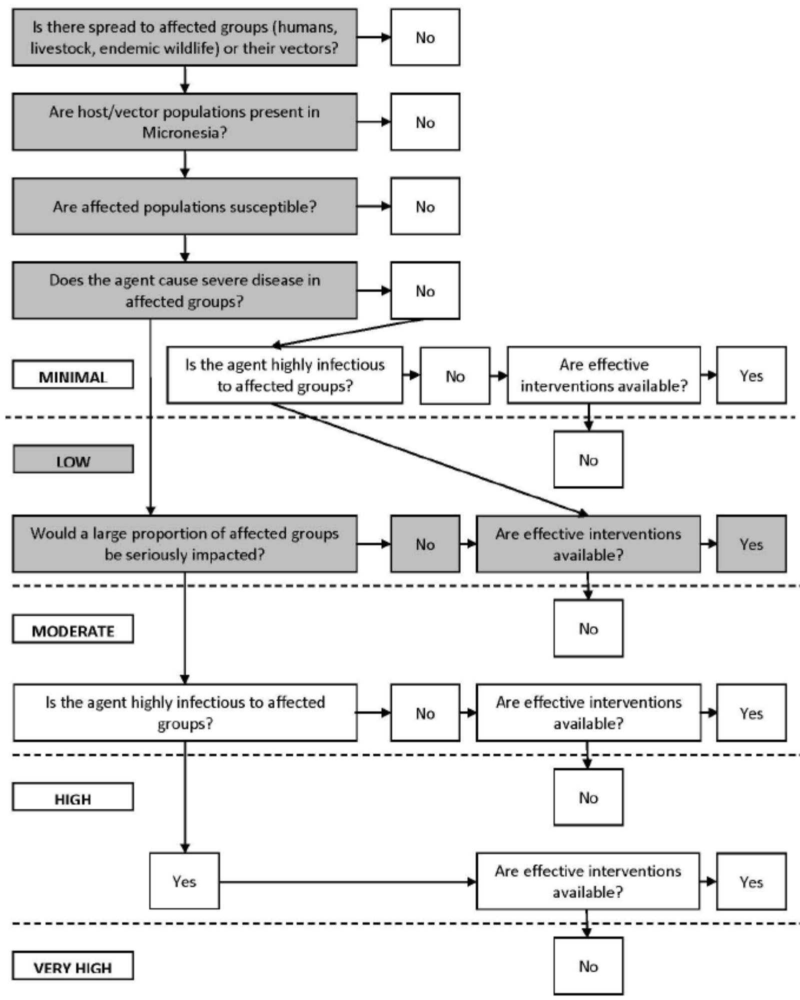


Figure A5-34: Impact of infection with *Yersinia pestis* (Plague) in the Micronesia Region



The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk assignment is considered, it is represented as light gray in the flow chart.

TICK-BORNE ENCEPHALITIS (described in Section A5.2.3.1)

PROBABILITY OF INFECTION (Figure A5-35)

Is the agent associated with wildlife? Yes, small rodents are important in the transmission cycle with incidental infection of larger mammals and birds.

Is the agent endemic in the Micronesia Region? No, the virus has never been isolated in the Micronesia Region.

Are there routes of introduction into the Micronesia Region? Yes, infected ticks or stowaway rodents may be introduced via shipping or cargo planes.

Are there effective control measures available? Yes, a vaccine is available for mitigation of human infections, but if the virus becomes established in rodent and tick populations, establishment is possible.

Do environmental conditions support reservoirs/vectors? Yes, the climate is appropriate and a genus of competent ticks has been identified in Palau.

Will there be human, livestock, or endemic wildlife exposure? Yes, human, livestock, and endemic wildlife exposure are possible.

Is the agent highly infectious to affected populations? Yes, humans and other mammals are highly susceptible, but most infections are asymptomatic.

Is the agent readily transmitted to affected populations via hosts or vectors? Yes, the agent is readily transmissible between rodents and ticks and between ticks and ticks.

Risk category: High

IMPACT OF INFECTION (Figure A5-36)

Is there spread to affected populations? Yes, the agent would be expected to spread readily via rodents where appropriate tick species have been identified (e.g., Palau).

Are wildlife hosts and/or vector populations present in the Micronesia Region? Yes, rodents and livestock are present and the vector is present in Palau.

Are affected populations susceptible? Yes, humans are very susceptible.

Does the agent cause severe disease in affected populations? No, TBEV does not cause severe disease in a majority of humans.

Alternative answer: Yes, while many humans experience asymptomatic or mild disease symptoms, others experience severe disease.

Is the agent highly infectious to affected populations? Yes.

Are effective interventions available? Yes, a vaccine is available for humans.

Would a large proportion of affected populations be seriously impacted? No, most cases are asymptomatic.

Risk category: Low

Alternative risk category: Moderate

Figure A5-35: Probability of Infection with TBEV in the Micronesia Region

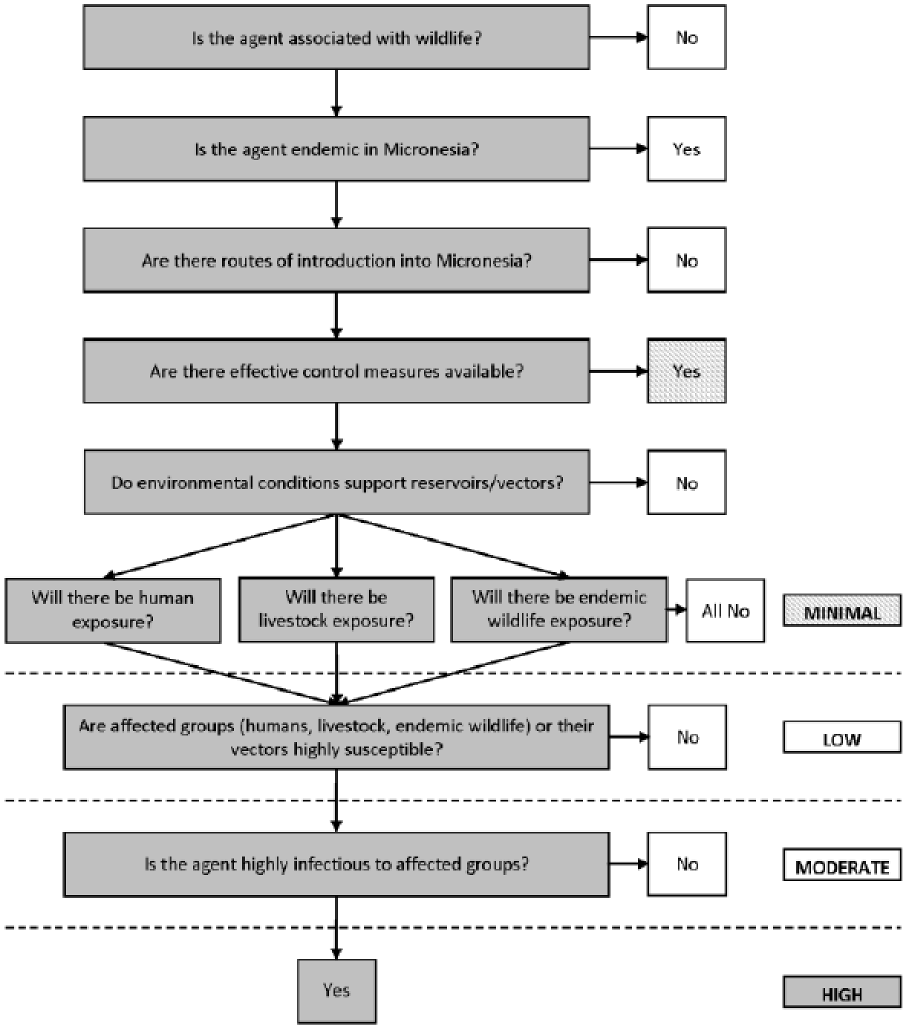
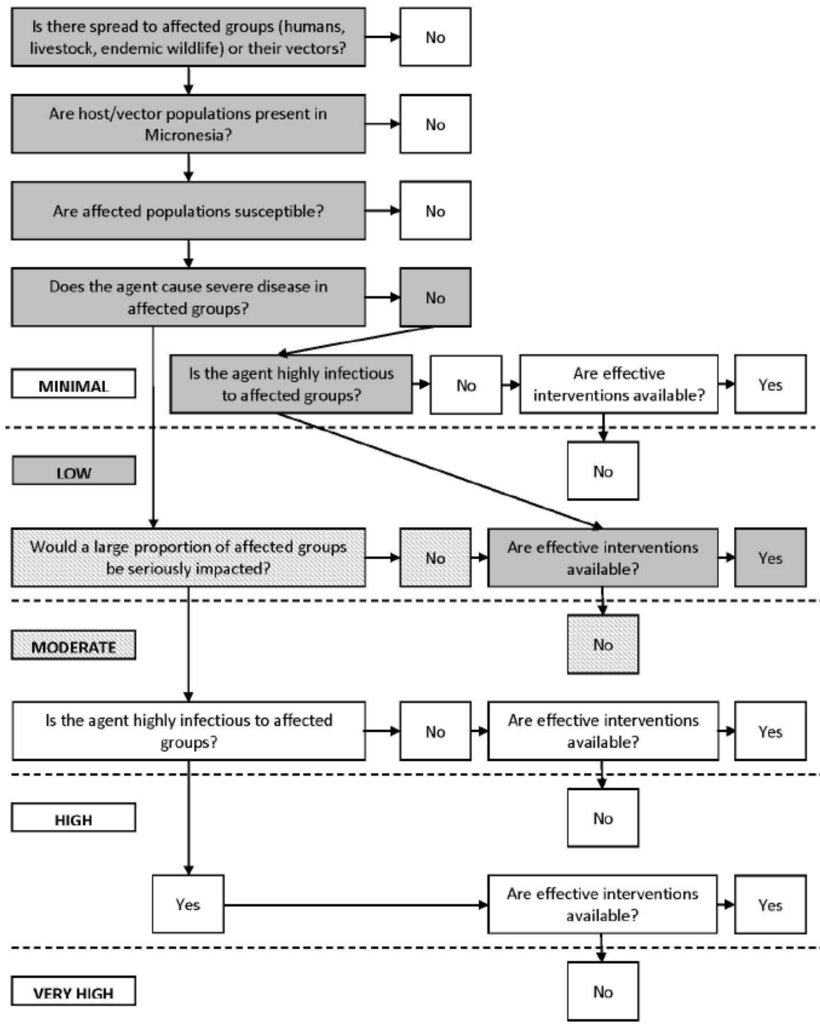


Figure A5-36: Impact of Infection with TBEV in the Micronesia Region



The more likely path and risk level assignment is filled as dark gray and, if an alternative path and risk assignment is considered, it is represented as light gray in the flow chart.

Table A5-12: Summary of Risks for Introduction of Wildlife-Associated Pathogens into the Micronesia Region

Pathogen	Probability of infection risk category	Alternative risk category	Impact of infection risk category	Alternative risk category	Comments
Hantaviruses	Moderate	Minimal	Low		
Rabies virus	Minimal		Low		

Pathogen	Probability of infection risk category	Alternative risk category	Impact of infection risk category	Alternative risk category	Comments
WNV	Minimal	High	High		Alternative risk associated with potential introduction of WNV into Hawai'i or Alaska
AIV	High		Moderate	Moderate	Risk category partially based on proximity to Asia. Introduction more likely from natural bird movement than from DoD-associated introductions.
JEV	High		Minimal	Low	
Avian malaria parasites (*Plasmodium* spp.)	High	Minimal	Moderate	Moderate	
Henipaviruses	Minimal	High	Moderate	Moderate	While the risk of introduction is low an alternative risk was considered for possible pathogen introduction via smuggling of bats or movement of infected bats in air or shipping cargo.
NDV	Minimal	High	Moderate	Moderate	The risk of NDV introduction is low, but possible.
Yersinia pestis (plague)	Minimal		Low		
Tick-borne encephalitis	High		Low	Moderate	

A5.3 DISCUSSION AND CONCLUSIONS

Within this report, we have focused on wildlife-associated pathogens. Arthropod vectors, however, should not be discounted in the overall risk assessment in this region. For example, *Aedes albopictus* is an invasive mosquito species of Guam (GISIN 2010). Unfortunately, this species is thought to be a competent vector for several distinct arboviruses (Gratz 2004). Table A5-10 outlines many other mosquito species that occur on Guam and in CNMI.

A5.3.1 General Threat of Wildlife-Associated Diseases

Of the 1,415 infectious organisms (pathogens) known to cause disease in humans, the majority (61%) are zoonotic, i.e., transmissible between humans and animals (Taylor et al. 2001; Jones et al. 2008), and zoonotic pathogens are twice as likely to be associated with diseases that have recently emerged in humans (Taylor et al. 2001). Considering these figures, along with the large number of exotic species already established in many locations in the Micronesia Region, a general threat of wildlife-associated diseases in this region is apparent. Many introduced species have, at a minimum, a potential to introduce a novel pathogen to a new area. Furthermore, on islands with established host populations (e.g., rats), the introduction of a single animal that has acquired a pathogen could (dependent on a myriad of factors) potentially introduce this pathogen into a novel population.

A5.4 RECOMMENDATIONS

A5.4.1 Adaptive Management

Information on wildlife-associated pathogens is often incomplete so risk assessments and their associated recommendations must be updated as new information becomes available. Moreover, distributions of pathogens, hosts, and vectors can change in response to changing environmental conditions, movements, or introductions. As conditions change, risk assessments need to be re-evaluated to determine if risks and associated recommendations need to be updated.

Adaptive management has been widely used in natural resource management (Nichols and Williams 2006) but has direct application to biosecurity. It is framed within structured decision making and emphasizes uncertainty about responses to management actions with the general objective being to reduce that uncertainty in order to improve management (Williams et al. 2007). Thus, adaptive management is an iterative learning process producing improved understanding and improved management over time. In terms of biosecurity, initial measures to prevent introduction of wildlife-associated diseases should be implemented with a surveillance and monitoring strategy to “test” whether measures are performing adequately, with these measures subsequently adjusted to improve biosecurity.

A5.4.2 General Recommendations

The importation of wildlife diseases into the Micronesia Region is a potential threat to human, agriculture, and wildlife health in this region. Although it is clear that the risk of the establishment of some pathogens is far greater than risks of others, a diversity of pathogens could have negative consequences to the Micronesia Region if they are introduced onto islands that are free of the pathogens in question. The importation of live animals (intentional or unintentional) is one of the biggest risk factors associated with the introduction of wildlife-associated pathogens in the Micronesia Region. Once established in this region, the movement of these pathogens to other islands in the Micronesia Region may increase due to the close proximity of some of the islands and frequent transportation events among islands. In general, prevention is more effective and more cost efficient than eradication (Kingsford et al. 2009). Consequently, investment in prevention measures is a high priority for reducing the risk of introduction of wildlife-associated diseases into this region.

A5.4.3 Specific Recommendations

Recently, it was suggested that the potential for importation of etiological agents causing zoonoses that could pose a major public health threat warrants that enhanced surveillance be conducted on imported wildlife in the United States (Pavlin et al. 2009). There is little doubt that this suggestion is warranted in other regions, such as the Micronesia Region. Some specific recommendations to prevent the importation of wildlife-associated diseases into the Micronesia Region include these:

- Strengthen USFWS inspections and interdiction capabilities.
- Extend training of customs personnel to be enhanced for wildlife surveillance and to recognize taxonomic groups that are a large threat to pathogen introduction.
- Use employee-trained dogs to detect wildlife and wildlife products.
- Ideally, all trade in live wildlife and wildlife products should be illegal or, at a minimum, heavily regulated and highly discouraged.
- Develop outreach programs to inform the public and military about the negative (and in some cases, lethal) consequences of wildlife disease introductions.
- Stop existing wildlife populations from interacting with introduced wildlife at ports of entry.
- Conduct background surveys at ports of entry to ensure customs and quarantine personnel are familiar with the local animals in the area.
- Develop a reference collection of plausible wildlife (i.e., taxidermy mounts) to aid in the identification of incoming species. In addition, adequate resources (taxonomic keys, microscopes) should be available for the assistance in taxonomic identifications.
- Set up an agreement with a genetics laboratory to identify species that cannot be identified through general morphology. In some instances, a genetics laboratory might also be useful in determining the origins of wildlife if an appropriate marker library has been developed for the species in question.
- Develop action plans for inadvertent wildlife introductions.
- Randomly sample imports (e.g., cargo containers, ships, planes) for wildlife. This may include actively trapping in the aforementioned vessels and containers to detect small, nocturnal, and secretive species. Be aware that some wildlife species are nocturnal while others are diurnal. As such, sampling programs may need to be modified to account for this behavioral ecology.
- Conduct periodic inspections of markets and pet shops for prohibited species.
- Utilize active rodent control methods in areas harboring incoming cargo.
- Establish surveillance/early detection programs for pathogens emerging in Pacific Rim countries.
- Establish isolated and/or captive populations of endemic wildlife to prevent extinction in response to outbreaks.

A5.5 ACKNOWLEDGMENTS

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A6 LIVESTOCK AND POULTRY DISEASES[9]

A6.1 SUMMARY

The following risk assessment was prepared to identify the increased risks of poultry and livestock disease agents entering the Micronesia Region as a result of the planned military relocation on Guam. We used primary data sources whenever possible, supplemented by substantial literature review when they were not, and used standard methods defined by the OIE.

We limited our consideration of the impacts to humans and pet dogs, cats, and birds to those that arise from their association with livestock or poultry disease hazards. In interpreting our findings, it is also important to note that we did not assess or define a baseline risk, but focused only on that incremental change in risk attributable to the influx of people and the associated changes that will come during the course of the relocation. The inevitable outcome of this approach is the paradox that we may conclude a risk to be present or even significant, yet discount it from further consideration if there is not an increase in risk that we can attribute to the military relocation. This is an unfavorable shortcoming of the approach used and should not be overlooked.

Our key findings are summarized in Table A6-1 below and at the end of this document. An estimate appears for each of the possible means (pathways) by which a given hazard might be introduced into Guam or the Micronesia Region. We considered the various preventive measures that might be in place, including regulations, prohibitions and inspection procedures, and which when effective, should mitigate against a hazard (although in reality these measure are likely not currently fully functional and without significant capacity building efforts will remain as such even for current import levels). Conversely we provide an estimate for the possible illegal pathways that might bypass these measures, including smuggling activities. If we assume that a hazard could be released, we estimated the likelihood that animals will become exposed, thereby allowing for spread and establishment of the hazard. Finally, we provide a combined estimate of risk that incorporates likelihood of hazard release and exposure, with an estimate of consequences to Guam, the Micronesia Region, and the rest of the United States.

We found that in most cases regulations are in place to mitigate the likelihood of the hazard being introduced. Further, we found that any incremental increase in risk for most hazards, specifically related to the relocation, was relatively small. However, there are pathways where the increased traffic related to the relocation may overwhelm the mitigations currently in place. Current mitigation measures are already overwhelmed in most locations and in need of additional capacity support. In addition, these same mitigation measures could be bypassed by illegal means in certain pathways, or if the measures were inconsistently or ineffectively applied. Smuggling of poultry or the illegal importation of food and

[9] This section was prepared by: 1)APHIS-Veterinary Services, Centers for Epidemiology and Animal Health, 2150 Centre Avenue, Building B, Fort Collins, Colorado 80526; 2) Veterinary Services, Western Region Office, Fort Collins, Colorado; and 3) Veterinary Services, National Center for Import and Export, Regionalization Evaluation Services, Raleigh, North Carolina. Suggested citation: Veterinary Services, Centers for Epidemiology and Animal Health. 2010. Livestock and poultry diseases. In Terrestrial plant and animal health risks associated with the U.S. military build-up in the Micronesian Region. United States Department of Agriculture, Animal and Plant Health Inspection Service. Washington, D.C.

other animal products would bypass the normal regulations and inspection procedures, as might the improper disposal of domestic and international garbage. Each of these hazards could result in the introduction and spread of foreign animal disease agents to susceptible domesticated and feral animals. In addition, their impact could extend beyond Guam and the Micronesia Region, posing a risk for spread to the rest of the United States that could impact trade with other countries. While the risks for any given hazard associated with the relocation are relatively low, it is these types of hazards that should receive attention as plans proceed.

Table A6-1: Summary of Risk Analysis Results

	Release Assessment			Consequence Assessment			
Pathway	**Legal introduction**	**Illegal introduction**	**Exposure assessment**	**Guam**	**Micronesia Region**	**United States[c]**	**Risk estimation**
Livestock[a]	Negligible	Negligible	N/A[b]	N/A	N/A	N/A	Negligible
Poultry	Negligible	Very low	Medium	Low	Low	Medium	Low
Non-poultry birds	Negligible	Very low	Very low	Low	Low	Medium	Very low
Cats and dogs	Negligible	Negligible	N/A	N/A	N/A	N/A	Negligible
Other animals[d]	Low	Low	Low	Very low	Very low	Medium	Low
Humans	Negligible	Negligible	N/A	N/A	N/A	N/A	Negligible
Animal products	Negligible	Low	Medium	Low	Low	Medium	Low
Garbage	Negligible	Very low	Medium	Low	Low	Medium	Low
Other cargo	Very low	N/A	Medium	Very low	Very low	Very low	Very low
Conveyances	Very low	N/A	Medium	Very low	Very low	Very low	Very low

[a] Domesticated equids.
[b] Not applicable. We conducted exposure and consequence assessments only for those pathways for which the release assessment result was non-negligible.
[c] Rest of the United States, other than Guam.
[d] Reptiles.

A6.2 INTRODUCTION

This analysis was prepared by USDA-APHIS, at the request of the DoD. The purpose of this analysis is to assess the likelihood that the military relocation will be associated with an increase in the risk of livestock or poultry infection in the Micronesia Region with a disease agent that is exotic to the region. For the purpose of this risk assessment, we define a disease agent as an etiologic agent of an OIE-notifiable disease of livestock or poultry (OIE 2010e).

While the scope of this risk analysis includes the entire Micronesia Region, many of the perspectives presented herein focus on Guam. The majority of DoD activities will occur directly on Guam, making this the area where consequences will be felt most immediately. In addition, Guam is the largest point of entry for the Micronesia Region, serving as both the gateway and bellwether for the rest of the Region; one assumption of our analysis is that exotic species issues significant in Guam are relevant throughout the Micronesia Region. Because Guam serves as a hub to the rest of the Micronesia Region, the risk to Guam serves as a proxy for the entire Micronesia Region. It may be convenient for importers to use

CNMI for transshipment of goods needed for the relocation on Guam. However, they would still need to comply with CNMI regulations, which, for animal disease concerns, are similar to those in the rest of the Micronesia Region. We consider impacts to individual islands in the Region if there is a specific concern associated with the pathway.

We include impacts to human and companion animal health only as related to the livestock and poultry disease agents that we consider. We consider wildlife and feral animals only as potential vehicles for exposure or spread of disease agents or their vectors. It is important to note that livestock are culturally important in the Micronesia Region, and cultural and societal impacts might be more significant than economic consequences; however, this assessment does not take into consideration these intrinsic values.

A6.3 RISK ASSESSMENT

A6.3.1 Methods

The methods we use in this risk analysis follow the guidelines outlined in the OIE Terrestrial Animal Health Code for import risk analysis (OIE 2010c). An import risk analysis, as defined by the OIE, includes a hazard identification step, followed by a risk assessment. The risk assessment components are release, exposure, and consequence assessments, followed by risk estimation. Below, we briefly summarize the methods we used for each step of this analysis. We used a qualitative approach in our analysis because insufficient information is available for meaningful quantitative assessment.

A6.3.1.1 *Hazard Identification Methods*

For the purpose of this analysis, we define a hazard as a disease agent that causes clinical illness in livestock or poultry, or an arthropod vector of such a disease agent. We limit disease agents to the etiologic agents of OIE-notifiable diseases of livestock and poultry (OIE 2010e). Animal diseases are listed as OIE-notifiable based on potential for rapid or international spread, zoonotic transmission, or significant mortality or morbidity, by agreement of the World Assembly of OIE Delegates (OIE 2010b, a). We define livestock and poultry as follows.

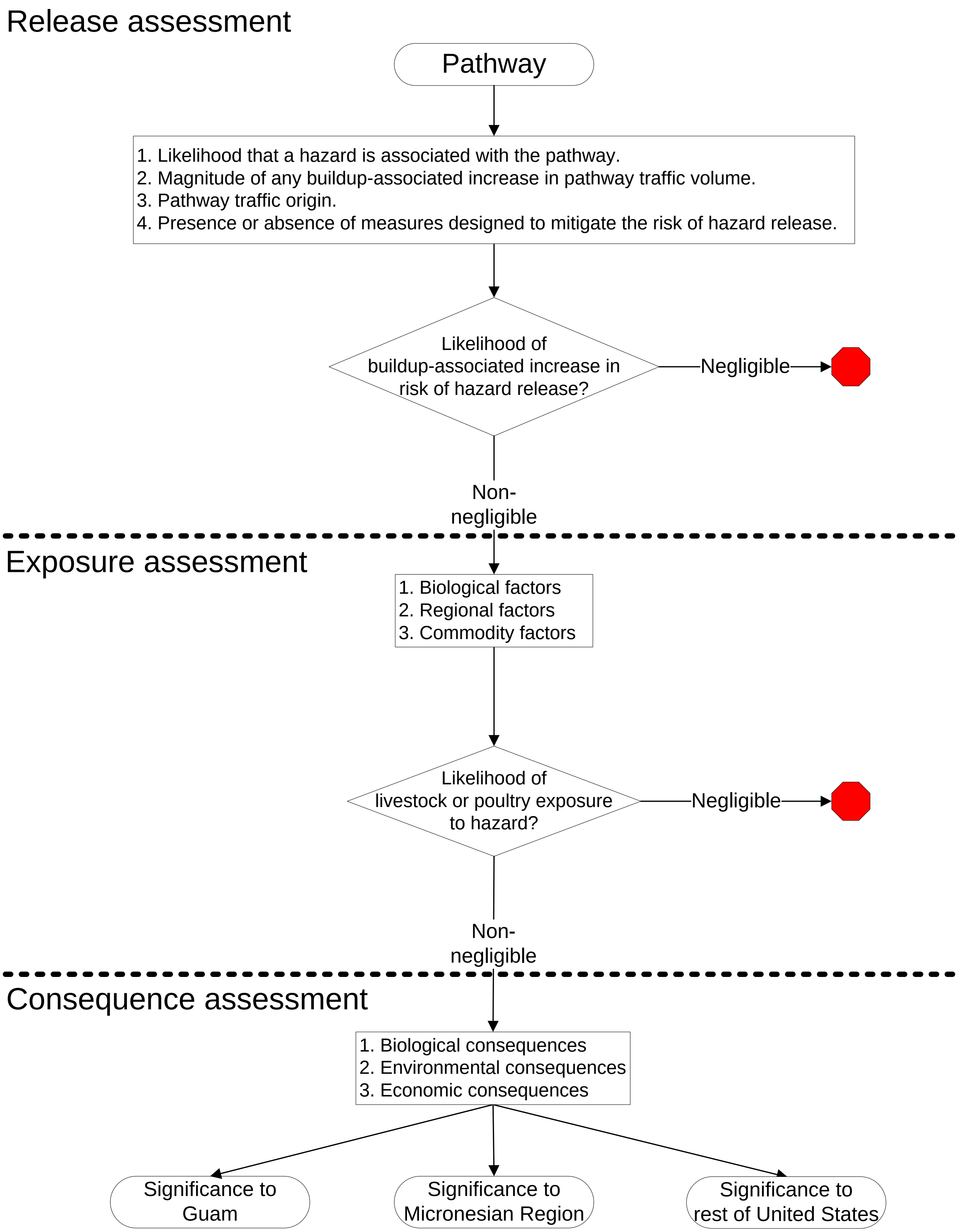
- Livestock: Domesticated ruminants (cattle, carabaos, sheep, and goats), domesticated swine including feral swine, and domesticated equids (horses, mules, and asses).
- Poultry: Chickens, doves, ducks, geese, grouse, guinea fowl, partridges, peafowl, pheasants, pigeons, quail, swans, and turkeys, including eggs for hatching (9 CFR § 93.100).

We excluded from our analysis hazards that are known or suspected to be present in the Micronesia Region.

A6.3.1.2 *Pathways Risk Analysis Methods*

First, we identified and characterized pathways by which hazards could be released into the Micronesia Region. Second, we determined which pathways are likely to increase in traffic volume as a direct or indirect result of the military relocation. For each pathway likely to increase in traffic volume as a result of the relocation, we performed a risk assessment, consisting of release, exposure, and consequence assessments, as outlined in Figure A6-1.

Figure A6-1: Risk Assessment: Release, Exposure, and Consequence Assessments



For each pathway likely to increase in traffic volume as a result of the relocation, we qualitatively assessed the likelihood that the military relocation will be associated with an increase in the risk of hazard release into the Micronesia Region through that pathway. Hazard release into the Micronesia Region by any of the pathways requires the presence of the hazard in the country of origin; the presence of the hazard in the pathway; and passage of the hazard through any mitigation procedures, such as inspection or quarantine. Therefore, for each release pathway, we based our likelihood estimation on: 1) the likelihood that a hazard is associated with the pathway, 2) the magnitude of any relocation-associated anticipated increase in pathway traffic volume, 3) pathway traffic origin, and 4) the presence or absence of measures in place that are designed to mitigate the risk of hazard release.

Then, for each pathway for which the release assessment result was non-negligible, we qualitatively assessed the likelihood of exposure of livestock or poultry in the Micronesia Region to hazards released through that pathway. We based our likelihood estimation on: 1) biological factors, such as disease agent survival characteristics; 2) regional factors, such as cultural practices and livestock demographics; and 3) commodity factors, such as the intended use of imported animals.

We expressed our likelihood estimates for release and exposure qualitatively, as negligible, very low, low, medium, high, or very high. These categories are intended to indicate relative likelihoods among the pathways. The levels are described in Table A6-2.

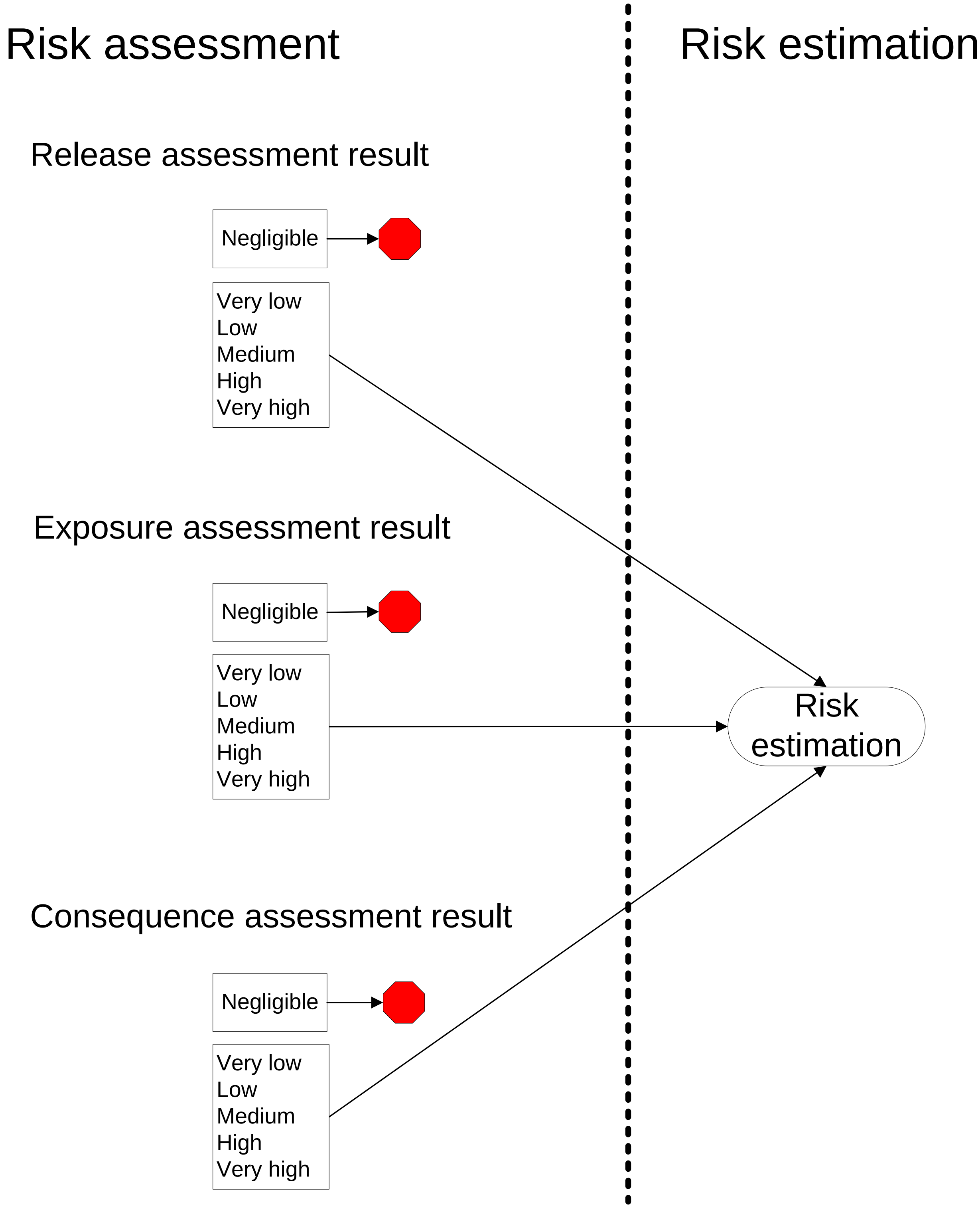
Table A6-2: Risk Assessment Estimation Terms and Definitions

Term	Definition
Negligible	So rare that it does not merit consideration
Very Low	Very rare but cannot be excluded
Low	Rare but does occur
Medium	Occurs regularly
High	Occurs very often
Very High	Occurs extremely often

For each pathway for which the exposure assessment result was non-negligible, we qualitatively evaluated the consequences of livestock or poultry exposure to hazards. The scope of the consequence assessment is limited to biologic, environmental, and economic consequences, in keeping with the OIE guidelines for import risk analysis (OIE 2010c). The biological consequences we considered include hazard characteristics, such as disease agent transmissibility; the number of susceptible host species; and the magnitude of impact of host species infection, in terms of morbidity and mortality. We considered biodiversity and impacts on environmental resources as environmental consequences of hazard exposure. The economic consequences we considered include the magnitude of production and trade losses and costs associated with surveillance and disease control as a result of host species exposure or infection.

We evaluated consequences in terms of significance to Guam, the Micronesia Region, and the rest of the United States, and expressed our results qualitatively as negligible, very low, low, medium, high, or very high. These categories are intended to indicate relative significance among the pathways.

Figure A6-2: Risk Estimation



For each pathway for which the consequence assessment result was non-negligible, we integrated the results of the release, exposure, and consequence assessments to produce an overall measure of risk posed by the pathway (Figure A6-2). We expressed risk levels qualitatively, as negligible, very low, low, medium, high, or very high. These categories are intended to indicate relative risk levels among the pathways.

A6.3.1.3 *Animal Health Data Sources and Limitations*

The information evaluated for this assessment includes data gathered from relevant scientific literature and other public sources, information provided to APHIS by the DoD, and information gathered by APHIS during two site visits to the Micronesia Region in November 2009 and January 2010. For information regarding livestock numbers and industry trends, we relied primarily on the most current USDA Census of Agriculture (2007) (USDA-NASS 2009b, a).

During the site visits to the Micronesia Region, APHIS staff interviewed staff of the University of Guam as well as federal and local government staff and agricultural industry representatives in Guam, CNMI, Palau, and FSM. Agencies represented include GCQA, GDOA, PPQ, the Joint Guam Program Office, the U.S. Army Veterinary Command, and NAVFAC Pacific. In addition, APHIS staff visited animal production facilities, animal research facilities, maritime and air ports of entry, postal facilities, and garbage handling facilities.

Veterinary and laboratory infrastructure is not well developed in the Micronesia Region, where no formal, systematic surveillance of animal health occurs (Poole 2009; SPC 2010). Therefore, little information is available regarding the status of animal health in the Micronesia Region. Our sources for animal health information include the OIE databases Handistatus II and the World Animal Health Information Database, which include sporadic reports for some island groups in the Micronesia Region from 1997 to 2010 (OIE 2004, 2010h). We also sourced reports of convenience sampling-based surveys of livestock health conducted in the 1990s in Guam, Palau, and FSM (Saville 1999; Duguies et al. 2000;Simms 2000).

Because data about tick interceptions from live animals, live plants, and inanimate articles arriving in Guam and elsewhere in the Micronesia Region are sparse, we used data on ticks intercepted from imports entering the United States to characterize the potential risks of tick-transporting pathways. Databases we used include the USDA national tick survey database which includes records from 1969 through 2006, and the USDA-APHIS-PPQ pest interception database which includes records from 1989 through 2009, as well as published reports of tick surveys (USDA-APHIS-VS CEAH 2006; USDA-APHIS-PPQ 2010a). Data on mosquitoes in tropical climates were more widely available.

In general, the data supporting this analysis are sparse and incomplete. Thus, our conclusions should be interpreted with caution, in the context of high levels of uncertainty.

A6.3.1.4 *Assumptions*

We assume that current regulations and inspection and quarantine procedures designed to mitigate hazard release are effectively enforced; and that the origins of pathway movement to the Micronesia Region will not substantially change as a result of the military relocation. We realize that our first assumption is not likely true, as is pointed out elsewhere within the MBP and this section. This is a unfortunate element of our risk assessment and may lead to less than ideal conclusions.

A6.3.2 Hazard Identification

We categorized our hazards as disease agents or vectors. Below, we list these hazards, further categorized based on whether they are known or suspected to be present in the Micronesia Region, or not known or suspected to be present in the Micronesia Region.

A6.3.2.1 *Disease Agents*

A list of disease agents that are known or suspected to be present in the Micronesia Region is presented in Table A6-3. Other disease agents might exist in the Micronesia Region, but where available data sources are not sufficient to allow us to conclude with confidence that they are present, we assume that they are not.

Because available data are inadequate to determine baseline and overall risk for the introduction of disease agents, our assessment is limited to the additional risk posed by the relocation on potential disease agents and their pathways. Similarly, we did not consider the risk for increased introduction of pathogens already known or believed to be present on Guam or in the Micronesia Region, nor new strains of these same pathogens. Thus, we did not consider these indigenous disease agents further in our analysis.

A list of disease agents that are not known or suspected to be present in the Micronesia Region is presented in Table A6-4. These disease agents are the focus of our analysis.

Table A6-3: Disease Agents Known or Suspected To Be Present in the Micronesia Region

Disease agent	Disease	References
	Multiple species	
Bluetongue virus	Bluetongue	Duguies et al. 2000; OIE 2004
Brucella melitensis	Ovine and caprine brucellosis	Benkirane 2006
Brucella suis	Swine brucellosis	OIE 2010h
Coxiella burnetii	Q fever	Duguies et al. 2000; OIE 2004
Leptospira spp.	Leptospirosis	Saville 1999; Duguies et al. 2000; Simms 2000, OIE 2004
Mycobacterium avium paratuberculosis	Paratuberculosis	Saville 1999
Pseudorabies virus	Aujeszky's disease	Simms 2000
Trichinella spp.	Trichinellosis	Saville 1999; OIE 2004
	Domesticated ruminants	
Anaplasma spp.	Bovine anaplasmosis	Duguies et al. 2000; OIE 2004
Babesia spp.	Bovine babesiosis	Duguies et al. 2000; OIE 2004
Bovine leukosis virus	Enzootic bovine leukosis	Saville 1999; Duguies et al. 2000; OIE 2004
Caprine arthritis/encephalitis virus	Caprine arthritis/encephalitis	Saville 1999
Infectious bovine rhinotracheitis/infectious pustular	Infectious bovine rhinotracheitis/infectious pustular	Saville 1999; Duguies et al. 2000; OIE 2004

Disease agent	Disease	References
vulvovaginitis virus	vulvovaginitis	
	Domesticated swine	
Taenia solium	Porcine cysticercosis	CFSPH 2005d
	Domesticated equids	
Equine herpesvirus-1	Equine rhinopneumonitis	Duguies et al. 2000
Equine influenza virus	Equine influenza	Duguies et al. 2000
Equine viral arteritis virus	Equine viral arteritis	OIE 2004
	Poultry	
Chlamydia psittaci	Avian chlamydiosis	Totten 2008
Gallid herpesvirus-2	Marek's disease	Duguies et al. 2000
Infectious bursal disease virus	Infectious bursal disease (Gumboro disease)	Saville 1999; Duguies et al. 2000
Infectious bronchitis virus	Avian infectious bronchitis	Saville 1999; Duguies et al. 2000
Infectious laryngotracheitis virus	Avian infectious laryngotracheitis	Duguies et al. 2000
Mycoplasma gallisepticum	Avian mycoplasmosis *(M. gallisepticum)*	Duguies et al. 2000
Mycoplasma synoviae	Avian mycoplasmosis *(M. synoviae)*	Duguies et al. 2000
Pasteurella multocida	Fowl cholera	(OIE 2008j

Table A6-4: Disease Agents not Known or Suspected to be Present in the Micronesia Region

Disease agent	Disease
	Multiple species
Bacillus anthracis	Anthrax
Brucella abortus	Brucellosis (*Brucella abortus*)
Cochliomyia hominivorax	New world screwworm myiasis
Chrysomya bezziana	Old world screwworm myiasis
Crimean Congo hemorrhagic fever virus	Crimean Congo hemorrhagic fever
Echinococcus granulosus; E. multilocularis	Echinococcosis/hydatidosis
Ehrlichia ruminantium	Heartwater
Foot and mouth disease virus	Foot and mouth disease
JEV	Japanese encephalitis
Leishmania spp.	Leishmaniasis
Rabies virus	Rabies
Rift Valley fever virus	Rift Valley fever
Rinderpest virus	Rinderpest
Vesicular stomatitis virus	Vesicular stomatitis
WNV	West Nile fever
	Domesticated ruminants
Bovine spongiform encephalopathy agent	Bovine spongiform encephalopathy
Bovine viral diarrhea virus	Bovine viral diarrhea
Brucella ovis	Ovine epididymitis
Campylobacter fetus venerealis; C. fetus fetus	Bovine genital campylobacteriosis
Capripoxvirus	Lumpy skin disease
Chlamydophila abortus	Enzootic abortion of ewes (ovine chlamydiosis)
Maedi-visna virus	Maedi-visna
Malignant catarrhal fever virus	Malignant catarrhal fever
Mycobacterium bovis	Bovine tuberculosis
Mycoplasma agalactiae; Mycoplasma spp.	Contagious agalactia

Disease agent	Disease
Mycoplasma capricolum capripneumoniae; M. mycoides capri	Contagious caprine pleuropneumonia
Mycoplasma mycoides mycoides	Contagious bovine pleuropneumonia
Nairobi sheep disease	Nairobi sheep disease
Pasteurella multocida subsp. *multocida*	Hemorrhagic septicemia
Peste des petits ruminants virus	Peste des petits ruminants
Salmonella Abortusovis	Paratyphoid abortion
Scrapie agent	Scrapie
Sheep pox and goat pox virus	Sheep pox and goat pox
Theileria spp.	Theileriosis
Tritrichomonas foetus	Trichomonosis
Trypanosoma spp. (African)	Trypanosomiasis (African animal)
	Domesticated swine
African swine fever virus	African swine fever
Classical swine fever virus	Classical swine fever
Nipah virus	Nipah virus encephalitis
Porcine reproductive and respiratory syndrome virus	Porcine reproductive and respiratory syndrome
Swine vesicular disease virus	Swine vesicular disease
Transmissible gastroenteritis virus	Transmissible gastroenteritis
	Domesticated equids
African horse sickness virus	African horse sickness
Babesia caballi and *Theileria equi*	Equine piroplasmosis
Burkholderia mallei	Glanders
Equine encephalomyelitis viruses (Eastern, Western, and Venezuelan)	Equine encephalomyelitis (Eastern, Western, and Venezuelan)
Equine infectious anemia virus	Equine infectious anemia
Taylorella equigenitalis	Contagious equine metritis
Trypanosoma equiperdum	Dourine
Trypanosoma evansi	Surra
	Poultry
Avian metapneumovirus	Turkey rhinotracheitis
Duck hepatitis virus types I, II, and III	Duck virus hepatitis
Exotic NDV	Exotic Newcastle disease
HPAIV	HPAI
Salmonella Gallinarum	Fowl typhoid
Salmonella Pullorum	Pullorum disease

A6.3.2.2 *Vectors*

Several of the disease agents that we consider in our analysis can be transmitted by arthropod vectors, such as ticks, mosquitoes, or midges. Introduction and establishment of exotic vectors can increase the likelihood of disease agent transmission to a susceptible vertebrate host (Korch Jr. 1994), and can be associated with disease outbreaks. For example, *Dermacentor (Anocenter) nitens*, a tick species that had not been seen in Florida prior to 1958, was the primary vector for an equine piroplasmosis outbreak in Florida during the 1960s (Strickland and Gerrish 1964: Knowles et al. 1966: Becklund 1968: Holbrook 1969).

Based on our list of disease agents (see Table A6-4), we developed a list of vectors of those disease agents. As we did for disease agents, we categorized the vectors based on whether they are known or suspected to be present in the Micronesia Region, or not known or suspected to be present in the Micronesian Region.

A list of vectors that are known or suspected to be present in the Micronesia Region is presented in Table A6-5. We did not consider these vectors further in our analysis. Although other vectors might be present in the Micronesia Region, where available data sources are not sufficient to allow us to conclude with confidence that they are present, we assume that they are not.

Table A6-5: Vectors Known or Suspected to be Present in the Micronesia Region

Vector	Disease	References
Tick		
Rhipicephalus (Boophilus) microplus	Equine piroplasmosis	Kohls 1953; Ueti et al. 2005; Wolf 2010
Mosquito[a]		
Aedes albopictus *Ae. pandani* *Ae. rotanus* *Ae. vexans*	*Aedes* spp. have been reported to transmit African horse sickness, equine encephalomyelitis (Eastern, Western, and Venezuelan), Japanese encephalitis, lumpy skin disease, Rift Valley fever, and vesicular stomatitis	CFSPH 2007h; Mackenzie 2007; CFSPH 2008c, a; OIE 2009n, p, v, f; Pepin et al. 2010; Wolf 2010
Anopheles indefinites	*Anopheles* spp. have been reported to transmit African horse sickness, equine encephalomyelitis (Western), Japanese encephalitis, and Rift Valley fever	Mackenzie 2007; CFSPH 2008a; OIE 2009p, f; Wolf 2010
Culex annulirostris *Cx. fusocephalus* *Cx. quinquefasciatus* *Cx. tritaeniorhynchus*	*Culex* spp. have been reported to transmit African horse sickness, equine encephalomyelitis (Eastern, Western, and Venezuelan), Japanese encephalitis, lumpy skin disease, Rift Valley fever, and West Nile fever	CFSPH 2007h; Mackenzie 2007; CFSPH 2008c, a, 2009q; OIE 2009n, p, f; Pepin et al. 2010; Wolf 2010
Other arthropod[a]		
Ceratopogonidae midges *Culicoides guttifer* *C. peregrinus*	Ceratopogonidae midges have been reported to transmit African horse sickness and vesicular stomatitis	CFSPH 2008g; OIE 2009f; Wolf 2010
Simulium aureohirtum *S. guamense*	*Simulium* spp. (blackflies) have been reported to transmit vesicular stomatitis	OIE 2009v; Wolf 2010
Stomoxys calcitrans	*Stomoxys* spp. have been reported to transmit equine infectious anemia and surra	CFSPH 2009n, i; OIE 2009t; Wolf 2010
Tabanus striatus	Tabanid flies have been reported to transmit equine infectious anemia, surra, and trypanosomiasis (African animal)	CFSPH 2009a, i; OIE 2009t; Wolf 2010

[a] Not all species of all families or genera transmit each of the etiologic agents of the diseases listed.

A list of vectors that are not known or suspected to be present in the Micronesia Region is presented in Table A6-6. These vectors we considered further in our analysis.

Table A6-6: Vectors Not Known or Suspected to be Present In the Micronesia Region

Vector[a,b]	Disease	References
Tick		
Amblyomma cajennense	Equine piroplasmosis	OIE 2009c
A. variegatum	Heartwater; Nairobi sheep disease; theileriosis	Musisi et al. 1984; CFSPH 2007g, 2009l
Amblyomma spp.	Heartwater; theileriosis	CFSPH 2007g, 2009p
Dermacentor (Anocentor) nitens	Equine piroplasmosis	Roby and Anthony 1963
D. marginatus	Equine piroplasmosis	Friedhoff 1988
D. nuttalli	Equine piroplasmosis	Friedhoff 1988; Rüegg et al. 2007
D. reticulatus	Equine piroplasmosis	Friedhoff 1988
D. silvarum	Equine piroplasmosis	Friedhoff 1988
Haemaphysalis intermedia	Nairobi sheep disease	CFSPH 2009l
Haemaphysalis spp.	Theileriosis	CFSPH 2009p
Hyalomma anatolicum subspecies anatolicum and *excavatum*	Equine piroplasmosis	Neitz 1956; Friedhoff 1988; Zapf and Schein 1994; Kumar et al. 2007; Taylor et al. 2007
Hy. dromedarii	Equine piroplasmosis	Neitz 1956; Zapf and Schein 1994
Hy. lusitanicum	Equine piroplasmosis	Zapf and Schein 1994; Kahn and Line 2008
Hy. marginatum	Equine piroplasmosis	Neitz 1956; Friedhoff 1988; Taylor et al. 2007
Hy. scupense (=Hy. detritum)	Equine piroplasmosis	Enigk 1944; Taylor et al. 2007
Hy. truncatum	Equine piroplasmosis	De Waal and van Heerden 2004; Rothschild and Knowles 2007
Hyalomma spp.	African horse sickness; theileriosis	CFSPH 2009p; OIE 2009f
Ornithodoros marocanus (erraticus)	African swine fever	Kahn and Line 2008
O. porcinus porcinus (O. moubata porcinus)	African swine fever	Kahn and Line 2008
Rhipicephalus appendiculatus	Nairobi sheep disease	CFSPH 2009l
R. bursa	Equine piroplasmosis	Enigk 1943; Neitz 1956; Taylor et al. 2007
R. evertsi evertsi	Equine piroplasmosis	Young and Purnell 1973, Potgieter et al. 1992, De Waal and van Heerden 2004
R. pulchellus	Nairobi sheep disease	CFSPH 2009l
R. simus	Nairobi sheep disease	CFSPH 2009l
Rhipicephalus spp.	African horse sickness; theileriosis	CFSPH 2009p; OIE 2009f
Mosquito		
Aedes spp.	African horse sickness; equine encephalomyelitis (Eastern, Western, and Venezuelan); Japanese encephalitis; lumpy skin disease; Rift Valley fever; vesicular stomatitis	CFSPH 2007h; Mackenzie 2007; CFSPH 2008c, a; OIE 2009n, p, v, f; Pepin et al. 2010
Anopheles spp.	African horse sickness; equine encephalomyelitis (Western); Japanese encephalitis; Rift Valley fever	Mackenzie 2007; CFSPH 2008a; OIE 2009p, f
Coquilletidia perturbans	Equine encephalomyelitis (Eastern)	CFSPH 2008a

Vector[a,b]	Disease	References
Culex spp.	African horse sickness; equine encephalomyelitis (Eastern, Western, and Venezuealan); Japanese encephalitis; lumpy skin disease; Rift Valley fever; West Nile fever	CFSPH 2007h; Mackenzie 2007; CFSPH 2008c, a, 2009q; OIE 2009n, p, f; Pepin et al. 2010
Culiseta melanura	Equine encephalomyelitis (Eastern)	CFSPH 2008a
Eretmapodites spp.	Rift Valley fever	OIE 2009p; Pepin et al. 2010
Mansonia spp.	Equine encephalomyelitis (Venezuelan); Japanese encephalitis; Rift Valley fever	Mackenzie 2007; CFSPH 2008a; OIE 2009p
Ochlerotatus spp.	Equine encephalomyelitis (Eastern); Japanese encephalitis; West Nile fever	Mackenzie 2007; CFSPH 2008a, 2009q
Psorophora spp.	Equine encephalomyelitis (Venezuelan)	CFSPH 2008a
Other arthropod		
Atylotus spp.	Surra	CFSPH 2009n; OIE 2009t
Chrysops spp.	Equine infectious anemia; surra	CFSPH 2009i, n
Culicoides spp.	African horse sickness; vesicular stomatitis	CFSPH 2008g; OIE 2009f
Glossina spp.	Trypanosomiasis (African animal)	CFSPH 2009a
Haematopota spp.	Surra	CFSPH 2009n
Hybomitra spp.	Equine infectious anemia	CFSPH 2009i
Lutzomyia spp.	Leishmaniasis; vesicular stomatitis	CFSPH 2009k; OIE 2009v
Lyperosia spp.	Surra	CFSPH 2009n; OIE 2009t
Musca spp.	Surra	CFSPH 2009n; OIE 2009t
Phlebotomus spp.	Leishmaniasis; vesicular stomatitis	CFSPH 2009k; OIE 2009v
Simuliidae	Vesicular stomatitis	OIE 2009v
Stomoxys calcitrans	Equine infectious anemia	CFSPH 2009i
Stomoxys spp.	Surra	CFSPH 2009n, OIE 2009t
Tabanidae	Trypanosomiasis (African animal)	CFSPH 2009a
Tabanus spp.	Equine infectious anemia; surra	CFSPH 2009i; OIE 2009t

[a] Species other than those listed in Table A6-5.

[b] Not all species of all families or genera transmit each of the etiologic agents of the diseases listed.

A6.3.3 Pathways Risk Analysis

Hazards can move into, through, or out of the Micronesia Region through any of numerous pathways, including movement of infected live animals or contaminated cargo. Types of movement can be categorized in terms of whether the movement is initiated by people (intentional movement), proceeding through either legal or illegal means, or not initiated by people (accidental movement), such as through natural spread or stowing away on conveyances. For the purpose of this analysis, stowaways are animals, including arthropods, which are carried by, but are not biologically associated with, a conveyance.

We defined pathways based on categories of traffic movement to which animal health import risk mitigations are typically applied (CFR; 9 GARR 1, Division 1, Chapter 1; OIE 2010g; USDA-APHIS 2010b). Table A6-7 lists the pathways that we considered feasible for transporting hazards along with the expected direct and indirect effects of the military relocation on pathway traffic volume, based upon the data and discussion elsewhere in this document. We excluded from further analysis pathways for which traffic volume is not expected to increase as a result of the relocation.

Table A6-7: Pathways and the Effect of the Military Relocation on Pathway Traffic Volume

Pathway	Description	Effect of military Relocation on Pathway Traffic Volume
Livestock		
Domesticated ruminants	Cattle, carabaos, goats, and sheep	No effect
Swine	Domesticated swine, including feral swine	No effect
Domesticated equids	Horses, mules, and asses	Increase
Livestock germplasm	Semen, ova, and embryos of livestock	No effect
Birds		
Poultry	Chickens, doves, ducks, geese, grouse, guinea fowl, partridges, peafowl, pheasants, pigeons, quail, swans, and turkeys, including eggs for hatching	Increase
Non-poultry birds	All birds, except poultry	Increase
Cats and dogs		
	Domesticated cats, and domesticated dogs, including working dogs	Increase
Other animals		
Large mammals	Ungulates and carnivores, other than livestock and domesticated cats and dogs	No effect
Small mammals	Small mammals species common in the pet trade, including rodents, lagomorphs, and hedgehogs	Increase
Reptiles and amphibians	Lizards, snakes, turtles, tortoises, frogs, toads	Increase
Humans		
	People and their accompanying baggage	Increase
Animal products		
	Products of animal origin, including meat and meat products, milk and milk products, blood and blood products, skins, feathers, wool and hair, animal feed containing products of animal origin	Increase
Garbage		
	All waste material that is derived in whole or in part from fruits, vegetables, meats, or other plant or animal (including poultry) material, and other refuse that has been associated with any such material	Increase
Other cargo		
	Live plants and inanimate objects, excluding animal products and garbage	Increase
Conveyances		
	Aircraft, maritime vessels, and shipping containers	Increase

Detailed data on the trends in live animal imports are available elsewhere in this document. We do not expect demand for imports of domesticated ruminants or swine into the Micronesia Region to increase as a result of the relocation. The USDA Census of Agriculture documents the decline of livestock farming in Guam; both the number of farms and the numbers of cattle, carabaos, goats, and swine have decreased in Guam over the past decade, and the relocation will place additional negative pressure on animal agriculture through increased urbanization and competition for land resources (USDA-NASS 2009a; U.S. Navy 2010a). Horseback riding is a popular adventure travel activity, and the adventure travel industry is growing worldwide (Heyniger 2006). Therefore, increases in population and tourism in the Micronesia Region may increase demand for animals associated with recreational activities, particularly horseback riding. Livestock industries in the Micronesia Region have not adopted assisted reproduction practices, such as artificial insemination or embryo transfer, to any degree and this is not expected to change (Duguies et al. 2000; Poole 2009). We expect the demand for game fowl used in cock fighting to increase during the military relocation, and therefore, imports of live poultry and hatching eggs may increase as a result. The increase in the human population in the Micronesia Region will likely be accompanied by an increase in demand for exotic pets, including birds, small mammals, and reptiles.

The relocation will be associated with a substantial increase in maritime and air conveyance traffic to the Micronesia Region. This traffic will support substantial increases in the volume of movement of people, animal products, garbage, and other cargo.

A6.3.3.1 *Livestock*

Livestock can be moved legally or they can be smuggled onto Guam; due to geographic barriers, accidental movement (straying) is not feasible.

Overall, livestock populations in the Region are declining (USDA-NASS 2009a, b). However, compared to other islands in the Region, beef cattle production on Tinian is large scale, with over 1,000 animals distributed among approximately 60 farms (USDA-NASS 2009b). The military is planning to increase training activities on Tinian, related to the relocation.

Cattle producers on Tinian are interested in improving production and range management practices, as well as increasing the size of their industry (Jimenez et al. 2009). Additionally, they are interested in developing a certified slaughter industry so they can sell their beef throughout the Region. However, current business opportunities for the beef cattle industry in Tinian are hampered by the lack of veterinary infrastructure, meat inspection services, and, possibly, by expansion of military operations.

At present, Tinian cattle are raised on the lease-back area controlled by the military. Expansion of training activities may result in reduced access to that land for grazing. This is a concern for Tinian ranchers. In addition, there is a concern that training activities may include weapons training, which could have a negative impact on cattle production (Jimenez et al. 2009).

While cattle production on Tinian may be impacted by military training activities, we do not expect that the military relocation will directly or indirectly increase legal or illegal traffic volume to the Region in most types of livestock, namely domesticated ruminants, swine, or their germplasm. Traffic volume in domesticated equids (horses, mules, and asses) to Guam might increase as a result of the military relocation. Therefore, we consider only those hazards associated with domesticated equids in the release and exposure assessments of the livestock pathway. We consider only intentional movement of domesticated equids to the Micronesia Region through legal means; smuggling of domesticated equids to the Micronesia Region is infeasible due to geographic barriers.

A6.3.3.1.1 *Hazards Associated with the Livestock Pathway*

Domesticated equids can play three roles in the transport of hazards: they can be infected hosts, they can be contaminated with disease agents and serve as fomites, or they can serve as hosts to tick vectors of disease agents. Table A6-8 lists hazards that are associated with domesticated equids through these three roles, including hazards for which domesticated equids may serve as dead-end hosts or play a minor or theoretical role in transmission.

Table A6-8: Hazards Associated with the Livestock Pathway (Domesticated Equids)

Hazard	Disease	Transport role[a]	References
Disease agent			
African horse sickness virus	African horse sickness	I	CFSPH 2006a, OIE 2009f
African swine fever virus	African swine fever	F	CFSPH 2010a
Babesia caballi and *Theileria equi*	Equine piroplasmosis	I	CFSPH 2008b, OIE 2008i
Burkholderia mallei	Glanders	I	CFSPH 2007f, OIE 2008l
Chrysomya bezziana	Old world screwworm myiasis	I	CFSPH 2007l
Classical swine fever virus	Classical swine fever	F	CFSPH 2009d
Cochliomyia hominivorax	New world screwworm myiasis	I	CFSPH 2007l
Echinococcus granulosus; E. multilocularis	Echinococcosis/hydatidosis	I	CFSPH 2009h
Equine encephalomyelitis viruses (Eastern, Western, and Venezuelan)	Equine encephalomyelitis (Eastern, Western, and Venezuelan)	I	CFSPH 2008a, OIE 2008g
Equine infectious anemia virus	Equine infectious anemia	I	OIE 2008h, CFSPH 2009i
Foot and mouth disease virus	Foot and mouth disease	F	CFSPH 2007e, 2008
JEV	Japanese encephalitis	I	CFSPH 2007h
Leishmania spp.	Leishmaniasis	I	CFSPH 2009k
Mycobacterium bovis	Bovine tuberculosis	I	CFSPH 2009c
Nipah virus	Nipah virus encephalitis	I	CDC
Pasteurella multocida serotypes 6:B and 6:E	Hemorrhagic septicemia	I	OIE 2009k
Rabies virus	Rabies	I	CFSPH 2009m
Taylorella equigenitalis	Contagious equine metritis	I	OIE 2008c, CFSPH 2009f
Trypanosoma equiperdum	Dourine	I	OIE 2008p, CFSPH 2009g
Trypanosoma evansi	Surra	I	OIE 2008q, CFSPH 2009n
Trypanosoma spp.	Trypanosomiasis (African animal)	I	CFSPH 2009a
Vesicular stomatitis virus	Vesicular stomatitis	I	CFSPH 2008g
WNV	West Nile fever	I	OIE 2008s, CFSPH 2009q
Vector			
Tick[b]			
Amblyomma spp.	Equine piroplasmosis; heartwater; Nairobi sheep disease; theileriosis	V	Kolonin 2009
Dermacentor spp.	Equine piroplasmosis	V	Kolonin 2009
Haemaphysalis spp.	Nairobi sheep disease; theileriosis	V	Kolonin 2009

Hazard		Disease	Transport role[a]	References
	Hyalomma spp.	African horse sickness; equine piroplasmosis; theileriosis	V	Kolonin 2009
	Rhipicephalus spp.	African horse sickness; equine piroplasmosis; Nairobi sheep disease; theileriosis	V	Kolonin 2009

[a] Pathway's role in hazard transport: I: infected host, F: fomite, V: vector transporter.
[b] Not all species of all genera feed on domesticated equids.

A6.3.3.1.2 *Release Assessment: Livestock Pathway*

Likelihood of Hazard Association

Infected domesticated equids are the primary source for the etiologic agents of African horse sickness, contagious equine metritis, dourine, equine infectious anemia, equine piroplasmosis, and glanders (CFSPH 2006a, 2007f, 2008b, 2009f, g, i). Domesticated equids can be infected with and serve as reservoirs for Nipah, rabies, Venezuelan equine encephalitis, and vesicular stomatitis viruses, but they are not the only, or the most important, hosts (CFSPH 2007j, 2008g, 2009m; OIE 2009u). Other hosts are epidemiologically more important than domesticated equids for harboring screwworms, *Echinococcus* spp., and *Leishmania* spp. parasites (Eckert and Deplazes 1999; CFSPH 2009k; OIE 2009q; Pavlin et al. 2009). Domesticated equids can be infected with, but do not serve as reservoirs for transmission of, *M. bovis*, and eastern equine encephalitis, Japanese encephalitis, western equine encephalitis, and WNV (Calisher 1994; CFSPH 2007h; 2009c, q).

African swine fever, classical swine fever, and foot and mouth disease viruses can be mechanically spread by domesticated animals, such as equids, which have been in contact with affected premises (CFSPH 2007e, 2009d, 2010a).

Domesticated equids are frequently reported hosts for tick species that are competent vectors for equine piroplasmosis, and less frequently host tick species that are competent vectors for heartwater (Estrada-Peña et al. 2004).

Traffic Volume

Detailed data on livestock imports are available elsewhere in this document. According to the Territorial Veterinarian of Guam, no livestock, including domesticated equids, have been imported to Guam over the last five years (Poole 2009). The equine industry on Guam is small; the USDA Census of Agriculture (2007) identified only two farms with horses on the island (USDA-NASS 2009a). The high cost of feed, most of which is imported, and the lack of services, such as farriers and equine practitioners, are cited as challenges to keeping horses on Guam (Earth.org 2009). If the volume of domesticated equid imports to Guam increases as a result of increased demand by the tourism industry, we expect the numbers to be very small. We do not expect the military relocation to be associated with an increase in traffic volume of domesticated equids to the rest of the Micronesia Region.

Traffic Origin

Any domesticated equids imported onto Guam will likely originate in the mainland United States, due to Federal regulations pertaining to importation of livestock, discussed below in mitigations. The United States is free of African horse sickness, African animal trypanosomiasis, dourine, foot and mouth disease, glanders, heartwater, Japanese encephalitis, Nipah virus encephalitis, screwworms, surra, and Venezuelan equine encephalomyelitis (USDA-APHIS 2008b). Outbreaks of contagious equine metritis, equine piroplasmosis, and vesicular stomatitis have recently occurred in parts of the United States (Webb et al. 1987; OIE 2008c; CFSPH 2009f; OIE 2009c, v).

Mitigations

APHIS regulations governing the importation of domesticated equids are set forth in 9 CFR Part 93. These regulations pertain to the movement of horses, mules, asses, and zebras from foreign countries into any of the 50 States, the Commonwealth of Puerto Rico, CNMI, the District of Columbia, and any territories and possessions of the United States. Domesticated equids intended for importation into the United States from any part of the world must be shipped directly to an approved port and be quarantined at the port until negative results to specified tests, depending upon the country of origin, are obtained and the equids are certified by the port veterinarian to be free from clinical evidence of disease. In special cases, unapproved ports may be designated as quarantine stations by the APHIS Administrator. No ports on Guam are approved for importation of livestock, and therefore, at this time, horses intended for import to Guam must first enter through ports in the continental United States.

Prior to importation, each domesticated equid must be inspected by a veterinarian at the premises of origin and found free of evidence of or exposure to communicable disease. Domesticated equids intended for import to the United States from regions affected by screwworm, contagious equine metritis, and Venezuelan equine encephalomyelitis are subject to inspection or treatment procedures specified in 9 CFR § 93.308. Imported domesticated equids, with limited exceptions for those originating in certain countries, cannot enter the United States until they have been tested for equine infectious anemia, equine piroplasmosis, dourine, and glanders by an official test with negative results. Before a horse imported from any part of the world is released from the port of entry into the Unites States, an inspector may require the horse and its accompanying equipment to be disinfected as a precautionary measure against the introduction of foot and mouth disease or any other disease dangerous to the livestock of the United States (9 CFR § 93.314).

APHIS regulations pertaining to interstate movement of domesticated equids are set forth in 9 CFR §§ 71 and 75. Animals, including domesticated equids, affected with any communicable disease are generally prohibited from interstate movement. Domesticated equids affected with equine piroplasmosis, dourine, glanders, contagious equine metritis, or screwworms may not be moved interstate. Domesticated equids that have tested positive on an official test for equine infectious anemia are prohibited from moving interstate, except under limited circumstances.

Specific regulations regarding the importation of live animals onto Guam can be found in the Guam Administrative Rules and Regulations (9 GARR 1, Division 1, Chapter 1). No animals that are affected with or have been exposed to an infectious, contagious, or communicable disease or ectoparasites or which originated in an area under state or federal quarantine shall be permitted to be introduced into Guam. Horses are subject to specific mitigations to prevent the entry of equine infectious anemia, and Eastern, Western, and Venezuelan equine encephalomyelitis viruses.

Summary

Traffic volume in domesticated equids to Guam might increase as an indirect result of the military relocation (increased demand for recreational activities). However, we expect that the increase in traffic volume will be very small. Due to federal regulations governing the importation of livestock, domesticated equids intended for importation to Guam are highly likely to originate in the continental United States, which is free of most of the hazards for which domesticated equids are the primary source. The risk of importation or interstate movement of hazards for which domesticated equids might play a significant role in transporting to Guam is mitigated by APHIS and Guam territorial regulations.

Livestock Pathway Release Assessment

The increased risk of release of hazards into the Micronesia Region due to the military relocation through the livestock pathway is negligible.

Livestock Pathway Risk Estimation

Because the increased risk of release of hazards into the Micronesia Region due to the military relocation through the livestock pathway is negligible, we conclude that the military relocation-associated overall risk for the livestock pathway is negligible.

A6.3.3.2 ***Poultry***

For the purpose of this risk assessment, poultry are chickens, doves, ducks, geese, grouse, guinea fowl, partridges, peafowl, pheasants, pigeons, quail, swans, and turkeys, including eggs for hatching. In this pathway, poultry can be moved legally or illegally; due to geographic barriers and characteristics of these species, we do not consider accidental movement (straying, migration, or stowing away) feasible.

We expect the popularity of cock fighting to temporarily increase during the military relocation because most temporary workers are expected to come from the Philippines (U.S. Navy 2010a). Cock fighting is very popular in the Philippines and is a major source of entertainment for Filipino immigrants in the continental United States (Bautista 1998). Additionally, previous waves of temporary construction-associated immigration from the Philippines have resulted in increased fight attendance (Sgambelluri et al. 2009).

Federal regulations and APHIS policy restrict importation of live poultry, poultry products, and hatching eggs from regions affected by exotic Newcastle disease (END) or HPAI subtype H5N1; several of these regions include Asia-Pacific countries (9 CFR §§ 93.201 and 94.6). Live poultry permitted to enter the United States (except those from Canada) must be inspected, quarantined for 30 days, and tested at a quarantine facility on the mainland United States (9 CFR § 93.209). Importers bear the cost of these import requirements. The importation of hatching eggs is restricted from countries affected by END, which includes the Philippines and several other Asia-Pacific countries (9 CFR § 93.209). These regulations reduce the practicality of importing foreign poultry (including hatching eggs and game cocks) to Guam from Asia-Pacific countries.

Experts believe the worldwide movement of people and their demand for familiar, culturally important foods and traditional items leads to the smuggling of poultry, particularly hatchlings and hatching eggs (Rosenthal 2006). Temporary foreign workers related to the relocation are expected to come primarily from Asia-Pacific countries where cock fighting is popular (Jimenez et al. 2009; Poole 2009). These workers may be tempted to smuggle fighting fowl onto Guam in order to circumvent import requirements. We expect that the military brelocation will increase the volume of illegal traffic in live poultry, particularly chickens and chicken eggs for hatching.

Because of increased urbanization and competition for land resources on Guam, the relocaiton will place additional negative pressure on animal agriculture; therefore, we do not expect shipments of live poultry for commercial purposes to increase. Nor do we expect that the increased number of military personnel or their dependents will result in increased importation of pet poultry species. The high cost of shipping and health certification relative to the perceived value of these birds is likely a deterrent to bringing pet poultry to Guam. For example, the cost of shipping a bird from Hawai'i to Guam, including fees for health certification, shipping box, and air freight, exceeds $75.00 (Poole 2009). In addition, military regulations prohibit poultry in private housing (U.S. Army 2008).

A6.3.3.2.1 *Hazards Associated with the Poultry Pathway*

Poultry can transport hazards in three roles: they can be infected hosts, they can be contaminated with disease agents and serve as fomites, or they can serve as hosts to tick vectors of disease agents. Table A6-9 lists hazards that are associated with the poultry pathway, including hazards for which poultry may serve as dead-end hosts or play a minor or theoretical role in transmission.

Table A6-9: Hazards Associated with the Poultry Pathway

Hazard	Disease	Transport role[a]	References
Disease agent			
African swine fever virus	African swine fever	F	CFSPH 2010a
Avian metapneumovirus	Turkey rhinotracheitis	I	OIE 2009w
Chrysomya bezziana	Old world screwworm myiasis	I	CFSPH 2007l
Classical swine fever virus	Classical swine fever	F	CFSPH 2009d
Cochliomyia hominivorax	New world screwworm myiasis	I	CFSPH 2007l
Duck hepatitis virus types I, II, and III	Duck virus hepatitis	I	OIE 2008d
Equine encephalomyelitis viruses (Eastern, Western, and Venezuelan)	Equine encephalomyelitis (Eastern, Western, and Venezuelan)	I	CFSPH 2008a, OIE 2008g
Exotic NDV	Exotic Newcastle disease	I	CFSPH 2008d
Foot and mouth disease virus	Foot and mouth disease	F	CFSPH 2007e, 2008
HPAIV	HPAI	I	OIE 2009m, CFSPH 2010b, USGS 2010
Salmonella Gallinarum	Fowl typhoid	I	OIE 2008k, CFSPH 2009j

Hazard	Disease	Transport role[a]	References
Salmonella Pullorum	Pullorum disease	I	OIE 2008k, CFSPH 2009j
WNV	West Nile fever	I	CFSPH 2009q
Vector			
Tick[b]			
Amblyomma spp.	Equine piroplasmosis; heartwater; Nairobi sheep disease; theileriosis	V	Kolonin 2009
Haemaphysalis spp.	Nairobi sheep disease; theileriosis	V	Kolonin 2009
Hyalomma spp.	African horse sickness; equine piroplasmosis; theileriosis	V	Kolonin 2009
Rhipicephalus spp.	African horse sickness; equine piroplasmosis; Nairobi sheep disease; theileriosis	V	Kolonin 2009

[a] Pathway's role in hazard transport: I: infected host, F: fomite, V: vector transporter.
[b] Not all species of all genera feed on poultry.

A6.3.3.2.2 *Release Assessment: Poultry Pathway*

Likelihood of Hazard Association

Infected poultry are the primary source for the etiologic agents of avian metapneumovirus, duck virus hepatitis, fowl typhoid, and pullorum (OIE 2008d, k; CFSPH 2009j; OIE 2009w). Poultry can be infected with and serve as reservoirs for END, HPAI, equine encephalomyelitis, and WNV, but they are not the only reservoir hosts (Calisher 1994; Falcon 2004; CFSPH 2009q; OIE 2009u; CFSPH 2010b). Infestation of poultry with screwworms occurs, but is rarely reported (OIE 2009q; USDA-APHIS 2009c).

African swine fever, classical swine fever, and foot and mouth disease viruses can be mechanically spread by domesticated animals, such as poultry, which have been in contact with affected premises (CFSPH 2007e, 2009d, 2010a).

Commercial poultry raised in confinement are unlikely to be infested by ixodid ticks; however, gamefowl, pet, and exhibition poultry may have opportunities to encounter ticks. Hyalomma ticks were removed from partridge (*Perdix perdix*) offered for importation into the United States in the 1960s (USDA-APHIS-PPQ 2010a).

Traffic Volume and Origin

Data on poultry imports are presented elsewhere in this document. We do not expect the military relocation to be associated with an increase of legally imported poultry to Guam or the rest of the Micronesia Region. Due to import regulations, most poultry breeding stock will likely continue to be imported from the continental United States and Hawai'i. The United States is free of African swine fever, classical swine fever, END, foot and mouth disease, HPAI, screwworms, and Venezuelan equine encephalomyelitis (USDA-APHIS 2008b).

Illegal importation of live poultry, including hatching eggs, is known to occur (Poole 2009). The increased interest in cock fighting, related to the number of temporary workers from the Philippines and other areas where cock fighting is legal, may result in an increase in smuggling of poultry and hatching eggs. END is widespread in Asia, and HPAI is present in some areas as well.

Mitigations

Federal regulations and APHIS policy restrict importation of live poultry, poultry products, and hatching eggs from regions affected by END or HPAI H5N1, including the Philippines and several other Asian countries, and from free regions that may import and commingle live poultry originating in an END-affected region (9 CFR § 92, 9 CFR § 93, 9 CFR §94). Legal poultry imports must be accompanied by an import permit issued by APHIS and be received and inspected at an approved port of entry with quarantine facilities. Approved bird quarantine facilities are located in New York, Miami, and Los Angeles. Birds are quarantined for 30 days, during which they are tested for certain communicable diseases. Since the implementation of quarantine requirements in 1972, introductions of END through legal importation of live birds declined substantially and were essentially eliminated after the requirements for approval of private quarantine facilities were strengthened in 1979 (USDA-APHIS-VS 2005).

A 2002 modification to the Animal Welfare Act made interstate trade of a bird or birds for the purpose of fighting illegal, regardless of the law in the destination state, including Guam (USDA-APHIS-VS 2003a). However, this amendment does not restrict the possession of fighting fowl for breeding or as show birds. In response to the changes to the Animal Welfare Act, United Airlines stopped accepting shipments of live adult poultry in 2007, although the airline continues to carry day-old poultry and hatching eggs (Huemer 2007). United Airlines provides air freight service to the Micronesia Region.

Guam territorial regulations require all imported birds and hatching eggs to be accompanied by an entry permit and a health certificate approved by the chief livestock sanitary officer, or a state or federal veterinarian (9 GARR 1 § 1110). The health certificate must be issued within 10 days prior to shipment attesting that the bird has been found free of ectoparasites and symptoms of transmissible disease. No poultry affected by or exposed to an infectious, contagious, or communicable disease or ectoparasites during state or federal quarantine shall be permitted on Guam and will be returned to the point of origin or destroyed.

Guam requires imported poultry to 1) originate from flocks and hatcheries free of pullorum disease or with a pullorum controlled status; in the latter case birds must be serologically negative for pullorum disease within 30 days of entry; 2) be vaccinated for NDV between 30 and 60 days prior to shipment; 3) be free of symptoms of Newcastle disease or other communicable diseases at the time of shipping; and 4) have a health certificate issued by an accredited veterinarian (9 GARR 1 § 1110). Requirements 2, 3, and 4 above do not apply to hatching eggs and day-old poultry accompanied by an affidavit from the shipper stating that the flock of origin has not been exposed to and is free of Newcastle disease within 60 days period prior to shipment. All poultry and hatching eggs shall be shipped in new (unused) containers and inspected by the territorial veterinarian or deputy prior to entry into Guam.

Guam has additional quarantine requirements for birds from the continental United States to prevent the introduction of WNV. These birds are required to be quarantined for a minimum of seven days in an approved quarantine facility or veterinary clinic followed by 30 days of isolation in a mosquito-proof cage on Guam (Poole 2009).

USPS regulations prohibit the mailing of hatchling (day-old) poultry vaccinated for Newcastle disease. Day-old chickens, ducks, emus, geese, guinea fowl, partridges, quail, and turkeys must be delivered to the addressee within 72 hours of hatching (USPS 2009).

Summary

The number of live poultry legally imported to Guam is unlikely to change as a result of the military relocation, but the number of illegally imported live poultry is likely to increase by an unknown quantity in response to demand for fighting cocks. The number of illegally imported hatching eggs may increase as well. The risk of hazard release through legal entry of live poultry to Guam is reduced by inspection and quarantine measures required by federal and territorial regulations. Illegally imported poultry bypass mitigations intended to reduce the likelihood of release of hazards.

Poultry Pathway Release Assessment

The increased risk of release of hazards into the Micronesia Region due to the military relocation through legal movement of poultry is negligible.

The increased risk of release of hazards into the Micronesia Region due to the military relocation through illegal movement of poultry is very low.

A6.3.3.2.3 ***Exposure Assessment: Poultry Pathway***

Biological Factors

Most poultry disease agent hazards are present in the feces or secretions of infected birds and are spread primarily through direct contact between birds. People, other animals, vehicles, and equipment can become contaminated with poultry feces or secretions and can carry disease agents from one location to another; END, e.g., is readily transmitted on fomites (CFSPH 2008d).

Regional Factors

Chickens are the primary poultry species raised on Guam (USDA-NASS 2009a). Since the disappearance of commercial layer operations on Guam, imports of day-old chicks have declined and most chicken imports supply birds to small, backyard flocks for domestic consumption or to cock fighting operations (Poole 2009). Like on other islands in the Micronesia Region, a sizeable population of feral chickens roams freely on Guam (Poole 2009; GTIS 2010). Epidemiologic investigations of outbreaks around the world have shown the close proximity of backyard flocks, feral chickens, and cockfighting operations to be related to spread of an introduced poultry disease (Awan et al. 1994; Swayne and King 2003; Falcon 2004). Outdoor housing and contact with feral and wild birds makes biosecurity for backyard flocks problematic. Similarly, cock fighting operations facilitate the spread of poultry diseases through the frequent movement and commingling of birds. END and HPAI can be spread through direct contact between live birds or contact between live birds and contaminated objects such as dead birds or contaminated hatching eggs.

If live poultry infected with an arbovirus, such as JEV or WNV, are imported to Guam or elsewhere in the Micronesia Region, the disease agent could be transmitted to an existing competent mosquito vector, such as *Aedes albopictus* or *Culex quinquefasciatus*, potentially resulting in establishment of the disease agent (Reeves and Rudnick 1951; Mitchell et al. 1993; Lounibos 2002).

Guam's existing livestock population and number of imported live poultry are both small, making contact between livestock and imported live poultry unlikely. Therefore, imported live poultry are unlikely to have contact with and serve as fomites for exposure of livestock to African swine fever, classical swine fever, and foot and mouth disease viruses.

Summary

Poultry imported to Guam are most likely destined for premises on which poultry already exist and have exposure to feral chickens and their disease agents. Contact between livestock and imported poultry is much less likely. Competent mosquito vectors for arboviruses are present in the Micronesia Region, and imported live poultry infected with an arbovirus could serve as a source to infect mosquitoes.

Poultry Pathway Exposure Assessment

The risk of exposure of livestock or poultry to hazards released into the Micronesia Region through the poultry pathway is medium.

A6.3.3.2.4 *Consequence Assessment: Poultry Pathway*

END and HPAI are hazards of high consequence associated with imported live poultry; therefore, these agents are the focus of the consequence assessment for the poultry pathway. Introduction of arboviruses from the importation of infected live birds, especially JEV and WNV, would have minimal effects on poultry populations, though the consequence to native wild bird populations and humans could be significant.

Biological Consequences

END and HPAI are two of the most severe poultry diseases in the world and their animal health consequences are significant. For both diseases, morbidity and mortality rates vary according to the strain of virus, but morbidity may approach 100% and mortality may approach 90% in susceptible chickens (CFSPH 2008d, 2010b).

Human health consequences of END are minor and generally limited to conjunctivitis, though rare serious opportunistic infections may occur in those with compromised immune systems (CFSPH 2008d). Humans are not normally susceptible to infection with avian strains of influenza and the risk from HPAI is therefore generally low to most people (CFSPH 2010b). However, on rare occasions, influenza viruses of avian origin have become more efficient at infecting humans, causing three pandemics within the past century (Rappole and Hubálek 2006). The spectrum and severity of AI symptoms in humans depends on the specific viral subtype (Capua and Alexander 2004; Hirst et al. 2004) and range from typical human influenza-like symptoms (e.g., fever, cough, sore throat, and muscle aches) or uncomplicated eye infections, to pneumonia, acute respiratory distress and life-threatening complications. In 1997, a virulent avian subtype, H5N1, was first identified as the cause of severe, yet sporadic influenza illness in humans. Human cases of H5N1 have since been reported in Asia, Africa, the Pacific, Europe, and the Near East according to the WHO (WHO 2010a). Indonesia and Vietnam have reported the highest number of human H5N1 cases to date with mortalities of up to 60%, especially in individuals hospitalized late in the course of their illness. Nearly all confirmed human cases have resulted from direct contact to poultry or their excreta (WHO, CDC 2010b), with little evidence for human-to-human transmission. To date, human cases of H5N1 remain rare.

The introduction of WNV and JEV would have minimal effects on poultry (Ghosh and Basu 2009; OIE 2010d). Experimental studies have shown that poultry rapidly develop an antibody response capable of neutralizing the virus. Infection in chickens is typically asymptomatic or with minimal clinical signs and pathology, and no mortality (Senne et al. 2000).

Some deaths have been reported in horses from WNV and JEV infection, though the number of clinical cases is very low compared to the total number of exposed animals (CFSPH 2007h; OIE 2010d). Because of the small number of horses in Guam and relatively low importance of this industry, and the availability of effective vaccines to protect horses against JEV and WNV, we conclude that the biological consequences of introduction of WNV or JEV to the livestock and poultry industries are negligible.

Guam's native birds have been driven nearly to extinction (Savidge et al. 1992). Exposure to END, HPAI, or WNV could have severe negative consequences to the remaining population.

As in the continental United States, the major impact of WNV establishment would be to humans. Once established in a tropical environment and in the absence of preventive measures, spread would be expected to be rapid among human populations with no prior exposure or immunity, as would be the case in Guam and throughout the Micronesia Region (Hayes et al. 2005). In humans the ratio of asymptomatic to clinical infection is high and the majority of clinical illness would be limited to mild febrile disease; however about one of every hundred infected may develop severe neurological disease with mortality rates as high as 14% (Madden 2003).

Establishment of Japanese encephalitis on Guam would also be of consequence to humans, especially to children. While asymptomatic infection can occur, approximately 30% of Japanese encephalitis cases are fatal and nearly half result in permanent neurological sequelae (Ghosh and Basu 2009). However, any such introduction might well be short lived. In 1990, a rare introduction of Japanese encephalitis on Saipan ended as the population of susceptible pigs which serve as amplifying hosts became infected and developed immunity, and Japanese encephalitis has not recurred (Paul et al. 1993).

Environmental Consequences

Environmental consequences of END or HPAI in poultry primarily result from the disposal of large numbers of carcasses due to death from disease or depopulation of flocks. Disposal of large amounts of litter and manure can also be problematic. Because Guam and the rest of the Micronesia Region lack large commercial poultry farms, disposal activities are unlikely to create a significant environmental impact.

On Guam, conservation programs maintain captive breeding populations of the endangered Guam rail, Micronesian kingfisher, and Marianas crow (Beauprez and Brock 1999). Guam and other islands of the Micronesia Region provide the only habitat for several critically endangered bird species (Sherley and Lowe 2000). Introduction of END, HPAI, or other high mortality avian diseases could have a catastrophic effect on the very small populations of the Micronesia Region's endangered bird species, potentially resulting in extinction.

The spread of WNV in the continental United States has caused a marked decline in the number of particular bird species in entire regions, such as the American crow and eastern bluebirds (Rappole et al. 2000). Native bird populations on Guam have been severely diminished as a result of invasive species and feral cats (Poole 2009); thus WNV, as with END and HPAI, could decimate remaining populations.

Economic Consequences

The assessment of economic consequences is largely based on historical experience of END or HPAI outbreaks in the United States, which can be characterized as having either relatively limited disease spread or relatively extensive disease spread.

The outbreaks in 2002-2003 in Arizona, Nevada, and Texas could each be considered representative of a relatively limited outbreak. Arizona and Texas each had only one premise on which infection was detected; 10 infected premises were identified in Nevada. Approximately $3.5 million were spent on eradication efforts in Arizona; $6.2 million in Nevada; and $4.2 million in Texas (USDA-APHIS-VS 2005).

Eradication efforts for the extensive 2002-2003 END outbreak in California were labor intensive and expensive (USDA-APHIS-VS 2005). Ultimately, birds from 920 premises in California tested positive for the disease, and nearly 4 million birds were depopulated. More than $160 million was spent on eradication efforts. More than 1,500 personnel were recruited from various federal, state, county, and metropolitan agencies to participate in disease control activities.

Information from the 2002-2003 outbreaks can be used to characterize the effects of an extensive END outbreak on U.S. trade. Immediately following the confirmation of END in the United States in 2002, trading partners imposed trade restrictions on live birds; fresh, frozen, or chilled poultry meat; and hatching eggs from the United States (USDA-APHIS-VS 2005). At the peak of the incident, 46 countries had imposed restrictions. The direct trade impacts were calculated from October 2002 to September 2003 for five categories of product: live poultry (other than ducks and geese), ducks and geese, poultry meat and offal, hatching eggs, and table eggs. The total estimated cost of the poultry restrictions for the roughly 12 month period of the END eradication effort was $121 million, approximately 7% of the trade recorded during that period. The trade losses were relatively low due to the regionalization approach taken by most countries, in which imports of live birds and products were banned from only areas adjacent to affected areas and/or affected areas alone.

Therefore, in the event of a poultry disease outbreak on U.S. islands in the Micronesia Region, involving a significant hazard like END or HPAI, countries would likely use a regionalization approach, in order to reduce the wider trade impacts to the United States as a whole. The local effect of trade restrictions is not likely to be significant to Guam or the rest of the Micronesia Region, where no commercial poultry export trade occurs.

Release and establishment of WNV or JEV would be expected to result in little or no economic loss to the poultry industry or to the few remaining equine operations on Guam; however, significant cost would be incurred for human public health and mosquito vector surveillance, and for vector control to prevent spread throughout the region. A 2005 outbreak of WNV in Sacramento County, California (population 1.3 million) resulted in 163 reported human cases and a response that included emergency aerial spray to control vectors. Costs for aerial spray totaled just over $700,000 and when added to estimated medical costs and patients' loss in productivity, the total economic impact was estimated at $2.98 million (Barber et al. 2010).

Summary

Guam's native birds have been driven nearly to extinction by predation, but conservation programs are operating in the Region and exposure to END, HPAI, or WNV could have severe negative consequences on their attempts to preserve avifauna biodiversity in the Micronesia Region. The islands of the Micronesia Region are connected to each other, Hawai'i, and the continental United States by air and sea transportation, so the appearance of END or HPAI in the Region poses a threat of introduction into North America. The economic impact of trade bans due to a poultry disease outbreak in the Micronesia Region is likely to be insignificant to Guam and rest of the region, which lacks commercial poultry industries, but potentially significant to the rest of the United States. Regionalization policies would likely reduce the trade consequences at the national level. Human health on Guam and other islands of the Micronesia Region could likewise be impacted by exposure to WNV, JEV, or other arboviruses released as a result of the importation of infected birds, though those risks appear limited and manageable.

Poultry Pathway Consequence Assessment

The significance of the consequences to Guam of livestock or poultry exposure to hazards released into the Micronesia Region through the poultry pathway is low.

The significance of the consequences to the rest of the Micronesia Region of livestock or poultry exposure to hazards released into the Micronesia Region through the poultry pathway is low.

The significance of the consequences to the rest of the United States of livestock or poultry exposure to hazards released into the Micronesia Region through the poultry pathway is medium.

Poultry Pathway Risk Estimation

Because the increased risk of release of hazards into the Micronesia Region due to the military relocation through the poultry pathway is very low, the risk of exposure of livestock and poultry is medium, and the significance of consequences of livestock and poultry exposure is low, we conclude that the military relocation-associated overall risk for the poultry pathway is low.

A6.3.3.3 *Non-poultry Birds*

In this pathway, we consider the movement of birds other than poultry as previously defined in this document. Non-poultry birds moved in this pathway may be intended for zoological collections or research, or to be used as pets, performing birds, or commercial birds, which are defined as birds imported for resale, breeding, public display, or any other purpose except those already mentioned (9 CFR § 93.100). Birds in this pathway may be moved through legal or illegal means. We do not consider accidental movement of non-poultry birds in our analysis because it is not expected to increase with the relocation. The risk posed by free-living birds is considered elsewhere in this document.

Birds are the fourth most common type of pet owned by U.S. households behind dogs, cats, and freshwater fish (APPMA 2008). Rates of pet bird ownership in the United States have remained steady for the past two decades at approximately 6% of households. Although few data are available regarding rates of pet bird ownership by military families, one survey of 184 military families found at least 7% reported keeping a pet bird (Anderson 1985). The sample for the survey was drawn from the population of military families recently transferred to duty stations in Hawai'i; roughly 16% of pet-owning military families brought their pets with them in the transfer and 41% had acquired their pet after transferring. Residents of military base housing on Guam are permitted to keep non-poultry pet birds (VETCOM 2009). Therefore, we expect the military relocation to result in an increase in the number of non-poultry pet birds legally imported to the island as pets or to be sold as pets.

Worldwide, the illegal trade in live birds is substantial and profitable (Wyler and Sheikh 2009). The United States is considered one of the largest markets for illegal wildlife from around the world and wild birds are major commodities (Wyler and Sheikh 2009). According to the USFWS, U.S. demand for illegally imported live wild animals is driven primarily by demand for exotic pets and tourist souvenirs (Wyler and Sheikh 2009). Because the military relocation will expand the human population of Guam, demand for live birds for personal use might increase and result in increased illegal traffic of live birds.

A6.3.3.3.1 *Hazards Associated with the Non-poultry Birds Pathway*

Non-poultry birds can transport hazards in three roles: they can be infected hosts, they can be contaminated with disease agents and serve as fomites, or they can serve as hosts to tick vectors of disease agents. Table A6-10 lists hazards that are associated with the non-poultry birds pathway, including hazards for which non-poultry birds may serve as dead-end hosts or play a minor or theoretical role in transmission.

Table A6-10: Hazards Associated With the Non-Poultry Birds Pathway

Hazard		Disease	Transport role[a]	References
Disease agent				
	African swine fever virus	African swine fever	F	CFSPH 2010a
	Chrysomya bezziana	Old world screwworm myiasis	I	CFSPH 2007l

Classical swine fever virus	Classical swine fever	F	CFSPH 2009d
Cochliomyia hominivorax	New world screwworm myiasis	I	CFSPH 2007l
Exotic NDV	Exotic Newcastle disease	I	CFSPH 2008d
Equine encephalomyelitis viruses (Eastern, Western, and Venezuelan	Equine encephalomyelitis (Eastern, Western, and Venezuelan	I	CFSPH 2008a, OIE 2008g
Foot and mouth disease virus	Foot and mouth disease	F	CFSPH 2007e, 2008
HPAIV	HPAI	I	OIE 2009m, CFSPH 2010b, USGS 2010
JEV	Japanese encephalitis	I	CFSPH 2007h, Mackenzie 2007, OIE 2010d
Salmonella Gallinarum	Fowl typhoid	I	OIE 2008k, CFSPH 2009j
Salmonella Pullorum	Pullorum disease	I	OIE 2008k, CFSPH 2009j
WNV	West Nile fever	I	OIE 2008s, CFSPH 2009q
Vector			
Tick[b]			
Amblyomma spp.	Equine piroplasmosis; heartwater; Nairobi sheep disease; theileriosis	V	Kolonin 2009
Haemaphysalis spp.	Nairobi sheep disease; theileriosis	V	Kolonin 2009
Hyalomma spp.	African horse sickness; equine piroplasmosis; theileriosis	V	Kolonin 2009
Rhipicephalus spp.	African horse sickness; equine piroplasmosis; Nairobi sheep disease; theileriosis	V	Kolonin 2009

[a] Pathway's role in hazard transport: I: infected host, F: fomite, V: vector transporter.
[b] Not all species of all genera feed on non-poultry birds.

A6.3.3.3.2 *Release Assessment: Non-poultry Birds Pathway*

Likelihood of Hazard Association

Like poultry, other birds can be infected with and serve as reservoirs for equine encephalomyelitis, END, HPAI, and WNV, but they are not the only reservoir hosts (Calisher 1994; Falcon 2004; CFSPH 2009q; OIE 2009u; CFSPH 2010b). Infected birds can serve as sources for the etiologic agents of fowl typhoid and pullorum. Infestation of birds with screwworms occurs, but is rarely reported (OIE 2009q, USDA-APHIS 2009c).

African swine fever, classical swine fever, and foot and mouth disease viruses can be mechanically spread by birds which have been in contact with affected premises, though it is difficult to definitively link birds as a primary source for spread in outbreaks and their role remains theoretical.

Psittacines (parrots, cockatiels, parakeets, budgerigars, and other parrot-like pet birds), the most popular pet birds in the United States, are uncommon hosts for vector hazards (Estrada-Peña et al. 2004, Estrada-Peña 2008). A variety of songbirds are captured and moved around the world in the caged bird trade, and some of these birds, particularly the buntings, sparrows, finches, and weavers of the families Emberizidae, Passeridae, and Ploceidae, are frequent hosts for European, Asian, or African ticks (Estrada-Peña et al. 2004). However, only two records of tick interceptions from imported pet birds were found in the USDA national tick survey database (USDA-APHIS-PPQ 2010a).

Traffic Volume

According to the Territorial Veterinarian, the number of pet birds brought to Guam in recent years averages less than twelve birds annually (Poole 2009). If, as we expect, the number of pet birds and commercial birds imported to the island will increase relative to the increase in the human population, the number of birds brought to Guam through legal means will remain small.

While no reliable estimates of illegal live pet bird import volumes are publicly available, analysts agree that demand for illegal wildlife in the United States is likely to parallel U.S. demand for legal wildlife (Wyler and Sheikh 2009). We assume this trend to be similarly true for Guam; thus demand for illegal live pet bird imports would also be expected to remain small.

Traffic Origin

Due to strict federal regulations, live birds imported legally to Guam as a result of the relocation are likely to originate from the mainland United States. The United States is free of African swine fever, classical swine fever, END, foot and mouth disease, heartwater, HPAI, Japanese encephalitis, screwworms, and Venezuelan equine encephalomyelitis (USDA-APHIS 2008b).

Most smuggled live birds seized by U.S. officials between 2004 and 2008 originated from Mexico, Central America, and South America, but smuggled birds have also been intercepted from Japan, Hong Kong, and Indonesia (USDA-APHIS 2006; USFWS 2009a).

Mitigations

USDA defines pet birds as those that are imported for the personal pleasure of their owners and are not intended for resale (USDA-APHIS 2009a). Commercial birds are those imported for resale, breeding, public display, or other similar purpose.

Birds not of U.S. origin must be accompanied by an import permit and be received and inspected by USDA personnel at an approved port of entry with quarantine facilities. Approved bird quarantine facilities are located in New York, Miami, and Los Angeles. Birds are quarantined for 30 days, during which they are tested for certain communicable diseases. USDA maintains trade restrictions on the importation of live birds from countries affected by HPAI H5N1 including certain countries in Africa, Europe, and Asia (USDA-APHIS 2009a).

Importation of exotic birds into the United States must comply with APHIS and USFWS requirements. Certain exotic birds are protected by CITES and the Wild Bird Conservation Act (Beissinger 2001). CBP and the USFWS enforce the international trade regulations related to exotic birds. The USFWS requires an importation permit and the Wild Bird Conservation Act limits imports to two birds per year, per person, and that person must have been continuously residing outside the continental United States for at least one year.

All birds entering the territory of Guam must be accompanied by an import permit and an official health certificate approved by the chief livestock sanitary officer, or a state or federal veterinarian. The health certificate must be issued within 10 days prior to shipment attesting that the bird(s) have been found free of ectoparasites and symptoms of transmissible diseases. Animals should have a leg band number identifying the scientific name of the animal. Any animal found to be clinically affected or recently exposed to any infectious, contagious, or communicable disease or infested with ectoparasites shall be returned to their point of origin or destroyed (9 GARR 1, Division 1, Chapter 1).

Regulations for the importation of pet birds (all birds except poultry) are found under Title 9 of the Guam Administrative Rules and Regulations, in chapter 2, §2101 and §2102 and require pet shops and importers to keep a record of each sale made for at least 90 days and make the record available to GDOA, if a quarantine is placed on the premises by the territorial veterinarian.

Guam has introduced additional quarantine requirements for the importation of birds from the continental United States to prevent the introduction of WNV. These regulations are similar to the ones in place in Hawai'i. All birds are required to be quarantined a minimum of seven days in an approved quarantine facility or veterinary clinic followed by 30 days of isolation in a mosquito-proof cage on Guam (Poole 2009).

According to USPS regulations, non-poultry birds cannot be transported via the mail (USPS 2009).

Illegal imports, by their very nature, are difficult to describe and quantify. Illegally imported birds and hatching eggs would need to enter Guam via boat or airplane. Both birds and hatching eggs may be carried on private vessels or fishing boats and are relatively easy to conceal. Hatching eggs may be carried in a suitcase, and can therefore be brought into Guam via commercial flights. GCQA attempts to enforce the regulations, mitigating the risks by these pathways.

Military personnel and families are unlikely to smuggle birds to Guam. However, it is possible that the increased population will lead to an increase in customers for pet shops on Guam. It is then possible that unscrupulous pet shop owners may attempt to acquire birds from illicit sources. Private boats or fishing vessels may be involved in supplying such trade.

It is assumed that foreign workers will be traveling to Guam by air, given the time involved in sea travel from many of the countries that will be providing workers. United Airlines is reportedly planning to increase flight frequencies to the Philippines to accommodate the workers (Arnaldo 2010). Opportunities for smuggling live birds on a commercial airline are present, though limited. Therefore, it is assumed that immigrant workers will also be unlikely to smuggle non-poultry birds into Guam. However, hatching eggs may be smuggled on board flights, as they are small and easily concealed in luggage. It is possible that private or fishing vessels may be involved in smuggling non-poultry birds for commercial sale. However, it is unlikely that the foreign workers would be supporting such efforts, because under the requirements of their contracts, involvement in an illegal activity such as smuggling will have serious consequences if they are caught.

Summary

The number of live non-poultry birds imported to Guam is currently small, and may increase slightly as a result of the military relocation, due to demand in the pet trade. The risk of hazard release through legal entry of live non-poultry birds to Guam is reduced by inspection and quarantine measures required by federal and territorial regulations. Illegally imported live non-poultry birds bypass mitigations intended to reduce the likelihood of release of hazards.

Non-poultry Birds Pathway Release Assessment

The increased risk of release of hazards into the Micronesia Region due to the military relocation through legal movement of non-poultry birds is negligible. Currently, pet birds arriving to Guam are to be quarantined by the owner at the owner's home. The Guam territorial veterinarian insures that a double mosquito netted quarantine cage is provided pet owner for this purpose, butregulating the quarantine period is not feasible at this time. The situation could be improved by developing a bird quarantine facility at GDOA and insure compliancy with current import regulations.

The increased risk of release of hazards into the Micronesia Region due to the military relocation through illegal movement of non-poultry birds is very low.

A6.3.3.3.3 ***Exposure Assessment: Non-poultry Birds Pathway***

Biological Factors

Deliberate or accidental release of imported non-poultry birds provides another potential route of exposure of livestock or poultry to hazards or opportunities for dissemination of vector hazards in suitable habitats for establishment. Sightings of non-native songbirds by U.S. birders have been attributed to accidental escape or deliberate release by importers, breeders, and disinterested pet owners (Craves 2008).

Regional Factors

Birds smuggled to Guam or CNMI could readily be dispersed throughout the Micronesia Region.

Summary

We expect the smuggling of non-poultry birds to be an infrequent event; however, once released, the opportunities for exposure of livestock and poultry are present, though the overall risk is considered to be very low.

Non-poultry Birds Pathway Exposure Assessment

The risk of exposure of livestock or poultry to hazards released into the Micronesia Region through the non-poultry birds pathway is very low.

A6.3.3.3.4 *Consequence Assessment: Non-poultry Birds Pathway*

Biological Consequences

Non-poultry pet birds may carry and serve as reservoir hosts for many of the same diseases as poultry, including equine encephalomyelitis, END, HPAI, and WNV viruses (Calisher 1994, Falcon 2004, CFSPH 2009q, OIE 2009u, CFSPH 2010b). Infected birds can serve as sources for the etiologic agents of fowl typhoid and pullorum. Infestation of birds with screwworms occurs, but is rarely reported (OIE 2009q, USDA-APHIS 2009c); these birds can also serve as fomites for the spread of African swine fever, classical swine fever, and foot and mouth disease viruses (CFSPH 2007e, 2009d, 2010a). The consequences would be most significant from the resultant release and exposure of END and HPAI, which may cause mortality approaching 100% for poultry on Guam.

Environmental and Economic Consequences

Release of infected non-poultry birds may result in similar environmental and economic consequences as for infected poultry.

Non-poultry Birds Pathway Consequence Assessment

The significance of the consequences to Guam of livestock or poultry exposure to hazards released into the Micronesia Region through the non-poultry birds pathway is low.

The significance of the consequences to the rest of the Micronesia Region of livestock or poultry exposure to hazards released into the Micronesia Region through the non-poultry birds pathway is low.

The significance of the consequences to the rest of the United States of livestock or poultry exposure to hazards released into the Micronesian Regio through the non-poultry birds pathway is medium.

Non-poultry Birds Pathway Risk Estimation

Because the increased risk of release of hazards into the Micronesia Region due to the military relocation through the non-poultry birds pathway is very low, the risk of exposure of livestock and poultry is very low, and the significance of consequences of livestock and poultry exposure is low, we conclude that the military relocation-associated overall risk for the livestock pathway is very low.

A6.3.3.4 *Cats and Dogs*

The domesticated cats and dogs moved in this pathway may be pets or serve as working animals performing tasks to assist or entertain people. Specifically, we consider the effect of the military relocation on risk to livestock and poultry health through movement of military working dogs and pet cats and dogs kept by military or civilian personnel to Guam. Discussion of impacts to human and companion animal health is limited to the livestock and poultry hazards associated with dogs and cats.

Cats and dogs are the most common types of pets owned by U.S. households (APPMA 2008). According to the 2007 American Pet Products Manufacturers Association survey, 39% of U.S. households keep at least one dog, and 34% keep at least one cat. Rates of cat and dog ownership among U.S. households have increased slightly over the past two decades. Although few data are available regarding rates of pet cat and dog ownership by military personnel, one survey of 184 military families found 34% reported keeping at least one dog and 18% reported keeping at least one cat (Anderson 1985). The sample for the survey was drawn from the population of military families who had recently transferred to duty stations in Hawai'i, where, similar to Guam, quarantine is required for dogs and cats imported from regions affected by rabies. Roughly 16% of the pet-owning military families in this survey brought their pets with them in the transfer, undeterred by quarantine requirements. Residents of military base housing on Guam are permitted to keep two pet dogs or cats (VETCOM 2009).

Currently, there are seven military working dogs on the Navy base and 16 on Andersen AFB (U.S. Navy 2009f). The number of military working dogs present on Guam will probably increase along with the military relocation (VETCOM 2009).

Dog fighting is an illegal activity occurring on Guam (Taijeron 2009) despite recently implemented regulations making dog fighting a felony. Additionally, the U.S. Army recently issued a memo banning "aggressive or potentially aggressive" dogs from military housing (US Army 2008, CDC 2010c). Therefore, we do not anticipate an increase in imports of dogs for fighting associated with the military relocation.

We expect the military relocation will result in increased numbers of domesticated cats and dogs being moved through legal means to Guam. Illegal introduction of dogs or cats to Guam might occur via private vessels, such as cruising or fishing vessels, which occasionally carry companion animals aboard (Sgambelluri et al. 2009), but we do not expect this traffic to increase as a result of the military relocation.

A6.3.3.4.1 *Hazards Associated with the Cats and Dogs Pathway*

Domesticated cats and dogs can transport hazards in three roles: they can be infected hosts, they can be contaminated with disease agents and serve as fomites, or they can serve as hosts to tick vectors of disease agents. Table A6-11 lists hazards that are associated with domesticated cats and dogs through these three roles, including hazards for which these animals may serve as dead-end hosts or play a minor or theoretical role in transmission.

Table A6-11: Hazards Associated With the Cats and Dogs Pathway

Hazard	Disease	Transport role[a]	References
Disease agent			
African horse sickness virus	African horse sickness	I	CFSPH 2006a, OIE 2009f
African swine fever virus	African swine fever	F	CFSPH 2010a
Chrysomya bezziana	Old world screwworm myiasis	I	CFSPH 2007l
Classical swine fever virus	Classical swine fever	F	CFSPH 2009d
Cochliomyia hominivorax	New world screwworm myiasis	I	CFSPH 2007l
Echinococcus granulosus; E. multilocularis	Echinococcosis/hydatidosis	I	OIE 2008e, CFSPH 2009h
Equine encephalomyelitis virus (Venezuelan)	Equine encephalomyelitis (Venezuelan)	I	OIE 2009u
Foot and mouth disease virus	Foot and mouth disease	F	CFSPH 2007e, 2008
HPAIV	HPAI	I	USGS 2010

Hazard	Disease	Transport role[a]	References
Leishmania spp.	Leishmaniasis	I	Dantas-Torres 2007, OIE 2008n, CFSPH 2009k
Rabies virus	Rabies	I	CDC 2008a, CFSPH 2009m
Salmonella Pullorum	Pullorum disease	I	CFSPH 2009j
Trypanosoma spp. (African)	Trypanosomiasis (African animal)	I	CFSPH 2009a
Trypanosoma evansi	Surra	I	OIE 2008q, CFSPH 2009n
Vector			
Tick[b]			
Amblyomma spp.	Equine piroplasmosis; heartwater; Nairobi sheep disease; theileriosis	V	Kolonin 2009
Dermacentor spp.	Equine piroplasmosis	V	Kolonin 2009
Haemaphysalis spp.	Nairobi sheep disease; theileriosis	V	Kolonin 2009
Hyalomma spp.	African horse sickness; equine piroplasmosis; theileriosis	V	Kolonin 2009
Rhipicephalus spp.	African horse sickness; equine piroplasmosis; Nairobi sheep disease; theileriosis	V	Kolonin 2009

[a] Pathway's role in hazard transport: I: infected host, F: fomite, V: vector transporter.

[b] Not all species of all genera feed on cats or dogs.

A6.3.3.4.2 *Release Assessment: Cats and Dogs Pathway*

Likelihood of Hazard Association

Domesticated dogs and cats can be infected with and serve as reservoirs for rabies (CFSPH 2009m; CDC 2010g). Domesticated dogs and cats, among many other mammalian hosts, can harbor screwworms, *Echinococcus* spp., *Leishmania* spp., and *Trypanosoma* spp. parasites (Barr et al. 1991; Bradley et al. 2000; Jenkins et al. 2000; USDA-APHIS 2000; Beard et al. 2003a; Dantas-Torres 2007; CFSPH 2009k; OIE 2009q, t). Cats and dogs are susceptible to infection with HPAI virus, although the significance of their roles in transmission of the virus has not been elucidated (CFSPH 2010b). Dogs can be infected with African horse sickness and Venezuelan equine encephalomyelitis viruses, and both cats and dogs can be infected with Salmonella Pullorum, but most sources suggest that dogs and cats do not play a significant role in the maintenance or spread of these hazards (CFSPH 2006a, 2008a, 2009j).

African swine fever, classical swine fever, and foot and mouth disease viruses can be mechanically spread by domesticated animals which have been in contact with affected premises (CFSPH 2007e, 2009d, 2010a). Theoretically, this would include dogs and cats, though it is difficult to definitively link dogs or cats as a primary source for spread in prior outbreaks.

Dogs are common hosts for several tick species that are competent vectors of equine piroplasmosis and heartwater (Estrada-Peña et al. 2004). In a few instances, hazard ticks, specifically *Amblyomma* spp., have been found on dogs imported to the United States (James and Freier 2004; USDA-APHIS-VS CEAH 2006). Hazard ticks are infrequently collected from domesticated cat hosts, perhaps because the grooming behavior of cats limits tick attachment (Hart 1990).

Traffic Volume

We were unable to find data on the importation to Guam of civilian pets, except for FY 2002 (Table A6-12) (GovGuam 2002; Campbell 2010c). The number of cats and dogs imported to Guam annually is low, with estimates ranging from 10 to 100 animals a year (Poole 2009). As described elsewhere in this document, the military and civilian population on Guam will grow during the military relocation, and some people will bring pet cats and dogs with them. A 1985 survey suggests that many pet owners choose not to bring their pets with them when transferring to an overseas assignment, after considering the time, expense, and animal's physiologic stress associated with shipping and quarantine procedures (Anderson 1985). Based upon the anticipated increase in the number of military and civilian families, U.S. household pet ownership rates, and the estimate of the rate of pets accompanying transferring military personnel, we estimate that at least 500 additional pet cats and dogs will be imported over the course of the relocation.

Due to the increased military presence on Guam, it is likely that the number of military working dogs will increase (VETCOM 2009). Estimates are not available, because decisions on redeployment have not yet been made, but the number of additional dogs is expected to be small.

Traffic Origin

The majority of past imports originated from the continental United States and Australia, with a few animals imported from Japan and CNMI (USDA-APHIS-PPQ 1997).

Table A6-12: Country of Origin and Total Numbers of Cats and Dogs Imported to Guam, 2002

Country of origin	Cats	Dogs
United States	0	53
Australia	20	54
Japan	4	4
CNMI	0	2
Total	24	113

Source: GovGuam 2002; Campbell 2010c

It is unusual for military personnel to have two consecutive assignments outside of the continental United States (VETCOM 2009). Therefore, most of the cats and dogs imported due to the relocation will come from the continental United States or Hawai'i. Civilian personnel employed by the military are also likely to come mostly from the continental United States or Hawai'i (VETCOM 2009). Guam territorial import regulations for cats and dogs, which are discussed below, are likely to dissuade or prevent many foreign temporary workers from bringing pets with them to Guam, except workers from regions unaffected by rabies, including Japan, Australia, and New Zealand.

Of the more than one million tourists that visit Guam yearly, 80% come from Japan. Japanese tourists average a three night stay on the island, making it unlikely that they will bring any pets with them (Mok and Iverson 2000). The time and expense of pet quarantine is likely to deter tourists from most other areas from traveling with their pets to Guam.

The United States is free of most of the livestock and poultry disease agents that can be associated with cats and dogs (see Table A6-11), with the exception of *Echinococcus* spp., *Leishmania* spp., and rabies (USDA-APHIS 2008b).

Mitigations

Under 42 CFR § 71.51, cats and dogs imported to the United States are subject to inspection at ports of entry and may be denied entry if they have evidence of an infectious disease that can be transmitted to humans. Dogs imported to the United States, with limited exceptions, must be accompanied by a certificate for rabies vaccination; imported cats are not required to be vaccinated for rabies. The entry of pets from areas affected by screwworms is subject to APHIS regulations (9 CFR § 93.600), requiring a health certificate stating that the dog was examined and found to be free of screwworm infestation within 5 days of export (USDA 2000; USDA-APHIS 2009c; 9 CFR § 93.600).

Guam's restrictions on the importation of cats and dogs are even more stringent than federal requirements and include additional specific quarantine requirements to protect its rabies-free status. Cats and dogs must enter Guam through A.B. Won Pat International Airport or the maritime port of Apra Harbor. All cats and dogs must be accompanied by documentation including an entry permit, a health certificate signed by a veterinarian no more than 14 days prior to shipment, and a confirmed quarantine kennel reservation. They must also have identification, comply with all quarantine procedures, and undergo rabies vaccination and testing prior to arrival (9 GARR 1, Division 1, Chapter 1). Dogs must have a rabies vaccination certificate dated no less than 30 days and no more than one year prior shipment; and a certificate of immunization against distemper, hepatitis, leptospirosis, parainfluenza, parvovirus, coronavirus, and bordetella. Cats must have a certificate of immunization for feline distemper, feline viral rhinotracheitis, calicivirus, panleukopenia, and chlamydia (9 GARR 1, Division 1, Chapter 1).

The importation of pets to Guam is regulated by GDOA (5 GCA § 60108). Title 10 Guam Code Annotated Chapter 34 Article 3 states that animals imported are to complete a maximum of 120-day confinement in a commercial quarantine facility. Animals may undergo 30 days of quarantine if they meet pre- and post-arrival requirements, including the administration of two doses of rabies vaccine; the presence of an adequate protective antibody titer against rabies based on a fluorescent antibody virus neutralization (FAVN) rabies test as tested by the GDOA quarantine program; and a properly implanted identification microchip (GCA 2010b). A five-day quarantine program is available for pets if the FAVN test is conducted by an eligible laboratory no less than 120 days or more than 12 months prior to arrival on Guam (GDOA 2007b). Under certain conditions, pets may qualify for the option of home quarantine (GDOA 2009).

Animals originating from Japan, Hong Kong, Oceania, and the continental United States (except for counties on the Mexican border) can be quarantined on Guam. Animals originating from elsewhere must be quarantined in Hawai'i prior to arrival on Guam. Cats and dogs originating from rabies-free areas, such as Hawai'i, New Zealand, Australia, and the United Kingdom, will be exempted from quarantine if they comply with all other requirements.

Other import regulations for cats and dogs are included in the Guam Administrative Rules and Regulations, Title 9, Division 1, Chapter 1, § 1109. All cats and dogs originating from Africa, Asia, or islands of the Pacific Ocean (except Australia, Hawai'i, and New Zealand) must have a certificate from the national chief livestock sanitary officer stating that the animals originated in a state, country, or other political subdivision officially declared free of surra, African animal trypanosomiasis, and leishmaniasis.

Cats and dogs that do not comply with regulations may be declared ineligible to enter and remain in the custody of the carrier at a designated inspection area at the port of entry until the animal is sent back (maximum 72 hours) or humanely disposed of. In addition, the carrier is fined between $500 and $1,000 for transporting the animal without an entry permit (GDOA, GCA 2010b).

The U.S. military has published rules and regulations for the importation of cats and dogs. These regulations include the federal and state requirements, and are published in the Quarantine Regulations of the Armed Forces (DoD 1992). General requirements for the admission of cats and dogs include these: 1) all animals arriving in the United States are subject to inspection by a public health or military quarantine officer; 2) animals will require testing and confinement when they do not appear in good health or in the event that they have been exposed during shipment to a sick or dead animal suspected to have a communicable disease; 3) unsanitary containers of cats and dogs arriving in the United States must be cleaned and disinfected before the animal can be admitted; and 4) a valid rabies certificate is required for dogs. The military requires dogs to be vaccinated for rabies and inspected at the port in accordance with Quarantine Regulations (DoD 1992). In addition, all pets belonging to military personnel must meet the requirements for importation to Guam.

GDOA does not operate a quarantine facility for imported cats and dogs. One private veterinary clinic on Guam maintains a quarantine facility. The military has one veterinary clinic and a boarding and quarantine facility at Andersen AFB and another veterinary treatment facility at the Navy base (USMA 2008). The Andersen AFB facility maintains 14 canine and 6 feline quarantine kennels. A new Navy facility will be constructed to include space for 10 military working dogs, a veterinary examination area, an outdoor dog wash, and 4 quarantine runs (U.S. Navy 2009f). The kennel will be fenced and the building and gate will have an intrusion detection system to avoid escape or intrusion of other animals into the kennel. The facilities are designed to prevent disease transmission between dogs. Solid waste will go to the Navy landfill.

Since the Vietnam War era, when many military working dogs could not return to the United States after deployment due to the threat of introduction of exotic diseases, veterinary care and treatment for military working dogs has significantly improved (English 2000). Following the 1990-1991 Persian Gulf conflict, the health records of 118 military working dogs were reviewed and none indicated evidence of zoonotic disease (Burkman et al. 2001). More recent studies have shown that few military working dogs are exposed to infectious diseases and that the major cause of mortality is natural death or euthanasia associated with advanced age (Moore et al. 2001; Evans et al. 2007).

Summary

The number of domesticated cats and dogs imported to Guam is likely to increase as result of the military relocation. Most of these animals are likely to originate from the continental United States, which is free of most of the poultry and livestock disease hazards for which domesticated cats and dogs are epidemiologically significant sources. The one important exception is rabies, which is present in the continental United States. However, the risk of importation or interstate movement of hazards for which domesticated cats and dogs might play a significant role in transporting to Guam is mitigated by U.S. military and Guam territorial regulations.

Cats and Dogs Pathway Release Assessment

The increased risk of release of hazards into the Micronesia Region due to the military relocation through the cats and dogs pathway is negligible.

Cats and Dogs Pathway Risk Estimation

Because the increased risk of release of hazards into the Micronesia Region due to the military relocaiton through the cats and dogs pathway is negligible, we conclude that the military relocation-associated overall risk for the cats and dogs pathway is negligible.

A6.3.3.5 *Other Animals*

In this pathway, we consider the effect of the military relocation on the risk to livestock and poultry health through the movement of terrestrial vertebrates, other than livestock, birds, cats, dogs, and humans, into the Micronesia Region. These animals include non-domesticated mammals, reptiles, and amphibians that might be intended for pets, food, zoological collections, research, or commercial trade. Animals intended for any of these purposes may be moved through legal or illegal means. We do not consider accidental movement of these animals in this analysis, because the risk posed by free-living non-domesticated animals is considered elsewhere in this document. In this section, discussion of risk to human and companion animal health is limited to the livestock and poultry hazards associated with these animals; information on other hazards is addressed elsewhere in this document.

With certain exceptions, live non-domesticated animals may legally enter the United States through Guam (Jenkins 2007; Jenkins et al. 2007). However, in the USFWS Law Enforcement Management Information System (LEMIS) database we found no records of importation of large exotic mammals to Guam between 2006 and 2008 (USFWS 2009a). On Guam, animal agriculture is in decline, due in part to competition for land use and the relatively high cost of feed, most of which must be imported (Poole 2009); these conditions probably also limit the potential for game ranching and the establishment or expansion of zoological collections. Therefore, we do not expect that the military relocation will alter this trend and increase traffic volume in large non-domesticated mammals, such as carnivores or hoofed animals.

On the other hand, the U.S. live animal trade in small mammals, reptiles, and amphibians has grown significantly since the 1990s, driven in part by the increasing popularity of exotic pets and demand for traditional foods and medicines (Jenkins 2007; TRAFFIC 2008). The United States is the leading import market in this global trade, receiving millions of animals each year (Bergman 2009; Pavlin et al. 2009). Worldwide, illegal trade in these animals is also substantial and profitable, though challenging to quantify (Wyler and Sheikh 2009). The larger human population resulting from the military relocation will likely increase demand for exotic pets and for traditional foods and medicines, and therefore, increase pathway traffic volume in small mammals and reptiles through either legal or illegal means.

A6.3.3.5.1 *Hazards Associated with the Other Animals Pathway*

The groups of terrestrial vertebrates considered in this pathway are limited to species common in the pet or wildlife trade, which have been associated with pathogen or vector hazards. These are small mammals (rodents, lagomorphs, and hedgehogs), and reptiles and amphibians (lizards, snakes, turtles, tortoises, frogs, and toads).

Small mammals, reptiles, and amphibians can transport hazards in three roles: they can be infected hosts, they can be contaminated with disease agents and serve as fomites, or they can serve as hosts to tick vectors of disease agents. Table A6-13 lists hazards that are associated with these animals through these three roles, including hazards for which these animals may serve as dead-end hosts or play a minor or theoretical role in transmission.

Table A6-13: Hazards Associated with the Other Animals Pathway (Small Mammals, Reptiles, and Amphibians)

Hazard	Disease	Transport role[a]	References
Disease agent			
African swine fever virus	African swine fever	F	CFSPH 2010a
Chrysomya bezziana	Old world screwworm myiasis	I	CFSPH 2007l
Classical swine fever virus	Classical swine fever	F	CFSPH 2009d
Cochliomyia hominivorax	New world screwworm myiasis	I	CFSPH 2007l
Echinococcus granulosus; E. multilocularis	Echinococcosis/hydatidosis	I	OIE 2008e, CFSPH 2009h
Equine encephalomyelitis viruses (Western and Venezuelan)	Equine encephalomyelitis (Western and Venezuelan)	I	CFSPH 2008a, OIE 2009u
Foot and mouth disease virus	Foot and mouth disease	F	Thomson et al. 2003, CFSPH 2007e
HPAIV	HPAI	I	USGS 2010
JEV	Japanese encephalitis	I	CFSPH 2007h
Rabies virus	Rabies	I	OIE 2008o, CFSPH 2009m
Salmonella Pullorum	Pullorum disease	I	CFSPH 2009j
Trypanosoma evansi	Surra	I	CFSPH 2009n
Trypanosoma spp. (African)	Trypanosomiasis (African animal)	I	CFSPH 2009a
Vesicular stomatitis virus	Vesicular stomatitis	I	OIE 2009v

Hazard	Disease	Transport role[a]	References
WNV	West Nile fever	I	OIE 2008s, CFSPH 2009q
Vector			
Tick[b]			
Amblyomma spp.	Equine piroplasmosis; heartwater; theileriosis	V	Kolonin 2009
Dermacentor spp.	Equine piroplasmosis	V	Kolonin 2009
Haemaphysalis spp.	Nairobi sheep disease; theileriosis	V	Kolonin 2009
Hyalomma spp.	African horse sickness; equine piroplasmosis; theileriosis	V	Kolonin 2009
Ornithodoros spp.	African swine fever	V	Kahn and Line 2008
Rhipicephalus spp.	African horse sickness; equine piroplasmosis; Nairobi sheep disease; theileriosis	V	Kolonin 2009

[a] Pathway's role in hazard transport: I: infected host, F: fomite, V: vector transporter.
[b] Not all species of all genera feed on other animals.

A6.3.3.5.2 *Release Assessment: Other Animals Pathway*

Likelihood of Hazard Association

Small mammals, reptiles, and amphibians can carry a variety of disease agents, either mechanically, as in the case of rodents spreading African swine fever, classical swine fever, or foot and mouth disease virus (CFSPH 2007e, 2009d, 2010a), or as biological hosts. All mammals are susceptible to screwworm infestation and rabies virus infection (CFSPH 2007l, 2009m). Rodents are intermediate hosts of *Echinococcus* species, and are reservoir hosts of Venezuelan equine encephalomyelitis virus (CFSPH 2008a; OIE 2008e). HPAI virus, Salmonella Pullorum, WNV, and JEV infections occur primarily in avian species but can also occur in rodents (CFSPH 2007h; Cardona et al. 2009; CFSPH 2009j, q; USGS 2010). The etiologic agents of surra and African animal trypanosomiasis have a wide host range that includes most domesticated mammals and some wild species, including rodents (CFSPH 2009n, a). Vesicular stomatitis affects primarily livestock, although evidence of infection has been detected in rodents (CFSPH 2008g). Although birds are the main reservoir hosts of Eastern and Western equine encephalomyelitis viruses, other animals including reptiles and amphibians can be infected with these viruses (CFSPH 2008a). JEV infections have also been reported to occur in reptiles and amphibians (CFSPH 2007h).

The increased international movement of reptiles for the pet trade has been cited as a high risk pathway for introduction of exotic ticks and pathogens to new geographic locations (Burridge and Simmons 2003). Members of the genera Amblyomma, Dermacentor, Haemaphysalis, Hyalomma, and Ornithodoros frequently parasitize reptiles, particularly terrestrial chelonians, snakes, and lizards, in tropical regions (Pietzsch et al. 2006). Numerous ticks, primarily exotic species of Amblyomma and Hyalomma, have been found on reptiles imported to the United States, sometimes after the animals had reached their destinations within the country (Burridge and Simmons 2003; USDA-APHIS-VS CEAH 2006). There is evidence that exotic ticks introduced with imported reptiles could be infected with organisms pathogenic to domestic livestock populations (Pietzsch et al. 2006). For example, *E. ruminantium*, the causative agent of heartwater, was detected in Amblyomma sparsum ticks collected from tortoises imported to the United States (Burridge et al. 2000).

Traffic Volume and Origin

The largest group of mammals imported to the United States from 2004 to 2008 was rodents, and the number of rodents imported during those years steadily increased from nearly 40,000 animals in 2004 to more than 240,000 in 2007 alone (USFWS 2009a). These imported rodents, which include popular pets such as rats, mice, hamsters, and gerbils, were almost exclusively bred and raised in captivity (USDA-APHIS-VS CEAH 2010). Lagomorphs (rabbits and hares) were also among the top four most frequently imported groups of animals from 2004 to 2008, although the total number of imported lagomorphs declined during that period of time (USFWS 2009a; USDA-APHIS-VS CEAH 2010). Imported rabbits and hares, like rodents, were almost exclusively bred and raised in captivity, and were imported for commercial purposes or as personal pets.

The international trade in reptiles and amphibians has grown dramatically in the last decade, and the U.S. pet trade is recognized as a major consumer of live reptiles and amphibians (Burridge and Simmons 2003). LEMIS records show that the United States imported an average of 1.5 million reptiles and amphibians in more than 8,000 shipments per year during 2004 to 2008 (USFWS 2009a). In contrast to the small mammal trade, most shipments of reptiles and amphibians imported to the United States include specimens captured from the wild (USFWS 2009a).

Data are unavailable to quantify the number of small mammals, reptiles, and amphibians imported to Guam or the Micronesia Region, although there is evidence that importation of these animals occurs, through both legal and illegal means. Pet stores exist in Guam, CNMI, and FSM, where small mammals, reptiles, and amphibians may be purchased (Vice 2010a). Several species of exotic snakes and turtles have been discovered in the Micronesia Region in recent years; their presence has been attributed to release by visitors on fishing vessels or by citizens returning from foreign travel (Buden et al. 2001, Vice 2010a).

As a result of USFWS requirements for most imported wildlife traffic to pass through designated ports on the mainland United States or Hawai'i, most small animals, reptiles, and amphibians shipped to Guam for the legal pet trade likely originate in or transit through the continental United States or Hawai'i (Wyler and Sheikh 2009). LEMIS records show that the Port of Guam received no direct shipments of live small mammals, reptiles, or amphibians from non-U.S. sources from 2006 to 2008, with the exception of one shipment of turtles originating in Hong Kong, which was refused entry (USFWS 2009a). Countries in Africa and southeast Asia represent the top ten most commonly declared countries of origin for reptile and amphibian shipments to the United States (USFWS 2009a). Illegal trade in wildlife is identified as an economically significant activity in southeast Asia (TRAFFIC 2008).

Mitigations

Importation of wild mammals, reptiles, and amphibians into the United States is regulated by the USFWS, whose major concern is compliance with the CITES agreement, which is intended to ensure that international trade in animals does not threaten the survival of endangered species. Beyond CITES regulations, no governmental agency in the United States has complete jurisdiction or comprehensive import regulations for wild mammals, reptiles, or amphibians. According to USFWS regulations, importers must declare animal shipments to USFWS inspectors at the port of entry and make the animals available for visual inspection prior to removing them from the port. The USFWS reportedly inspects approximately 25% of declared wildlife shipments at the U.S. border (Wyler and Sheikh 2009).

Other federal agencies regulate imports of certain wild animal species through a patchwork of controls. Importation of African rodents into the United States is prohibited by Centers for Disease Control and Prevention restrictions intended to prevent the spread of monkeypox (CDC 2003). The Department of Health and Human Services regulates importation and sale of small freshwater turtles to prevent the spread of Salmonella bacteria to humans (21 CFR § 1240.62) (CDC 2007c). Since 1991, federal regulations intended to prevent the spread of foot and mouth disease have restricted the importation of hedgehogs (all members of the family Erinaceidae) (9 CFR § 93.700-707). Importation of leopard tortoises (*Geochelone pardalis*), African spurred tortoises (*Geochelone sulcata*), and Bell's hingeback tortoises (*Kinixys belliana*) into the United States is prohibited and interstate movement of these three species in restricted to prevent the spread of exotic ticks (9 CFR § 93.701 and 9 CFR § 74.1) (USDA-APHIS 2001).

Live animals entering the territory of Guam must be accompanied by an import permit and an official health certificate approved by the chief livestock sanitary officer, or a state or federal veterinarian. Animals imported to Guam are subject to inspection and quarantine, and any animal found to be clinically affected or recently exposed to any infectious, contagious, or communicable disease or infested with ectoparasites shall be returned to its point of origin or destroyed (9 GARR 1, Division 1, Chapter 1). It is unclear to what extent these regulations are enforced for small mammals, reptiles, or amphibians legally imported to Guam for the pet trade.

Summary

The larger human population resulting from the military relocation will likely increase demand for exotic pets and for traditional foods and medicines, and therefore, we expect a slight increase in pathway traffic volume in small mammals and reptiles.

Caged, captive-bred small mammals are unlikely to encounter livestock or poultry pathogens or host ticks of importance to livestock. Although the role of small mammals in the introduction of hazards listed in Table A6-13 to new regions is theoretically possible, we found no documentation of release of hazards through importation of captive-bred rodents or lagomorphs. The Centers for Disease Control and Prevention ban on importation of African rodents indirectly reduces the risk of introduction of livestock diseases endemic in Africa, such African swine fever, foot and mouth disease, and trypanosomiasis, through the small mammal pathway.

The United States is a major importer of reptiles and amphibians, and import records show that many of these animals are captured from the wild in African countries. The primary hazards of concern associated with reptiles or amphibians are tick vectors of several livestock pathogens, including the etiologic agent of heartwater, which is endemic to regions of Africa. Reptiles are frequently parasitized by several species of hazard ticks exotic to the Micronesia Region, and current mitigations are not sufficient to prevent importation of tick-infested reptiles to the United States (Burridge and Simmons 2003). Illegal introductions of reptiles into the Micronesia Region have been reported (Buden et al. 2001; Vice 2010a).

Other Animals Pathway Release Assessment

The increased risk of release of hazards into the Micronesia Region due to the military relocation through intentional movement of reptiles (legal or illegal) is low.

The increased risk of release of hazards into the Micronesia Region due to the military relocation through intentional movement of non-domesticated mammals and amphibians is negligible.

A6.3.3.5.3 ***Exposure Assessment: Other Animals Pathway***

Biological Factors

Amblyomma ticks known to be capable of transmitting heartwater are generally hardy, long-lived species that attach to their reptile hosts for prolonged periods of time, possibly weeks to months (Petney et al. 1987). The etiologic agent of heartwater, *E. ruminantium*, has been shown to persist in these ticks for up to 15 months (Ilemobade 1976). These characteristics are favorable for both tick and pathogen to survive transit with their imported reptile host to a new environment where susceptible hosts may be present.

Populations of exotic ticks, including heartwater vectors, have become established in Florida, after introduction via imported tick-infested reptiles (Burridge et al. 2000). After arrival in Florida, the ticks apparently were disseminated from reptile importers to breeders, zoos, wildlife theme parks, pet stores, and private hobbyists. Intentional release and subsequent establishment of exotic reptiles in the United States has been documented, providing evidence of another plausible route for introduction and establishment of exotic tick species (Brown et al. 1995).

Regional Factors

There are several examples of exotic ticks successfully invading tropical island ecosystems. Originating in Southeast Asia, the cattle fever tick R. (B). microplus has spread throughout the tropics, including islands such as Guam, the Mariana Islands, Puerto Rico, and the U.S. Virgin Islands (Jongejan and Uilenberg 2004). The tropical bont tick *Amblyomma variegatum*, along with heartwater, has become established in several Caribbean islands, presumably following introduction with imported cattle from West Africa in the 18th or 19th century (Jongejan and Uilenberg 2004).

The presence of suitable habitat for tick survival in the Micronesia Region strongly influences the likelihood that an introduced exotic tick species will become established and therefore, the likelihood that a domesticated animal will be exposed to an exotic tick or tick-borne disease. Two essential factors that control habitat suitability for ticks are the presence of hosts and a favorable environment (Keirans and Durden 2001).

Among the most significant tick pests of livestock, ticks of the genera Amblyomma, Hyalomma, and Rhipicephalus, in general, are well-adapted to tropical environments (Rajput et al. 2006). More specific statements about candidates for establishment in the Micronesia Region, based upon habitat suitability, cannot be made with certainty, because there is limited data on tick distributions throughout the tropics, and much of the information about tick distributions in the Micronesia Region is anecdotal or outdated.

Maintenance of water balance is essential to tick survival. In tropical environments, ticks seek sheltered, humid microenvironments, generally woodlands and grasslands, to avoid desiccation (Sonenshine and Mather 1994). Human alteration of natural communities and ecological changes at a local level are factors that contribute to movement or emergence of tick populations and tick-borne disease (Korch Jr. 1994). When human pressures on the local environment are relaxed to allow lush growth of vegetation, such as through reforestation or allowing cultivated fields to lie fallow, expansions of tick populations have occurred (Sonenshine and Mather 1994). Conversely, habitat modification by destroying vegetation through mowing or burning is a proven method of reducing tick populations (Piesman and Gray 1994).

The military relocation in Guam is likely to reduce favorable tick habitat by altering vegetation on the island. Construction activities associated with the military relocation are expected to result in loss of woodlands and grasslands in Guam. For example, in Guam, construction could result in clearing of more than 600 hectares of limestone forest, approximately 3.5% of existing limestone forest (U.S. Navy 2009f, i). Estimates of potential impact also include clearing of almost 200 hectares of scrub, shrub, and tangantangan forest; and approximately 8 hectares of savanna (U.S. Navy 2009i).

A tick requires a suitable host as a blood source which is needed for development and reproduction. Host availability may be more important than climate in determining tick abundance (Estrada-Peña 2008, Randolph 2008). Introduced predators and land use changes in Guam limit the populations of small mammals, birds, and large hoofed mammals, three important groups of vertebrate hosts for ticks. Due to the presence of BTS, there are areas in Guam that lack all native vertebrates except for a few species of small lizards (Rodda and Savidge 2007). Most species of birds have been extirpated from Guam as a result of BTS predation, and small mammals are less numerous than before the arrival of the snake (Rodda and Savidge 2007). The USDA Census of Agriculture documents the decline of livestock farming in Guam; both the number of farms and the numbers of cattle, carabaos (*Bubalus bubalis*), goats, and swine have decreased in Guam over the past decade (USDA-NASS 2009a).

Although Guam's populations of farmed hoofed mammals are in decline, wild hoofed mammals are thriving and serve as hosts for introduced ticks. Feral populations of carabaos, Philippine deer (*Cervus mariannus*), and swine are present and increasing in Guam (Specht 2003; Wiles 2005). In Guam, carabaos and deer are frequently infested by R. (B.) microplus ticks (Kohls 1953). Bovids and cervids, in general, are preferred as hosts for numerous species of ticks (Kolonin 2009).

Because Guam serves as a distribution point for the rest of the Micronesia Region, exotic ticks introduced to Guam could be disseminated elsewhere in the Region. The distribution of suitable vertebrate hosts for ticks, particularly birds and small mammals, differs on other islands of the Micronesia Region from that in Guam, and other islands may provide more suitable habitat for introduced ticks than Guam.

Summary

Given the opportunity through introduction, exotic tick species currently existing in tropical areas may extend their distributions to the Micronesia Region. In Guam, availability of vertebrate hosts and suitable microclimate environments are limiting factors to the likelihood of establishment of exotic tick species. The low density of some groups of vertebrate hosts for ticks may reduce the likelihood that some exotic tick species, if introduced, will find suitable hosts and establish a population in Guam. The military relocation is predicted to result in development in some woodlands and grasslands in Guam, and therefore, remove some habitat suitable for ticks and their vertebrate hosts. There is no indication that the military relocation will create a more favorable environment for tick establishment, and therefore, the military relocation is unlikely to increase the risk of exposure of domesticated animals to exotic ticks or tick-borne disease.

Other Animals Pathway Exposure Assessment

The risk of exposure of livestock or poultry to hazards released into the Micronesia Region through the intentional movement of reptiles is low.

A6.3.3.5.4 ***Consequence Assessment: Other Animals Pathway***

The two potential adverse events caused by the introduction of tick-infested reptiles are introduction of an exotic tick-borne disease carried by an exotic tick, or establishment of an exotic tick species that serves as a more effective vector of endemic disease, or causes more severe physical damage to hosts than endemic ticks. *Ehrlichia ruminantium*, the etiologic agent of heartwater, a tick-borne disease of ruminants, is a hazard of high consequence associated with imported reptiles; therefore, this agent is the focus of the consequence assessment for this pathway.

Biological Consequences

Mortality due to infection with *E. ruminantium* in naive populations of ruminants may be high; mortality rates of 40, 60, and 90% have been observed in calves, adult cattle, and goats, respectively (Kasari et al. 2010). *Ehrlichia ruminantium* is not thought to be zoonotic (CFSPH 2007g). Heartwater is readily introduced into new regions in infected animals or ticks, and therefore, the presence of heartwater in Guam would increase the risk of introducing this disease into the rest of the Micronesia Region, Hawai’i, or the continental United States (CFSPH 2007g). If heartwater is introduced into the continental United States, critical factors of tick vectors, suitable environment, and susceptible hosts are present to support establishment of the disease (Kasari et al. 2010).

The direct effects of tick infestation of livestock, such as dermatitis, anemia, and loss of condition, due to new tick/host interactions, are difficult to predict. Parasitism of cattle by the heartwater vector *Amblyomma variegatum* is associated with bovine dermatophilosis, a severe skin disease with significant impact on tropical animal health and production (Morrow et al. 1996).

Environmental Consequences

Chemical control using acaricides continues to be the primary means of tick control and eradication (Kunz and Kemp 1994). Intensive use of these products on livestock has led to resistance in ticks to several classes of pesticides. Environmental concerns, particularly the persistence of pesticide residues in the environment and their effects on non-target species, have been raised regarding the use of pesticides on livestock. The environmental costs of area-wide or large-scale host applications of acaricides may be unacceptable (Kunz and Kemp 1994).

Fatal heartwater infections have been reported in water buffalo and several species of deer and antelope (Peter et al. 2002). Presumably, Philippine deer and feral carabaos on Guam would be susceptible to infection, suffer high mortality, and serve as reservoirs, but confirmation is lacking.

Economic Consequences

Historically, the United States has responded to the establishment of exotic tick species by mounting eradication campaigns. These programs are expensive and require long-standing efforts, exemplified by ongoing attempts to eradicate Amblyomma variegatum from the Caribbean. To date, control efforts have reduced the numbers of ticks on some islands and eradicated them from others, but complete eradication throughout the Caribbean remains elusive (CFSPH 2007g). Creating and executing a successful tick eradication program in the present era is a difficult, if not impossible, task due to several challenges: acaricide resistance, the abundance of white-tailed deer and other wildlife hosts, restrictions on the use of pesticides, cost, and public attitudes (George et al. 2002).

Heartwater is a serious constraint to livestock production in areas of the world where it is endemic (CFSPH 2007g). The greatest direct economic losses due to heartwater in endemic areas are attributable to tick control costs, milk revenue loss, and livestock treatment costs (Mukhebi et al. 1999). In 1993, USDA estimated that, if heartwater became established in the United States, the value of potential livestock losses could total $494 million over five years (USDA-APHIS 1993). In addition to direct losses, introduction of heartwater into the continental United States would likely result in severe indirect economic effects due to trade restrictions. In the event of a heartwater disease outbreak on U.S. island territories, such as Guam or CNMI, countries would likely use a regionalization approach, imposing restrictions on ruminants from the affected area only. The effect of regionalization would most likely reduce the trade consequences at the national level. The local effect of trade restrictions for live ruminants is not likely to be significant to Guam or the rest of the Micronesia Region, where no commercial ruminant export trade occurs.

Summary

Importation of reptiles is a recognized pathway for introduction and establishment of exotic ticks and exotic tick-borne diseases of livestock, such as heartwater. Establishment of exotic tick species or introduction of heartwater in Guam, the rest of the Micronesia Region, or the rest of the United States poses a significant threat in terms of biological, environmental, and economic consequences.

Other Animals Pathway Consequence Assessment

The significance of the consequences to Guam of livestock or poultry exposure to hazards released into the Micronesia Region through intentional movement of reptiles is very low.

The significance of the consequences to the rest of the Micronesia Region of livestock or poultry exposure to hazards released into the Micronesia Region through intentional movement of reptiles is very low.

The significance of the consequences to the rest of the United States of livestock or poultry exposure to hazards released into the Micronesia Region through the intentional movement of reptiles is medium.

Other Animals Pathway Risk Estimation

Because the increased risk of release of hazards into the Micronesia Region due to the military relocation through the intentional movement of reptiles is low, the risk of exposure of livestock and poultry is low, and the significance of consequences of livestock and poultry exposure to Guam, the rest of the Micronesia Region, and the rest of the United States is low, we conclude that the military relocation-associated overall risk from reptiles is low.

A6.3.3.6 *Humans*

In this pathway, we consider the effect of the military relocation on risk to livestock and poultry health through the movement of people into the Micronesia Region. The number of people travelling into the Region will increase as a result of the military relocation. Discussion of risk to human health is limited to the livestock and poultry hazards associated with people.

In this section, we do not cover objects potentially carried by humans, such an animal products or smuggled live birds. Those are covered in the animal products and poultry pathways, respectively.

A6.3.3.6.1 *Hazards Associated with the Humans Pathway*

People can transport hazards in three roles: they can be infected hosts, they can be contaminated with disease agents and serve as fomites, or they can serve as hosts to tick vectors of disease agents. Baggage or other personal belongings accompanying travelers can be contaminated with disease agents or transport tick vectors. Animal products can also be carried in baggage or personal belongings; this possibility is covered in the animal products pathway. Table A6-14 lists hazards that are associated with people or their accompanying baggage through the roles associated with humans, including hazards for which humans may serve as dead-end hosts or play a minor or theoretical role in transmission.

Table A6-14: Hazards Associated with the Humans Pathway

Hazard	Disease	Transport role[a]	References
Disease agent			
African swine fever virus	African swine fever	F	CFSPH 2010a
Bacillus anthracis	Anthrax	I	CFSPH 2007a
Brucella abortus	Brucellosis (*Brucella abortus*)	I	CFSPH 2009b, OIE 2009a
Burkholderia mallei	Glanders	I	CFSPH 2007f
Campylobacter fetus venerealis; C. fetus fetus	Bovine genital campylobacteriosis	I	OIE 2008b
Chlamydophila abortus	Enzootic abortion of ewes (ovine chlamydiosis)	I	OIE 2008f
Chrysomya bezziana	Old world screwworm myiasis	I	CFSPH 2007l, OIE 2009q
Classical swine fever virus	Classical swine fever	F	CFSPH 2009d, OIE 2009h
Cochliomyia hominivorax	New world screwworm myiasis	I	CFSPH 2007l, OIE 2009q
Equine encephalomyelitis viruses (Eastern, Western, and Venezuelan)	Equine encephalomyelitis (Eastern, Western, and Venezuelan)	I	CFSPH 2008a
Exotic NDV	Exotic Newcastle disease	I, F	CFSPH 2008d
Foot and mouth disease virus	Foot and mouth disease	F	CFSPH 2007e, 2008
HPAIV	HPAI	I, F	CFSPH 2010b
JEV	Japanese encephalitis	I	OIE 2010d
Leishmania spp.	Leishmaniasis	I	CFSPH 2009k
Mycobacterium bovis	Bovine tuberculosis	I	CFSPH 2009c, OIE 2009b
Nipah virus	Nipah virus encephalitis	I	CFSPH 2007j, WHO 2009e
Rabies virus	Rabies	I	OIE 2008o
Rift Valley fever virus	Rift Valley fever	I	OIE 2009p, WHO 2010i
Salmonella Gallinarum	Fowl typhoid	F	Shivaprasad 2003
Salmonella Pullorum	Pullorum disease	F	Shivaprasad 2003
Trypanosoma spp. (African)	Trypanosomiasis (African animal)	I	OIE 2008r
Vesicular stomatitis virus	Vesicular stomatitis	I	OIE 2009v
WNV	West Nile fever	I	OIE 2008s
Vector			
Tick[b]			
Amblyomma spp.	Equine piroplasmosis; heartwater; Nairobi sheep disease; theileriosis	V	Kolonin 2009
Dermacentor spp.	Equine piroplasmosis	V	Kolonin 2009
Haemaphysalis spp.	Nairobi sheep disease; theileriosis	V	Kolonin 2009
Hyalomma spp.	African horse sickness; equine piroplasmosis; theileriosis	V	Kolonin 2009
Rhipicephalus spp.	African horse sickness; equine piroplasmosis; Nairobi sheep disease; theileriosis	V	Kolonin 2009

[a] Pathway's role in hazard transport: I: infected host, F: fomite, V: vector transporter.
[b] Not all species of all genera feed on humans.

A6.3.3.6.2 *Release Assessment: Humans Pathway*

Likelihood of Hazard Association

Infected humans can serve as reservoirs for transmission of Leishmania parasites to other mammals. Worldwide, the incidence of human leishmaniasis is widespread and increasing, with 1 to 2 million estimated new cases each year according to the WHO. Spread of leishmaniasis is facilitated by international travel, and cases have been identified among military personnel after their return to the United States from deployment to the Middle East (Aronson et al. 2006).

Infected humans can potentially serve as sources of transmission of *Bacillus anthracis* (CFSPH 2007a), *Brucella abortus* (CFSPH 2007d), *Burkholderia mallei* (CFSPH 2007f), *Mycobacterium bovis* (CFSPH 2009c), or Nipah (CFSPH 2007j), rabies (CFSPH 2009m), Rift Valley fever (CFSPH 2007k), Venezuelan equine encephalomyelitis (CFSPH 2008a), and vesicular stomatitis viruses (CFSPH 2008g), though the role of humans in transmission of these disease agents is either theoretical or rarely reported. Other hosts are epidemiologically more important than humans for harboring Campylobacter fetus bacteria and screwworms (CFSPH 2009o). Human infection with trypanosomes that cause African animal trypanosomiasis is very rare (OIE 2008r). Humans are generally thought to be dead-end hosts for *Echinococcus* parasites and Eastern and Western equine encephalomyelitis, Japanese encephalitis, and WNV (CFSPH 2007h, 2008a, 2009h).

Human infection with END or HPAI viruses can occur, but people play a more important role as fomites, particularly by carrying the disease agents on contaminated clothing, than as infected hosts. African swine fever, classical swine fever, and foot and mouth disease viruses and Salmonella bacteria can be mechanically spread by people, clothing, or other personal belongings, which have been in contact with affected premises (Sellers 1971; Pharo 2001; Sanchez et al. 2002; CFSPH 2009d, 2010a).

Ticks, including heartwater vectors *Amblyomma variegatum* and *A. hebraeum*, have been intercepted from international travelers and their baggage arriving in the United States (Burridge et al. 2002; USDA-APHIS 2009a).

Traffic Volume and Origin

Population summary information for the Micronesia Region can be found elsewhere in this document, including expected increases in population from off-island individuals. Details concerning traffic volume and origin information in this section may be found elsewhere in this document unless specifically referenced below.

Significant increases in traffic will occur for military personnel and their dependents, who will be assigned a tour of duty on Guam, either directly from other areas of the United States, or by way of the United States for those being reassigned from current overseas locations. Hence, the impact to Guam from additional military personnel and dependents will be from exposures common to the entire United States which is free of foot and mouth disease, African swine fever, classical swine fever, END, screwworms, Venezuelan equine encephalomyelitis, and HPAI.

The construction process will bring significant foreign labor forces to Guam. Foreign temporary workers will include mainly small numbers of H1 professional and larger numbers of H2-B non-agricultural workers. Direct impacts will be from a temporal influx of as many as 23,000 foreign, non-immigrant temporary workers to support the relocation. We are assuming that the majority will be coming from the Philippines, based on past worker recruitment patterns for Guam. In the past, the military has preferred to hire Filipino workers because they are conversant in English. Smaller numbers of managerial (H1) positions will be expected to come from Japan and Korea, in addition to the continental United States or Hawai'i.

In-migrant workers are those who enter Guam from the Freely Associated States, including FSM, Palau, and RMI, and thus share similar work status to Guam residents and are considered distinct from foreign workers. They would be expected to marginally increase in numbers; however, their impact would be minimal since they share common exposures in the Micronesia Region to those presently on Guam.

In terms of temporary visitors, Guam accommodates over one million tourists every year, primarily from Japan, Korea, Taiwan, Hong Kong, and the Philippines, but also from the rest of the United States. However, we have no reason to expect a significant increase in temporary visitors, specifically related to the relocation.

The majority of tourism originates from Asia and the rest of the United States. Travel between Guam and areas known to pose a risk for disease-carrying ticks in baggage or attached to returning travelers, including Africa and the Caribbean, is not common. This is not expected to change with the military relocation.

Guam has been subject to waves of illegal immigration in past decades, primarily from Asia. However, intense efforts on the part of the Immigration and Naturalization Service to crack down on those attempting to enter the United States through Guam or CNMI were effective in reversing this trend and there is no reason to believe illegal trafficking of humans will increase with the military relocation (1999).

Mitigations

All international flights are channeled to the international airport on Guam. GCQA has customs jurisdiction, and passengers from flight arrivals go through GCQA inspections.

All flights from Guam to the mainland United States go through Hawai'i where all passengers and cargo are treated as foreign arrivals by Honolulu PPQ inspectors. In Hawai'i, all passengers, officers, and crew members arriving by commercial aircraft or vessel and carrying plants, animals, microbial cultures, or soil must complete the mandatory agricultural declaration form and submit the imported items for inspection.

Currently U.S. CBP declaration forms for arriving international passengers collect information that enables customs officials to identify those travelers who have been in recent contact with livestock or poultry and to require disinfection of shoes and clothing or other steps as necessary to prevent disease spread. The effectiveness of this measure will depend on awareness of the animal disease outbreak status in countries of origin or embarkation and the ability of GCQA staff to rapidly adapt procedures accordingly.

Summary

Traffic volume for temporary visitors is unlikely to increase as a result of the military relocation. Nor do we expect a change in travel patterns to areas that would increase risk for hazard introduction from returning travelers or their baggage.

Military personnel and dependents will arrive directly from other parts of the United States, or after having spent time in the rest of the United States following previous overseas deployment (Jimenez et al. 2009). We assume that the time spent in other areas of the United States between deployments would be sufficient to allow for the development of symptoms from most infections acquired while overseas and thus allow for diagnosis and treatment. Thus, the risks that they will bring to Guam will largely reflect those present in the rest of the United States and are considered to be negligible.

We expect a significant increase in temporary workers, with the majority expected to come from the Philippines. A number of livestock diseases of concern are present in this area. However, the likelihood of introduction via humans as fomites is mitigated by the inspection processes in place.

Current customs procedures allow for identification of international passengers that report recent contact with livestock or poultry or presence on farms. If, as we believe, procedures are in place to identify passengers arriving from areas with ongoing outbreaks of foot and mouth disease, END, HPAI, and similar hazards, and exposure to farms, the risk will be negligible.

Humans Pathway Release Assessment

The increased risk of release of hazards into the Micronesia Region due to the military relocation through the legal movement of people is negligible.

The increased risk of release of hazards into the Micronesia Region due to the military relocation through the illegal movement of people is negligible.

Humans Pathway Risk Estimation

Because the increased risk of release of hazards into the Micronesia Region due to the military relocation through the movement of people is negligible, we conclude that the military relocation-associated overall risk for the human pathway is negligible.

A6.3.3.7 *Animal Products*

In this pathway, we consider the effect of the military relocation on the risk to livestock and poultry health through the movement of animal products into the Micronesia Region. For the purpose of this analysis, animal products are defined as products of animal origin, including meat and meat products, milk and milk products, blood and blood products, skins, feathers, wool and hair, and animal feed containing products of animal origin. Animal products may be moved through legal or illegal means. The volume of animal products moving into the Region will increase as a result of the military relocation, due to increased numbers of people travelling into Guam and demands for animal products by a larger population.

A6.3.3.7.1 *Hazards Associated with the Animal Products Pathway*

Animal products can transport hazards as fomites. Table A6-15 lists hazards that can be associated with animal products, including hazards for which animal products may serve as only a minor or theoretical source.

Table A6-15: Hazards Associated with the Animal Products Pathway

Hazard	Disease	Transport role[a]	References
Disease agent			
African horse sickness virus	African horse sickness	F	(CFSPH 2006a, OIE 2009f)
African swine fever virus	African swine fever	F	(OIE 2009g, CFSPH 2010a)
Babesia caballi and *Theileria equi*	Equine piroplasmosis	F	(CFSPH 2008b)
Bacillus anthracis	Anthrax	F	(CFSPH 2007a)
Bovine spongiform encephalopathy agent	Bovine spongiform encephalopathy	F	(CFSPH 2007c)
Brucella abortus	Brucellosis (*Brucella abortus*)	F	(CFSPH 2009b)
Capripoxvirus	Lumpy skin disease	F	(OIE 2009o)
Classical swine fever virus	Classical swine fever	F	(CFSPH 2009d, OIE 2009h)
Duck hepatitis virus types I, II, and III	Duck virus hepatitis	F	(Kahn and Line 2008)
Echinococcus granulosus; E. multilocularis	Echinococcosis/hydatidosis	F	(CFSPH 2009h)
Equine encephalomyelitis virus (Eastern)	Equine encephalomyelitis (Eastern)	F	(CFSPH 2008a)
Exotic DV	Exotic Newcastle disease	F	(CFSPH 2008d)
Foot and mouth disease virus	Foot and mouth disease	F	(CFSPH 2007e, OIE 2009j)
HPAIV	HPAI	F	(OIE 2009m, CFSPH 2010b)
Maedi-visna virus	Maedi-visna	F	(CFSPH 2007i)
Mycoplasma agalactiae; Mycoplasma spp.	Contagious agalactia	F	(CFSPH 2009e)
Mycobacterium bovis	Bovine tuberculosis	F	(CFSPH 2009c)
Nairobi sheep disease virus	Nairobi sheep disease	F	(CFSPH 2009l)
Porcine reproductive and respiratory syndrome virus	Porcine reproductive and respiratory syndrome	F	(FAO 2007b)
Rabies virus	Rabies	F	(CFSPH 2009m)
Rift Valley fever virus	Rift Valley fever	F	(CFSPH 2007k)
Rinderpest virus	Rinderpest	F	(CFSPH 2008e)
Salmonella Abortusovis	Paratyphoid abortion	F	(CFSPH 2005b)
Salmonella Gallinarum	Fowl typhoid	F	(CFSPH 2009j)
Salmonella Pullorum	Pullorum disease	F	(CFSPH 2009j)
Scrapie agent	Scrapie	F	(OIE 2009e)
Sheep and goat pox viruses	Sheep and goat pox	F	(CFSPH 2008f)
Swine vesicular disease virus	Swine vesicular disease	F	(CFSPH 2007m, OIE 2009r)

Hazard	Disease	Transport role[a]	References
Theileria spp.	Theileriosis	F	(OIE 2009s)
Transmissible gastroenteritis virus	Transmissible gastroenteritis	F	(Cook et al. 1991)
Trypanosoma evansi	Surra	F	(CFSPH 2009n)
Trypanosoma spp. (African)	Trypanosomiasis (African animal)	F	(OIE 2008r)
WNV	West Nile fever	F	(CFSPH 2009q)
Vector			
Ticks[b]		V	

[a] Pathway's role in hazard transport: I: infected host, F: fomite, V: vector transporter.
[b] See Table A6-6. Not all species of all genera are associated with animal products.

A6.3.3.7.2 *Release Assessment: Animal Products Pathway*

Likelihood of Hazard Association

A variety of animal products, including milk, eggs, meat, blood, and other tissues, can serve as disease agent sources. The disease agents listed in Table A6-15 have been detected in animal products, and could at least theoretically be transported to the Micronesia Region in animal products. Such products can enter the Micronesia Region in cargo, mail, or passenger baggage.

However, many of these disease agents are spread to susceptible species primarily through routes other than direct exposure to contaminated animal products. For example, African horse sickness virus, Capripoxvirus, Eastern equine encephalomyelitis virus, Nairobi sheep disease virus, Rift valley fever virus, WNV, and the etiologic agents of equine piroplasmosis, surra, African animal trypanosomiasis, and theileriosis are spread primarily by vectors (CFSPH 2006a, 2007k, 2008a, b, OIE 2008r, CFSPH 2009l, q, n, OIE 2009f, o, s). Other disease agents are spread primarily through close contact with infected animals; these agents include Brucella abortus, duck hepatitis virus, END virus, HPAI virus, sheep and goat pox viruses, rinderpest virus, porcine reproductive and respiratory syndrome (PRRS) virus, and Salmonella Abortusovis, Gallinarum, and Pullorum (CFSPH 2005b, 2008d, f, e; Kahn and Line 2008; CFSPH 2009b, j, OIE 2009m; CFSPH 2010b). Rabies is usually transmitted in saliva through bites from an infected animal (CFSPH 2009m).

Bacillus anthracis transmission in animals occurs by ingestion or inhalation of spores; in humans, spread is primarily through cutaneous contact, such as with contaminated hides or skins, or through ingestion of contaminated meat (CFSPH 2007a). *Mycobacterium bovis* is transmitted through ingestion or inhalation, or through breaks in the skin (CFSPH 2009c). The most common route of human infection with *M. bovis* is through aerosol inhalation, or ingestion of contaminated dairy products (CFSPH 2009c). Contaminated milk or colostrum is a primary source of transmission of Maedi-visna virus and the *Mycoplasma* spp. that cause contagious agalactia (CFSPH 2007i, 2009e).

Echinococcus granulosus and *E. multilocularis* are spread primarily through ingestion of contaminated tissues. The bovine spongiform encephalopathy agent is spread primarily through ingestion of contaminated tissues, or feed that contains ruminant-derived protein (Sejvar et al. 2008). The scrapie agent is transmitted through ingestion of contaminated blood, tissues, or secretions including milk (Sejvar et al. 2008, OIE 2009e).

African swine fever, classical swine fever, foot and mouth disease, and swine vesicular disease viruses are readily spread to swine through ingestion of contaminated meat, typically through garbage feeding (OIE 2009g, h, j, r). foot and mouth disease virus can also be spread through ingestion of contaminated milk (OIE 2009j).

The duration that disease agents remain viable in animal products varies by agent and environmental conditions. For example, African swine fever virus can remain viable in blood at 4°C for 18 months, in meat at 4°C for 5 months, in salted dried ham for more than 4 months, and in frozen carcasses for years (CFSPH 2010a). Similarly, classical swine fever virus can remain infectious for three months in refrigerated meat, more than 4 years in frozen meat, and more than 6 months in cured and smoked meats (CFSPH 2009d). Foot and mouth disease virus is inactivated in animal muscle as pH decreases to less than 6.5 after death, but can survive in chilled lymph nodes and bone marrow (CFSPH 2007e). Foot and mouth disease virus in milk can be inactivated by heating at 100°C for more than 20 minutes, but is not inactivated by low-temperature pasteurization (72°C for 15 seconds) (CFSPH 2007e). Swine vesicular disease virus can remain viable in ham for 6 months, dried sausage for more than 1 year, and processed intestinal casings for more than 2 years (OIE 2009r). Bacillus anthracis spores can remain viable for decades on processed animal products such as dried hides or wool, and for 10 years in milk (CFSPH 2007a).

Imported meat has been confirmed or strongly implicated as a disease agent source. For example, classical swine fever virus was detected in frozen meat imported into Switzerland from China in 1993 and from Romania in 1994 (Krassnig et al. 1995). Imported meat was identified as the most likely disease agent source in a foot and mouth disease outbreak in the United Kingdom in 2001 and classical swine fever outbreaks in Germany and Switzerland in the 1990s (Hofmann and Bossy 1998; Fritzemeier et al. 2000; DEFRA 2002). Imported unpasteurized cheese has been identified as a source of *Mycobacterium bovis* in the United States (Winters et al. 2005; Harris et al. 2007; Kinde et al. 2007).

Hides, skins, hair, or wool are animal products that are plausible as transport vehicles for ticks. Ticks reside on the hide or skin of living animals; however, the host becomes unattractive once the animal is slaughtered and the tick is no longer able to ingest blood. There is evidence that some partially fed ixodid ticks will detach from a recently slaughtered animal to seek a living host (Ergönül 2007). The USDA national tick survey and PPQ pest interception databases include records of nearly 100 interceptions of vector ticks on hides, skins, hair, or wool (James and Freier 2004; USDA-APHIS-VS CEAH 2006; USDA-APHIS-PPQ 2010a). The tick collection reports do not indicate whether the ticks were alive or dead at the time of collection, or whether the hides were raw or processed. Exotic ticks of the genera Rhipicephalus and Hyalomma were the ticks identified most commonly in association with hides and skins.

Illegal imports, by their nature, are difficult to describe and quantify. However, immigrant workers have been reported to carry prohibited animal products in their accompanying baggage. For example, immigrant construction workers have reportedly carried eggs and animal products for medicinal purposes (Sgambelluri et al. 2009). Studies conducted in Taiwan and the United Kingdom agreed that a large percentage of illegally introduced meat and meat products were introduced by passengers coming from Asian countries (Shih et al. 2005; Hartnett et al. 2007). We have no data on the amount of animal products seized at the A.B. Won Pat International Airport. However, during our site visit, agents from GCQA seized products containing meat, animal feed of foreign origin, and smuggled live animals during inspections conducted at the airport. Passenger baggage inspections are targeted toward flights deemed high risk, such as those from the Philippines (Jimenez et al. 2009). In our visit to A.B. Won Pat International Airport, the level of staffing was adequate to handle the number of inspections conducted given the volume of passenger traffic and passenger baggage inspections were supported with dog teams. However, infrastructure needed for operational support was lacking. For example, none of the four x-ray machines were operational, and not all passenger baggage could be screened. Since current staffing levels are operating at maximum capacity for conducting inspections, additional passenger traffic associated with the relocation will require additional resources.

Animal products are likely more frequently smuggled in passenger baggage than via maritime cargo routes. In cargo routes, prohibited agricultural products are commonly smuggled by misidentification of contraband on manifests, such as relabeling of prohibited items as permitted goods (Wyler and Sheikh 2009). Increases in cargo and passenger traffic volume and potential changes in the location of trading partners related to the relocation may contribute to an increase in the rate of prohibited animal products entering Guam. The risk associated with food is mainly limited to demand for specialty foods since the major exporters of these products to the Micronesia Region are from countries free of major livestock diseases of importance, such as the United States, Australia, and New Zealand as detailed elsewhere in this document. In addition, there have been reports of animal products such as pet food from prohibited sources being found in local stores on Guam (Jimenez et al. 2009). These products are generally less expensive than similar products from the United States, Australia, or New Zealand, which might contribute to their appeal, especially for lower paid military personnel or their dependents (Jimenez et al. 2009).

Because the United States is free of many diseases of concern, such as foot and mouth disease and classical swine fever, domestic mail does not pose a risk for introduction of these agents; however, mail from foreign locations may pose such a risk. All mail originating in the United States and most international packages destined for the Micronesia Region are processed in Honolulu, Hawai'i, before being sent to Guam. However, it is unclear to what degree foreign mail destined for Guam is inspected in Honolulu. While Guam postal officials seem to rely on Hawai'i Department of Agriculture inspectors to inspect this mail (Ericksen 2010; Shimizu 2010a), postal officials in Hawai'i seem to believe that GCQA is carrying out these inspections (Gonzalez 2010). During the first site visit, we were advised that all foreign mail that had passed through the Hawai'i facility was considered domestic mail, and was not inspected in Guam. Furthermore, because it was domestic mail, GCQA inspectors could not open any first class mail, even if it obviously contained agricultural products. Postal Service employees may notify GCQA when they suspect non-first class mail to contain illegal plants or animals, and GCQA may obtain a search warrant (Jimenez et al. 2009).

Evidence of smuggling activities via domestic mail comes from pilot studies conducted by USDA showing that a large number of packages leaving Hawai'i for the mainland United States contained undesirable organisms (Miller et al. 1992). We do not have estimates on the volumes and types of seized commodities but several models have assessed that the risk of introduction of meats via mail is relatively small compared with the risk from other pathways such as passenger baggage. A study in Great Britain estimated that less than 0.5% of the total weight of illegal meat imports entered via post or courier (Hartnett et al. 2007).

The recent outbreaks of foot and mouth disease in Asia and Europe are a reminder of the vulnerability of the Micronesia Region to exotic animal diseases. Factors such as proximity to regions with endemic disease, large amounts of boat traffic, larger population, and a large influx of tourists elevate the risk for the illegal introduction of pathogens in animal products into Guam and the Micronesia Region. The illegal importation of animal products provides a pathway around biosecurity controls and may allow contaminated animal products to enter Guam.

Risk of illegal introduction of pathogens in animal products will come primarily from Asian regions, particularly from the Philippines, as the movement of people and products to Guam will increase as a result of the military relocation (Jimenez et al. 2009). A clear example of the potential threat is classical swine fever, which occurs in several countries in Asia, including the Philippines (OIE 2009h; 2010h).

Traffic Volume

Summary data for military and civilian imports may be found elsewhere in this document.

We do not have data on the expected increase in the volume of foreign imports of animal products resulting from the potential 45% expansion in Guam's population during the military relocation. As a proxy, we reviewed the population increase and corresponding increase in food commodity imports between 1990 and 2009. Over this period, the population increased 34% (U.S. Navy 2009f). This was associated with a more than a 200% increase in the total volume of imports of commodities; total imports of eggs remained stable, while imports of meat and dairy products increased 125 and 450%, respectively (GTIS 2010).

Detailed information for human travel may be found in the human pathways section.

Traffic Origin

According to data provided by the Guam Bureau of Statistics and Plans for 2009, the major import partners for all imported commodities to Guam, as measured in terms of U.S. dollar value, were the rest of the United States (50%), Japan (14%), Western Europe (France, Italy and Switzerland) (13%), and other Asian countries or regions (16%) (including China, Korea, Taiwan, Hong Kong, Singapore, Thailand, and the Philippines). Food commodities and non-alcoholic beverages represented the largest commodity group, making up over 30% of all imports in 2009 (BSP 2009b).

However, most animal product imports to Guam originate in the continental United States and the majority of foreign imports of animal products are from New Zealand and Australia (GovGuam 2002;

Campbell 2010c). In FY 2009, imports from the continental United States accounted for more than 85%of meat products, 98% of eggs and egg products, and 75% of dairy products. Data for imports of animal products and byproducts from foreign sources over the period 2005 to 2009 were obtained from the Global Trade Atlas (GTIS 2010). Limited veterinary services and lack of slaughter facilities throughout the Micronesia Region limit commercial trade in locally produced animal products, including meat, eggs, and milk.

Specialty egg products, such as salted eggs and balut (embryonated, salted eggs) for which imports are not restricted, have been exclusively imported from Asia (Japan, the Philippines, Taiwan, and Thailand), but overall import volumes are small and have remained constant over the last decade.

It is expected that during the military relocation there will be an increase in the Asian population, primarily workers from the Philippines (U.S. Navy 2009f), and that some immigrant workers will remain on Guam after the construction phase is completed (U.S. Navy 2009g). Hence, there may be an increase in demand for animal products from Asian countries. However, we assume that increase in demand will have minimal impact on the origin of animal products. It is also assumed that during the construction phase food services will be provided by contractors to foreign employees and those products will be sourced from U.S. suppliers. Additionally, while Filipinos constitute a large segment of the immigrant population working abroad, which is true for all of the United States, including Guam, historically there is no evidence that an associated demand for foreign animal products has contributed to the introduction of animal disease.

The relocation will increase the number of pets, primarily cats and dogs, on Guam. Most commercial pet food that is imported into Guam is produced in and imported from the continental United States, and foreign imports must comply with federal regulations for the processing of commercial animal food.

The Defense Commissary Agency provides groceries to military personnel, retirees and their dependents (Melton 2009). All perishable food products procured by the Defense Commissary Agency, including meat, eggs, and fresh dairy products, come to Guam from elsewhere in the United States. All meat products procured by the Defense Commissary Agency require USDA certification and are sourced from Nebraska. The amount of locally sourced food items is limited and provided by less than 20 local retailers or businesses. Most suppliers of locally procured food products are from CNMI (Saipan and Rota) (DeCA 2009, Melton 2009).

Information on origin of human travelers can be found in the human pathways section.

Mitigations

Federal rules and regulations for the import of animal products are included in the USDA-APHIS-PPQ Animal Product Manual and 9 CFR (USDA-APHIS 2010a). Guam laws and regulations are contained in the Guam Administrative Rules and Regulations and the Guam Code Annotated (Supreme Court of Guam, Compiler of Laws, Guam Administrative Rules and Regulations http://www.justice.gov.gu/compileroflaws/gar.html).

Various sections of 9 CFR regulate importation of meat, poultry meat and eggs, animal byproducts, milk and milk products, hides, skins, wool, hair, animal feed, and garbage. Most regulations restrict importation from countries known to be affected with specific diseases of concern, including African swine fever, classical swine fever, swine vesicular disease, foot and mouth disease, rinderpest, bovine spongiform encephalopathy, HPAI H5N1, and END. Animal products are also restricted for anthrax and animal disease vectors, including ticks. Furthermore, the Animal Product Manual cites regulations administered by APHIS as well as certain Food Safety and Inspection Service requirements that must be met in order to import certain animal products and byproducts and makes reference to other agencies such as the Food and Drug Administration, whose requirements must also be followed (9 CFR § 94, USDA-APHIS 2010a). Like live animals, animal products must be imported into the United States through an approved port (9 CFR § 92, 9 CFR § 93, 9 CFR § 94, 9 CFR § 95,).

In addition to federal regulations, several Guam territorial laws and regulations are applicable. These may be found in the Government Code of Guam Public Law (1956) and the Guam Administrative Rules and Regulations. Regulations covered by these two documents pertain primarily to issues of food safety, including import regulations that require milk pasteurization and grade standards. Additionally, the Guam Administrative Rules and Regulations provide rules for processing garbage used to feed any livestock species (26 GARR 14).

Importation of animal skin to Guam is limited to inspected tanned and chromed leather hides, which, in contrast to untreated skins from freshly slaughtered animals, would be unlikely to harbor ticks (Ergönül 2006).

In 2008, 8,985 cargo documents (cargo manifests) were reviewed and cleared, and 19,180 cargo inspections were conducted by GCQA inspectors, representing more than 19% of incoming cargo. Data provided by the Maritime port indicate that two shipments for the FY 2009 contained prohibited meat. Also, officials from GCQA have reported the entry of high risk cargo including eggs from Japan, China and Korea (Sgambelluri et al. 2009).

The U.S. Army and Air Force have veterinarians who provide food safety and inspection services. Food purchased by the military comes to the warehouse in the military port where it is inspected by military veterinarians prior to distribution.

International flights to Guam arrive at A.B. Won Pat International Airport. GCQA has customs jurisdiction and passengers from arriving flights go through GCQA inspections. Passenger inspections are targeted towards flights considered to be high risk for importation of prohibited animal products, including flights originating from Korea, China, the Philippines, Palau, and CNMI (Sgambelluri et al. 2009; Taijeron 2009). Approximately 9% of passengers from high risk flights have their baggage inspected. GCQA detector dog teams trained to detect agricultural products conduct regular operations in arrival halls at the airport. Four dogs work two shifts for morning and night flights. Detection of undeclared items may result in flight delays and fines up to $1,000.

All seized goods containing animal products are destroyed. In the past, the use of x-ray machines permitted the rapid screening of 100% of passenger baggage. At the time of our visit in November 2009, four x-ray machines were present at the airport, but they were not functioning. While the use of x-ray machines is important for detecting prohibited agricultural products, use of dogs can increase detection by as much as two-fold (Shih et al. 2005). Overall, studies have found that the combined use of detector dogs with x-ray screening results in 85% of meat products being detected (Pharo 2001). It is not clear that there are sufficient functional x-ray units and detector dogs on Guam to achieve this level of efficacy, however.

All flights from Guam to the mainland United States go through Hawai'i where all passengers and cargo are treated as foreign arrivals by Honolulu PPQ inspectors. In Hawai'i, all passengers and crew members arriving by commercial aircraft or vessel who are carrying plants, animals, microbial cultures, or soil must complete a mandatory agricultural declaration form and submit the items for inspection. Movement of plant products between Guam and the rest of the United States is restricted; however, movement of animal products from Guam to the rest of the United States is considered a domestic movement and, therefore, is not restricted.

Most military personnel and their dependents will be relocated to Guam from the mainland United States and therefore will not pose a risk for introduction of contaminated animal products. In addition, the military has procedures in place to mitigate the risk of introduction of prohibited animal products into Guam. According to personnel at Andersen AFB, no cargo has ever been rejected (Hicks 2010). If the regulations are properly enforced and inspections are performed appropriately, the risk should be adequately mitigated.

Summary

The volume of imports of animal products, including food commodities, animal feed, and hides and skins, will increase with the military relocation. Most animal product imports to Guam originate in the continental United States, New Zealand, and Australia, areas free from most hazards considered in this assessment that could be associated with animal products. Federal and territorial regulations and inspection procedures provide further mitigation against hazards for legal imports. However, interdiction of smuggled products is unlikely to be 100% and increased demand for such products is likely.

Despite current inspection procedures and GCQA fines for violations, passengers continue to bring high-risk animal products into Guam. The predicted large influx of immigrant workers and progressive increase in the number of tourists originating from Asian countries is likely to increase the volume of smuggled animal products and the likelihood of introduction of livestock or poultry disease agents associated with animal products. Passenger baggage passenger may be an important pathway of introduction of contaminated animal products. In addition, there may be gaps in inspection of international mail destined for the Region and animal products may therefore enter the Micronesia Region through the mail.

Animal Products Pathway Release Assessment

The increased risk of release of hazards into the Micronesia Region due to the military relocation through legal movement of animal products is negligible.

The increased risk of release of hazards into the Micronesia Region due to the military relocation through illegal movement of animal products is low.

A6.3.3.7.3 *Exposure Assessment: Animal Products Pathway*

Biological Factors

Contaminated meat and other animal products may readily serve as fomites for the spread of a number of important viruses, including African swine fever, classical swine fever, foot and mouth disease, HPAI, and END viruses (Thomas et al. 2008). Livestock and poultry on Guam could be infected with these viruses through being fed uncooked contaminated meat or poultry products, such as in table scraps or other garbage. Many of these same issues and factors will also apply to the garbage pathway, a discussion of which follows; they will be discussed there in additional detail.

Regional Factors

Throughout the Micronesia Region, pigs are often reared in backyards and fed meat scraps. Feral swine and poultry are present throughout the Region. Contaminated animal products could end up in waste that is intentionally fed to pigs or disposed of where feral swine and poultry can access it.

Feral animals and birds contribute to spread where there is access to garbage or landfills by dropping scraps in proximity to other livestock or feral animals (Hartnett et al. 2007), which is discussed in greater detail in the garbage pathway section that follows.

Commodity Factors

Illegal introduction of specialty and culture-specific foods, including meat and eggs, may increase in volume, with the influx of workers. The high cost of importing commercial feed may also serve as an incentive for illegal importation of animal products.

Summary

Livestock and poultry on Guam may be exposed to animal disease agents through the feeding of contaminated meat or poultry products. The presence of backyard poultry and swine, feral poultry and swine, and garbage-fed swine operations increases the opportunities for exposure and subsequent spread.

Animal Products Exposure Assessment

The risk of exposure of livestock or poultry to hazards released into the Micronesia Region through the animal products pathway is medium.

A6.3.3.7.4 *Consequence Assessment: Animal Products Pathway*

Biological Consequences

Spread of HPAI and END can be enhanced by the presence of feral and backyard free-ranging chickens. Morbidity may approach 100% and mortality may be as high as 90% for both diseases in susceptible chickens (CFSPH 2008d, 2010b). A similar situation is present with respect to feral swine and the swine diseases of concern. Spread by similar means could occur with exposure of swine, cattle, pigs, sheep, goats, and carabaos to foot and mouth disease virus, resulting in significant morbidity (CFSPH 2007e).

Because these disease agents are exotic to the United States, their introduction into Guam would likely result in severe restriction of movement of animals and animal products from Guam to the rest of the United States.

Environmental Consequences

In the face of an outbreak of an exotic livestock or poultry disease, such as END, classical swine fever, or foot and mouth disease, it is likely that steps would be implemented to control or eradicate the disease, which may include depopulation of sick and exposed animals as well as feral animals in the area. Disposal of large numbers of carcasses, as well as litter and manure, would adversely impact the environment, e.g. by leaching contaminants into the soil.

Economic Consequences

Control of even limited outbreaks could be costly. For example, Arizona and Texas each had only one premises on which END infection was detected in 2002-2003; 10 infected premises were identified in Nevada. Approximately $3.5 million were spent on eradication efforts in Arizona, $4.2 million in Texas, and $6.2 million in Nevada (USDA-APHIS-VS 2005).

Even more significant may be the possibility of trade restrictions being imposed by other countries on trade in animals or animal products from the rest of the United States. Restrictions on trade from anywhere in the United States could remain in place until steps are taken to regionalize Guam, which would likely involve restricting the current free movement of animals and animal products from Guam to the rest of the United States and through the Micronesia Region.

While livestock are not economically important to inhabitants of Guam and the rest of the Micronesia Region, as evidenced by the total value of agricultural sales, estimated at $2.8 million, and the size of the agricultural sector as compared to other sectors, approximately 0.52% of the total workforce (USDA-NASS 2009a), they are culturally important. Cultural and societal impacts might be more significant than the economic consequences; however, this assessment does not take into consideration these intrinsic values.

Summary

We expect the illegal importation of meat or other animal products contaminated with exotic livestock or poultry disease agents to be a rare occurrence; however, once present in the Micronesia Region, there are opportunities for exposure of livestock and poultry. Consequences of an outbreak of a disease exotic to the United States would be significant.

Animal Products Pathway Consequence Assessment

The significance of the consequences to Guam of livestock or poultry exposure to hazards released into the Micronesia Region through the animal products pathway is low.

The significance of the consequences to the rest of the Micronesia Region of livestock or poultry exposure to hazards released into the Micronesia Region through the animal products pathway is low.

The significance of the consequences to the rest of the United States of livestock or poultry exposure to hazards released into the Micronesia Region through the animal products pathway is medium.

Animal Products Pathway Risk Estimation

Because the increased risk of release of hazards into the Micronesia Region due to the military relocation through the animal products pathway is low, the risk of exposure of livestock and poultry is medium, and the significance of consequences of livestock and poultry exposure is low, we conclude that the military relocation-associated overall risk for the animal products pathway is low.

A6.3.3.8 *Garbage*

Imported garbage includes refuse generated during a voyage, rejected cargo, and prohibited items removed from passenger baggage at ports of entry. The main potential sources of garbage arriving in the Micronesia Region are military aircraft and maritime vessels, private yachts, commercial airlines, and civilian maritime vessels engaged in fishing or carrying passengers and cargo. Imported garbage may enter the Micronesia Region through legal or illegal channels.

The relocation is expected to bring additional people, aircraft, cargo and cargo ships, and military ships from foreign countries (U.S. Navy 2010a). Therefore, we expect the military relocation to result in an increased volume of imported garbage, including rejected cargo and seizures of prohibited items from passenger baggage.

A6.3.3.8.1 *Hazards Associated with the Garbage Pathway*

Garbage can transport hazards in two roles: it can be, or be contaminated with, a disease agent and serve as a fomite; or it can harbor vectors of disease agents. In this analysis, we consider garbage to be a potential source of all hazards (see Table A6-4 and Table A6-6), including hazards for which garbage may serve as only a minor or theoretical source.

A6.3.3.8.2 *Release Assessment: Garbage Pathway*

Likelihood of Hazard Association

Any of the hazards listed in Tables A6-4 and A6-6 could at least theoretically be transported to the Micronesia Region in or as garbage. For many of these hazards, garbage is not a major means of spread. However others, in particular disease agents associated with animal products, are readily spread through contact with garbage. For example, contaminated meat in garbage is a well known source of transmission of African swine fever, classical swine fever, foot and mouth disease, and swine vesicular disease viruses, typically through garbage feeding to swine (OIE 2009g, h, j, r).

Garbage, including imported garbage, has been confirmed or strongly implicated as a disease agent source in several outbreaks of African swine fever, classical swine fever, and foot and mouth disease. Feeding swine with imported garbage that contains uncooked pork is the most common means of introduction of African swine fever virus into uninfected swine herds in African swine fever-free regions outside of Africa (EFSA 2010). For example, an African swine fever outbreak in Portugal in 1957 was attributed to feeding of swine with contaminated garbage from an international flight (EFSA 2010). Ship's garbage fed to swine was identified as the most likely source of foot and mouth disease virus in foot and mouth disease outbreaks in California in the 1920s (USDA-APHIS-VS CEAH 1994). Illegally imported ship's garbage fed to swine was implicated as a source of classical swine fever virus in an outbreak in New Zealand in 1933 (Davidson 2002). Discarded food scraps in garbage sourced from a naval shore base were identified as the most likely source of classical swine fever virus in a classical swine fever outbreak in New Zealand in 1953 (Watt and Wallace 1954). More recently, discarded meat fed to swine was identified as the most likely disease agent source in classical swine fever outbreaks in Germany in the 1990s and an foot and mouth disease outbreak in the United Kingdom in 2001 (Fritzemeier et al. 2000; DEFRA 2002).

The duration that disease agents remain infectious in the environment varies by agent and environmental conditions. Garbage can provide a dark, moist environment rich in organic matter that is conducive to survival of some disease agents. For example, AIVs can survive for weeks in cool, moist environments that contain organic matter (OIE 2009m). *Echinococcus* species can remain viable for weeks to months in dark, moist environments (CFSPH 2009h). END virus can survive for weeks in contaminated litter or soil (CFSPH 2008d). As noted above, African swine fever, classical swine fever, and swine vesicular disease viruses can remain viable in dried meats and other animal products for months to years. In contrast, other disease agents, such as the etiologic agents of dourine, heartwater, and Japanese encephalitis, are much less stable outside of living hosts (CFSPH 2007h; OIE 2009i, l).

Accumulated garbage and trash provides food and harborage for rodents and breeding grounds for arthropod vectors, including Culex and Aedes species mosquitoes, thereby potentiating risk for Japanese encephalitis and dengue outbreaks (Gratz 1999a; Gratz 1999b).

Traffic Volume

We expect the volume of garbage arriving in Guam to increase as a result of the relocation-associated increase in the volume of movement of people and conveyances to Guam. The current system for disposal of garbage in Guam appears to be working at capacity, and likely will not be able to accommodate an increase in demand for capacity.

Traffic Origin

Garbage imported into the Micronesia Region can be derived from a wide variety of sources, including animal and plant products from regions of origin, embarkation, or transit of people and conveyances arriving in the Region. Additionally, according to data provided by the Guam Bureau of Statistics and Plans for 2009, the major import partners for all imported animal products to Guam were the United States (50%), Japan (14%), Western Europe (France, Italy and Switzerland) (13%) and other Asian countries or regions (16%) (including China, Korea, Taiwan, Hong Kong, Singapore, Thailand, and the Philippines). After these animal products are used, they would be discarded as garbage and represent the potential sources of disease agents. Additionally, garbage generated during training and military exercises in Tinian is transported back to Guam. This is problematic, since it may contribute to the spread of both agricultural disease agents and invasive species. For this reason, current federal regulations prohibit such movement.

Mitigations

Details on the regulation of garbage and solid waste are presented elsewhere in this document.

For federal regulatory purposes, the term “garbage” refers to all waste material that is derived in whole or in part from fruits, vegetables, meats, or other plant or animal (including poultry) material, and other refuse that has been associated with any such material (9 CFR §94).

Importation of garbage from all foreign countries except Canada into the United States is prohibited and movement of garbage from Hawai’i, Puerto Rico, American Samoa, CNMI, FSM, Guam, the U.S. Virgin Islands, RMI, and Palau to any other State is prohibited with few exceptions. We note, however, that the garbage generated during training and military exercises in Tinian is transported back to Guam.

Garbage is regulated if it is on or removed from a conveyance that has been in any port outside the United States and Canada within the previous 2 years. Garbage generated during international or interstate movements, including food scraps, table refuse, galley refuse, food wrappers or packaging materials, and other waste material from stores, food preparation areas, passengers' or crews' quarters, or dining rooms, is regulated; this also includes meals and other food that were available for consumption by passengers and crew on an aircraft but were not consumed (9 CFR § 94).

While on board a conveyance, all regulated garbage must be contained in tight, covered, leak-proof receptacles. For Guam and CNMI, this generally extends to territorial waters, 12 nautical miles offshore. If unloaded, regulated garbage must be moved under the direction of an inspector to an approved facility for incineration, sterilization, or grinding into an approved sewage system (9 CFR § 94). Within the Micronesia Region, port demand for waste reception facilities is highest in Guam (Nawadra et al. 2002). Waste, including regulated garbage, from large merchant vessels is generally not accepted in Guam, and the commercial port generally does not accept waste from international vessels. At the commercial port, commercial marinas, and fisheries wharves in Guam, waste is collected by private waste collection companies under compliance agreements with APHIS and is subject to Port Authority and government policies and regulations. In general in the Micronesia Region, waste from international vessels that contains food waste is treated as quarantine regulated garbage. In Guam, regulated garbage and rejected cargo seized from international vessels are incinerated.

Solid waste generated on land can be broadly categorized as municipal, commercial, or industrial. Domestic solid waste generated on Pacific islands, including islands of the Micronesia Region, has been estimated to include large proportions of packaging waste, food waste, and garden waste (WHO 1996). Municipal, commercial, and industrial waste in Guam is disposed of at Ordot Dump, an unlined, uncapped landfill that is scheduled to be closed in 2011 (GSWRIC 2010). A new landfill is under construction. Household food waste is fed to pigs and chickens, or used as fertilizer (Nawadra et al. 2002). Quarantine and hospital waste is incinerated (Nawadra et al. 2002).

DoD waste is disposed of at the Navy Sanitary Landfill located on the Navy base, or at a landfill located at Andersen AFB (U.S. Navy 2010a). At both of these landfills, waste is buried daily. Wood, such as crates, and other green waste at the Andersen AFB landfill is shredded; the shredded waste is used for landscaping on and off base. Waste from Navy ships berthed at Apra Harbor is disposed of at the Navy Sanitary Landfill.

Summary

Garbage is a potential source of introduction and spread of several hazards. The volume of international and domestic garbage arriving in Guam is expected to increase as a result of the military relocation. As risk increases with additional volumes of animal products imported, so too will the risk from the garbage created from illegal imports of animal products. Despite the strength of regulations that serve to mitigate risk, we conclude that some residual additional risk of hazard release remains.

Garbage Pathway Release Assessment

The increased risk of release of hazards into the Micronesia Region due to the military relocation through legal movement of imported garbage is negligible.

The increased risk of release of hazards into the Micronesia Region due to the military relocation through illegal movement of imported garbage is very low.

A6.3.3.8.3 *Exposure Assessment: Garbage Pathway*

Biological Factors

Disease agents associated with animal products are readily spread through contact with garbage. Fomite spread of African swine fever, classical swine fever, foot and mouth disease, and swine vesicular disease viruses from contaminated meat in garbage is well known to occur, typically exposing livestock through garbage feeding to swine (OIE 2009g, h, j, r). Similarly, feeding uncooked chicken or other fowl contaminated with HPAI or END viruses to poultry can result in poultry infection with these viruses (Thomas et al. 2008).

Regional Factors

The relocation is expected to bring additional people, airplanes, cargo and cargo ships, and potentially additional military ships from foreign countries. Increased garbage, seizures from baggage, and rejected commodities can reasonably be expected. This increase may overburden the system to the point where it cannot adequately address the risk these items may pose to Guam.

Pigs and poultry are the two production animal species of importance on Guam and are most likely to be fed uncooked food waste, given the high cost of importing commercial feed and limited space for garbage disposal on the island. Other livestock exposure to food waste is generally considered to be limited to accidental access to improperly disposed of waste.

The feeding of garbage (as defined above) to swine is regulated by USDA (9 CFR § 166). While feeding personal household garbage is not restricted, any garbage collected from other premises, including restaurants, must be cooked and handled as described in the regulations. These regulations are not currently enforced for backyard swine on Guam, leaving this pathway open.

Feral animals may be exposed to contaminated garbage while foraging in landfills. Scavenger species can frequent landfills, including primarily feral pigs, but also dogs, cats, and birds. Landfills are fenced to inhibit wind dispersal and to exclude animals from accessing the landfill. However, fencing is not always fully effective. Although the military landfills have a perimeter fence, they may need a redesign or upgrading to ensure that they are feral pig proof. Certain birds, in particular gulls (the black-headed gull, *Larus ridibundus*) are scavengers at landfills and may carry meat scraps offsite, increasing risk of exposure of other animals, including livestock and other feral animals (Hartnett et al. 2007).

Summary

The expected increase in the volume of garbage imported into Guam may overburden the waste disposal system in Guam to the point at which it cannot adequately mitigate the risk that imported garbage poses to livestock and poultry health on Guam. We expect importation of garbage containing meat or other animal products contaminated with livestock or poultry disease agents to be a rare occurrence, generally as importation of prohibited garbage; however, once garbage is imported, opportunities for exposure of livestock and poultry are present. In addition, items illegally moved into Guam as passenger baggage may end up in garbage fed to swine. The Swine Health Protection regulations are not enforced on Guam, providing a pathway for disease agents to enter the swine population.

Garbage Pathway Exposure Assessment

The risk of exposure of livestock or poultry to hazards released into the Micronesia Region through the garbage pathway is medium.

A6.3.3.8.4 *Consequence Assessment: Garbage Pathway*

Biological Consequences

While the biological consequences are dependent on disease agent exposure to poultry or livestock on Guam, END, HPAI, or foot and mouth disease virus, if introduced, could be spread widely by fomites. Chickens are very susceptible to END and HPAI, experiencing significant mortality as a consequence of infection. The presence of feral and backyard free-ranging chickens would likely enhance spread. For both diseases, morbidity and mortality rates vary according to the strain of virus, but morbidity may approach 100% and mortality may approach 90% in susceptible chickens (CFSPH 2008d, 2010b). Spread by similar means could occur with exposure of swine cattle, pigs, sheep, goats, and carabaos to foot and mouth disease virus, resulting in significant morbidity though generally low mortality (CFSPH 2007e).

Because these disease agents are exotic to the United States, their introduction into Guam would likely result in severe restriction of movement of animals and animal products from Guam to the rest of the United States.

Environmental Consequences

The volume of international and domestic garbage arriving in Guam is expected to increase as a result of the military relocation. Such an increase would tax existing resources for disposal. In the face of an outbreak of an exotic disease, such as END, classical swine fever, or foot and mouth disease, it is likely that steps would be implemented to control or eradicate the disease, which may include depopulation of sick and exposed animals as well as feral animals in the area. Disposal of large numbers of carcasses, as well as litter and manure, would adversely impact the environment, e.g. by leaching contaminants into the soil.

Economic Consequences

Control of even limited outbreaks would be costly. For example, Arizona and Texas each had only one premise on which END infection was detected in 2002-2003; 10 infected premises were identified in Nevada. Approximately $3.5 million were spent on eradication efforts in Arizona, $4.2 million in Texas, and $6.2 million in Nevada (USDA-APHIS-VS 2005).

Even more significant may be the possibility of trade restrictions being imposed by other countries on trade in animals or animal products from the rest of the United States. Restrictions on trade from anywhere in the United States could remain in place until steps are taken to regionalize Guam, which would likely involve restricting the current free movement of animals and animal products from Guam to the rest of the United States and through the Micronesia Region.

While livestock are not economically important to inhabitants of Guam and the rest of the Micronesia Region, as evidenced by the total value of agricultural sales, estimated at $2.8 million, and the size of the agricultural sector as compared to other sectors, approximately 0.52% of the total workforce (USDA-NASS 2009a), they are culturally important. Cultural and societal impacts might be more significant than the economic consequences; however, this assessment does not take into consideration these intrinsic values.

Summary

In a worst case scenario, an outbreak of a foreign animal disease such as END, HPAI, or foot and mouth disease in the Micronesia Region poses a threat of introduction into Hawai'i or the continental United States, given the interconnections between the islands of the Micronesia Region to each other, Hawai'i, and the continental United States by air and sea. The economic impact of trade bans due to a poultry or livestock disease outbreak in the Micronesia Region is likely to be insignificant to Guam and rest of the Region, which lacks commercial livestock and poultry industries, as evidenced by the limited value of agricultural sales and size of the agricultural workforce, but significant to the rest of the United States (USDA-NASS 2009a). Regionalization policies would likely reduce the trade consequences at the national level.

Garbage Pathway Consequence Assessment

The significance of the consequences to Guam of livestock or poultry exposure to hazards released into the Micronesia Region through the garbage pathway is low.

The significance of the consequences to the rest of the Micronesia Region of livestock or poultry exposure to hazards released into the Micronesia Region through the garbage pathway is low.

The significance of the consequences to the rest of the United States of livestock or poultry exposure to hazards released into the Micronesia Region through the garbage pathway is medium.

Garbage Pathway Risk Estimation

Because the increased risk of release of hazards into the Micronesia Region due to the military relocation through the garbage pathway is very low, the risk of exposure of livestock and poultry is medium, and the significance of consequences of livestock and poultry exposure is low, we conclude that the military relocation-associated overall risk for the garbage pathway is low.

A6.3.3.9 *Other Cargo*

In this pathway, we consider the effect of the military relocation on the risk to livestock and poultry health through the movement of cargo other than live animals, animal products, or garbage into the Micronesia Region. Mail is considered within this pathway. We expect that pathway traffic volume in cargo moved through legal or illegal means will increase as a result of the military relocation, due to demands for consumer goods by a larger population.

A6.3.3.9.1 *Hazards Associated with the Other Cargo Pathway*

Cargo can transport hazards in two roles: it can be, or be contaminated with, a disease agent and serve as a fomite; or it can harbor vectors of disease agents. In this analysis, we consider cargo to be a potential source of all hazards (Table A6-4 and Table A6-6), including hazards for which other cargo may serve as only a minor or theoretical source.

A6.3.3.9.2 *Release Assessment: Other Cargo*

Likelihood of Hazard Association

Although ticks have a biotic requirement for living hosts, they are only intermittent parasites. Most tick species spend the majority of their lifecycle free within the environment, and ticks at all lifecycle stages have been reported to survive off the host for long periods of time, sometimes for months or years (Randolph 2004). Ticks have been found on a wide variety of other inanimate articles offered for importation. The USDA national tick survey database and PPQ pest interception database include records of approximately 50 tick interceptions on various articles, ranging from construction materials to pottery to wood packing materials (USDA-APHIS 2009a). The PPQ pest interception database includes records of more than 80 instances of ticks having been transported to the United States on a wide variety of imported live plants and plant material such as cut flowers, dried herbs, or handicrafts. There is no distinguishable pattern in these interceptions. Most of the interceptions were of R. sanguineus, a cosmopolitan tick species already present in the Micronesia Region, but exotic ticks of the genera Amblyomma, Dermacentor, Haemaphysalis, and Hyalomma were also found. In general, it is possible for ticks to be associated with almost any article, but considering the large number of articles that enter the United States each day, relatively few interceptions have been recorded. Ticks have occasionally been intercepted from the hides and skins of recently slaughtered animals.

In the 1990s, the majority of interceptions of non-indigenous mosquito species occurred around seaport areas. Multiple studies have identified such interceptions (Whelan 1998; Whelan et al. 2001; Derraik 2004; Frampton 2005). Past and current data show that cargo containers are a pathway for the successful introduction of non-indigenous mosquitoes at seaports (Lounibos 2002). Lounibos noted that most successful mosquito invaders arrived by ship as larvae in containers or cargo (Lounibos 2002). It takes approximately five to 15 days for a ship to travel to Guam from an Asian (China, Korea, Japan, Indonesia, Malaysia, Philippines, Singapore), Oceanic (Australia and New Zealand), or American seaport. It is likely that any adult mosquitoes aboard will die or disperse before the ship reaches Guam. However, modern vessels can transport containers and cargo, which can carry a large number of propagules (Frampton 2005).

Container shipping and the global used tire industry have contributed to the increased geographic distribution of selected mosquito species (Frampton 2005). Approximately 75% of mosquitoes intercepted on board cargo vessels were found in used machinery or used tires on board ships (Derraik 2004). Live mosquito larvae have also been found in tires and other salvage equipment brought back from combat areas in the Pacific (Frampton 2005). Examples of recent introductions of non-indigenous mosquitoes associated with the transport of used tires have occurred in Europe (Romi et al. 1997; Schaffner 2004; Roiz et al. 2007). There are numerous reports of the importation of exotic mosquito species to Australia (Whelan 1991, 1995; Whelan 1998; Lamche et al. 2004; Nguyen and Whelan 2007), and sea containers have been proposed as a potential pathway for the introduction of mosquitoes into Australia and New Zealand (Derraik and Calisher 2004). On a global scale, many insect vector invasions go unnoticed because of a lack of adequate surveillance.

To better understand the risk associated with the movement of containers, we utilized data published in New Zealand where a strict surveillance system, including exhaustive cargo inspection and a detailed recording of findings, was implemented at ports of entry (Border Management Group 2003). New Zealand received an annual total of 260,000 loaded sea containers in 2003. More than 11,000 sea containers were inspected by New Zealand's Ministry of Agriculture and Forestry. In the review, it was found that approximately one in five containers contained some form of contamination, and that most of the contamination was inside rather than outside the containers. Vehicles and machinery accounted for 33% of product seizures, with nearly 29% of all vehicles intercepted requiring treatment. Cane ware and used tires that require mandatory fumigation on arrival accounted for 24% of seizures. The Pacific Islands were the region with the highest incidence of risky cargo (72%) and contamination in loaded (40%) and unloaded (22%) containers. Nearly half of empty containers (45.8%) arriving in New Zealand came from the Pacific Islands. Organisms, of which 40% were insects, were found in 6.1% of loaded containers and 1.3% of unloaded containers. Approximately 40% of the containers had live organisms. Organisms were found on the inside and outside of containers (Gadgil et al. 1999). A total of nine containers held mosquitoes, four of them with live specimens (Border Management Group 2003).

Despite past occurrence of outbreaks of arboviral diseases on Guam, such as Japanese encephalitis, the occurrence of arboviral diseases in Guam in the last 30 years is rare and mostly related to low-level sporadic transmission of dengue viruses (Gubler 2003). WNV and JEV are pathogens of importance based on the relatively high prevalence of these diseases in parts of the world. They can be introduced via adult infected mosquitoes or eggs and immature forms, as the mosquitoes have been shown to vertically transmit the viruses to their offspring (Rosen et al. 1989; Baqar et al. 1993). It is not always clear whether recent introduction of these arboviruses is due primarily to mosquitoes or to infected birds or humans travelling into new areas, and thereby introducing virus to the local mosquitoes. Humans remain infectious with JEV for a short period of time making transmission back to biting mosquitoes unlikely (Fischer et al. 2009); thus, there is reason to assume that arriving infected mosquitoes have been the source for spread of JEV, similar to the pattern seen with the reintroduction of dengue and spread through the Micronesia Region (Paul et al. 1993; Gubler 2002). The current level of surveillance on Guam is not sufficient for detection and interception of infested cargo, particularly for mosquito eggs and larvae; nor does a surveillance system exist in seaport areas for the detection of newly introduced non-indigenous vectors.

As to Culicoides species (biting midges), a 2007 assessment of risk for the importation of bluetongue into Ireland from the United Kingdom estimated the risk of transportation of parous infected Culicoides in vehicles or containers or in hay straw or plants to be low. There is no evidence from the literature that such accidental transportation of Culicoides has ever occurred or that parous female midges could survive the transport conditions (Duignan et al. 2007).

Traffic Volume

Additional data on cargo imports are presented elsewhere in this document. Guam depends on imports from foreign nations. In the last decade, the total number of sea lift containers increased over 35%

(103,000 in 2007) and it is expected to reach 190,000 (84% increase) at the peak of the military relocation.

Traffic Origin

In 2009, more than half of the total dollar value of imports to Guam came from the United States (53%), with about 30% and 13% coming from Asia and Europe, respectively (BSP 2009b; Ferrier 2009; Guam Visitors Bureau 2009).

Mitigations

GCQA serves as the primary filter for goods that represent a threat to the agriculture of the island. Agents from GCQA are responsible for inspecting and clearing imports from all vessels, cargo and people entering Guam, whether from the mainland United States or foreign countries. If GCQA agents discover any plants, plants materials, insects or certain types of animal products, they will refer the material to USDA-APHIS-PPQ for further inspection.

GCQA requires a manifest from the shipping agent for all incoming cargo. Upon arrival the shipper holds imported goods against a bond. GCQA will always inspect certain types of cargo considered to be of high risk before granting entry. Most of the inspection activities apply only to shipments entering Guam from foreign sources. Inspections are complemented by the use of an x-ray machine. Container inspection takes 30 minutes and most commodity inspections occur during two consecutive weekdays coinciding with the arrival of the majority of domestic cargo from the United States. Low staffing levels relative to the large volume of goods entering Guam do not allow for inspection of all cargo. Instead GCQA relies on documentation such as a manifest for identification and internal inspection of high risk containers. All declared items that include animals, animal products and byproducts, and propagative plant materials are considered risk goods and GCQA agents will inspect them. Holds are placed on shipments of interest that are fully inspected and remain unloaded until cleared. In 2008, 8,985 cargo documents (cargo manifests) were reviewed and cleared and 19,180 cargo inspections were conducted by GCQA; that represents inspection of over 19% of all incoming cargo shipments. Inspections conducted in Guam during fiscal year 2009 found live insects in one cargo shipment. However, we do not know the number of containers that were opened and inspected. We do not have information on the species, number of specimens intercepted, and whether they were dead or alive (GCQA 2009). In Guam, inspections are more stringent for outbound than inbound cargo due to the lack resources and infrastructure (Brown 2010a).

Military maritime and airport facilities are subject to GCQA inspection, but such inspections are limited due to the lack of staff and difficulties getting permission from military command. GCQA is currently establishing cooperative agreements with military bases that will clarify each agency's inspection and interception responsibilities. Although Guam is a territory of the United States, it is outside of CBP jurisdiction.

Relocation of military and dependents to Guam will occur mostly from the mainland United States. If some personnel are transferred from foreign locations, the military has procedures in place to mitigate the risk of introduction of arthropod vectors via this route. Military Customs Inspections inspectors are responsible for implementation of federal customs statutes for transfer of military personnel and goods from overseas destinations into a territory within U.S. jurisdiction. These inspectors will conduct inspections on aircraft arriving from foreign destinations for the presence of insects in cabin areas and spray when necessary. Air Force Joint Instruction (AFJI) 48-104, the Quarantine Regulations of the Armed Forces (DoD 1992), incorporate regulations to mitigate the risk of introduction and dissemination of arthropod vectors by movement of vessels, aircraft, and other transport of the Armed Forces arriving at or leaving installations in the United States and foreign countries, ports or other facilities where arthropod vector-borne diseases are known to exist. The information on the materials and procedures for disinsectation can be found in the Military Entomology Operational Handbook (NAVFAC M0-310, Army TM 5-632, Air Force AFM 91-16) (U.S. Navy 1972; USAPHC 2010).

Summary

The military relocation is expected to be accompanied by a significant increase in cargo imports to Guam. Cargo will likely come from the United States rather than countries of concern for ticks carrying exotic livestock disease. This fact, along with inspection, should adequately mitigate the risk for release of disease-carrying ticks through the movement of cargo.

Low numbers of mosquito vectors have been identified hitchhiking on cargo in numerous studies, primarily focused on tires and equipment. Because we expect an increase in cargo coming into the Micronesia Region as a result of the relocation, the probability of introduction of vectors will likely increase concurrently. While vectors may be introduced, the likelihood that an introduced mosquito will be infected with an animal disease agent is reported in multiple studies to be less than 0.1% (Nasci and Mitchell 1996; Kramer and Bernard 2001; O'Leary et al. 2004; Reisen et al. 2004).

Other Cargo Pathway Release Assessment

The increased risk of release of hazards into the Micronesia Region due to the military relocation through the movement of cargo other than live animals, animal products, or garbage is very low.

A6.3.3.9.3 ***Exposure Assessment: Other Cargo***

Biological Factors

Increased risk for the exposure of livestock or poultry to hazards via mosquitoes introduced by this pathway would require an infected mosquito to find its way aboard a conveyance and survive to release a disease agent on Guam. Alternatively, an adult mosquito could lay eggs on that conveyance, and pass the agent along to its offspring through its eggs. The eggs would hatch and complete the cycle to production of adult mosquitoes that will require exposure to a susceptible animal on Guam and in most cases, a competent alternative mosquito host present on the island to maintain infection. Fewer than a dozen mosquito species were reported in the Micronesia Region at the beginning of the 20th century, and no major disease vectors were present. However, in the course of the last century, this number increased four-fold with the introduction of exotic species, such as Aedes albopictus and Aedes aegypti (Reeves and Rudnick 1951) and numerous Culex species, which may be competent alternative hosts for the etiologic agents of several arboviral diseases of human and animal importance (Lounibos 2002), in particular WNV and JEV (Mitchell et al. 1993).

Regional Factors

Mosquitoes released on Guam may be able to bite and infect susceptible populations of wild birds such as pigeons and Eurasian tree sparrows (*Passer montanus*) that are abundant on Guam, and other known susceptible passerine birds, e.g. the Micronesian starling (*Aplonis opaca*) and the Marianas crow (*Corvus kubaryi*). There is evidence of the establishment of exotic vectors as a result of accidental introduction related to human activity; however, circumstantial evidence of a disease outbreak via infected vectors has only been seen in the case of malaria (Lounibos 2002). In the case of WNV, spread is more likely to occur from introduction of an infected live bird transmitting the disease agent to an established competent mosquito vector, such as *Aedes albopictus, Ae. vexans and Ochlerotatus japonicus* (Turell et al. 2005).

Backyard and feral pigs serve as amplifying hosts for JEV and are present in sufficient numbers to establish an outbreak, as occurred in 1990 on Saipan (Paul et al. 1993).

Summary

Mosquitoes released on Guam will be able to bite and infect susceptible populations of wild birds, transmitting arboviruses, including WNV and JEV. Competent alternative mosquito vectors are present on Guam, Saipan, and potentially other islands of the Micronesia Region and could sustain infection. Susceptible populations of domestic and feral pigs are present and can serve as amplifying hosts for JEV. Thus, we conclude that the factors necessary for exposure are present.

Other Cargo Pathway Exposure Assessment

The risk of exposure of livestock or poultry to vector hazards released into the Micronesia Region through the movement of cargo other than live animals, animal products, or garbage is medium.

A6.3.3.9.4 ***Consequence Assessment: Other Cargo***

Biological Consequences

The predominant impacts from the introduction of WNV and JEV would be to humans and to native wild bird populations, with minimal effects on poultry (Ghosh and Basu 2009; OIE 2010d). WNV is a threat to the native wildlife population and may have profound effects on native wild bird populations, resulting in elimination of some susceptible species. Native bird populations on Guam have been severely diminished as a result of invasive species and feral cats and the expected impacts of WNV on remaining native bird populations might result in elimination of some species. Experimental studies have shown that poultry rapidly develop an antibody response capable of neutralizing the virus. Infection in chickens is typically asymptomatic or with minimal clinical signs and pathology, and no mortality (Senne et al. 2000).

Some deaths have been reported in horses from WNV and JEV infection, though the number of clinical cases is very low compared to the total number of exposed animals (CFSPH 2007h; OIE 2010d). Because of the small number of horses in Guam and relatively low importance of this industry, and the availability of effective vaccines to protect horses against the viruses, we conclude that the biological consequences for introduction of WNV or JEV to the livestock and poultry industries are negligible.

As in the continental United States, the major impact of WNV establishment would be to humans. Once established in a tropical environment and in the absence of preventive measures, spread would be expected to be rapid among human populations with no prior exposure or immunity, as would be the case in Guam and throughout the Micronesia Region (Hayes et al. 2005). In humans the ratio of asymptomatic to clinical infection is high and the majority of clinical illness would be limited to mild febrile disease; however about one of every hundred infected may develop severe neurological disease with mortality rates as high as 14% (Madden 2003).

Establishment of Japanese encephalitis on Guam would also be of consequence to humans, especially to children. Annually, up to 50,000 cases of Japanese encephalitis are reported worldwide and more than 15,000 deaths are reported in eastern and southern Asia. While asymptomatic infection can occur, approximately 30% of Japanese encephalitis cases are fatal and nearly half result in permanent neurological sequelae (Ghosh and Basu 2009). However, any such introduction might well be short lived. In 1990, a rare introduction of Japanese encephalitis on Saipan ended as the population of susceptible pigs which serve as amplifying hosts had been infected and developed immunity, and has not recurred (Paul et al. 1993).

Environmental Consequences

Native bird populations on Guam have been severely diminished as a result of invasive species and feral cats (Poole 2009). WNV, as with END and HPAI viruses, could decimate remaining populations.

Economic Consequences

Release and establishment of WNV or JEV would be expected to result in little or no economic loss to the poultry industry or to the few remaining equine operations on Guam; however, significant cost would be incurred for human public health and mosquito vector surveillance, and for vector control to prevent spread throughout the region. A 2005 outbreak of WNV in Sacramento County, California (population 1.3 million) resulted in 163 reported human cases and a response that included emergency aerial spray to control vectors. Costs for aerial spray totaled just over $700,000 and when added to estimated medical costs and patients' loss in productivity, the total economic impact was estimated at $2.98 million (Barber et al. 2010).

Other Cargo Pathway Consequence Assessment

The significance of the consequences to Guam of livestock or poultry exposure to hazards released into the Micronesia Region through the other cargo pathway is very low.

The significance of the consequences to the rest of the Micronesia Region of livestock or poultry exposure to hazards released into the Micronesia Region through the other cargo pathway is very low.

The significance of the consequences to the rest of the United States of livestock or poultry exposure to hazards released into the Micronesia Region through the other cargo pathway is very low.

Other Cargo Pathway Risk Estimation

Because the increased risk of release of hazards into the Micronesia Region due to the military relocation through the other cargo pathway is very low, the risk of exposure of livestock and poultry is medium, and the significance of consequences of livestock and poultry exposure is very low, we conclude that the military relocation-associated overall risk for the other cargo pathway is very low.

A6.3.3.10 *Conveyances*

In this pathway, we consider the effect of the military relocation on the risk to livestock and poultry health through the movement of conveyances, in which vector hazards are transported at large (in the absence of vertebrate hosts), into the Micronesia Region. For the purpose of this analysis, conveyances are defined as aircraft, maritime vessels, and shipping containers. Vector hazards include mosquitoes, ticks, and other arthropods (see Table A6-6). The relocation will be associated with a substantial increase in conveyance traffic to the Micronesia Region.

A6.3.3.10.1 *Hazards Associated with the Conveyances Pathway*

Conveyances can transport vectors of disease agents. In this analysis, we consider other conveyances to be a potential source of all vectors (see Table A6-6), including vectors for which conveyances may serve as only a minor or theoretical source.

A6.3.3.10.2 *Release Assessment: Conveyances Pathway*

Likelihood of Hazard Association

Ticks have been found at large in conveyances, including airplanes and containers (USDA-APHIS 2009a). Recently, a soft tick of seabirds, *Carios capensis* (previously, *Ornithodoros capensis*), was identified as a competent vector for transmission of WNV in New Zealand (Spurr and Sandlant 2004; Hutcheson et al. 2005). It is not known whether the species currently inhabits Guam or other islands in the Micronesia Region, though it has been sporadically reported in the past (Kohls 1957); it does occur in Hawai'i (Alicata 1948) and seabirds carrying the tick might find their way aboard conveyances.

The origin of most military personnel coming to Guam as a result of the relocation will be the continental United States, and for workers, the Philippines (Jimenez et al. 2009), areas of little concern for importation of most important animal disease-transmitting tick species aboard conveyances to Guam. Import records confirm that cargo is most likely to be coming from the United States. While there is evidence of ticks successfully establishing in tropical island ecosystems, introduction is more likely to occur as a result of introduction of infested animals into the region and is considered in the livestock and cats and dogs pathways.

Large flies from the Philippines and much of Asia may find their way aboard vessels. Blowflies, including the Old World screwworm (*Chrysomya* spp.), could theoretically reproduce on aircraft, ships, or boats. However, reproduction requires rotting flesh or other sources of filth in which to lay eggs and to maintain optimal temperature, and a prolonged number of days to complete the life cycle (Bram and George 2000). This is a less likely scenario on commercial airlines, commercial ships or military conveyances not transporting animals. The lack of reproduction will reduce the vector numbers at the destination.

Based on historical evidence, mosquito vectors are the most likely vectors to be introduced into a new area via this pathway. In 1961, the U.S. Public Health Service published comprehensive survey findings of insects found in aircraft over a 13 year period. Among the more than 20,000 insects were 92 species of mosquito, 51 of which were not known to be present in the United States,Hawai'i, or Puerto Rico. Since then several similar reports have echoed these findings (Gratz et al. 2000). Mosquito species commonly intercepted from flights of Asiatic origin include *Culex pipiens*, *Culex quinquefasciatus*, *Culex tritaeniorhynchus*, *Ochlerotatus japonicus*, *Aedes albopictus*, *Aedes aegypti*, and *Anopheles subpictus indefinitus* (Joyce 1961; Takahashi 1984; Goh et al. 1985). The variety of mosquitoes on Guam and throughout the Micronesia Region increased nearly six-fold from just prior to World War II to the end of the Vietnam War, and may be traced to increased air and maritime traffic associated with the rapid deployment of troops and equipment (Savidge 1984).

The survival of mosquitoes in aircraft in empirical and experimental situations has been extensively studied. Laird (Laird 1947) reported that mosquitoes can survive an air journey under a variety of conditions. He reviewed several studies regarding the ability of mosquitoes to survive air travel. The longest survival period recorded aboard aircraft was 6-1/2 days. Furthermore, adult and newly hatched mosquitoes can survive and go on to breed and lay eggs in other locations (Laird 1947). Mosquitoes tend to remain aboard an airliner despite multiple stopovers. Flights from major Asian countries to Guam are on average less than 5 hours. The cabin in modern commercial aircraft is pressurized and kept at an ambient temperature, which implies that mosquitoes aboard will be able to survive for the duration of the flight.

Adult insects travel almost exclusively within the fuselage. It seems that they are attracted more to the illuminated cabins than to the baggage compartments. The exterior surface and wheel housing are of lesser importance (Goh et al. 1985). Several researchers (Sullivan 1958; Russell 1987) have studied mosquito survival rates under various conditions in different compartments of jet aircraft. Russell has shown that *Cx. quinquefasciatus* can survive on a wheel bay during the course of an international flight despite high altitude and external temperatures of less than -40^{o}C.

A recent U.S. study determined an average of 0.1 mosquitoes may be found aboard an inbound flight (Board on Environmental Studies and Toxicology 2002). In the same study, the average number of insects recovered per plane ranged from one to 20 and the average percentage of infected aircraft ranged from 10 to 100%.

The primary areas of concern for the risk of introduction of mosquito species to Guam are Southeast Asia, Japan, and other Pacific Islands. In a 1974 Japanese study, Joyce and colleagues examined 36 passenger and seven cargo aircraft, with over half originating in China or Southeast Asia. A total of 24%

carried pests, including numerous mosquitoes, mainly in aircraft originating from Bangkok, Manila, and Hong Kong, which may be attributed to the high prevalence of mosquitoes in these areas (Joyce 1961).

The regular occurrence of airport malaria in the United States and Europe suggests that aircraft are a potential pathway for introduction of exotic mosquitoes and vector-borne diseases (Gratz et al. 2000). There is at least one report of airport dengue fever in a German couple who travelled to Hawai'i in 1998 (Jelinek et al. 1998). According to the authors, the most plausible explanation is that the couple was bitten by one or more infected mosquitoes on an aircraft in Hawai'i that originated in an Asian country.

By contrast, adult mosquitoes are rarely intercepted on maritime vessels. Of the invasive pests and exotic mosquitoes that are intercepted, most are found in containers or commodities, such as tires or plants. Therefore, the role of maritime conveyances in the introduction of exotic mosquito species is mainly the transport of infested goods and materials. As additional evidence, decades of seaport and vessel surveillance in Honolulu have not detected adult or larval mosquitoes aboard sea conveyances (Joyce 1961); other studies have reported low prevalence of people complaining of mosquitoes and other biting insects aboard ferries (Mouchtouri et al. 2008).

Traffic Volume

The military relocation is expected to increase the volume of maritime and air traffic in the Micronesia Region. Additional data on conveyances are presented elsewhere in this document.

Traffic Origin

Import records confirm that conveyances carrying cargo are most likely to be coming from the United States, rather than countries of concern for ticks carrying exotic livestock disease, though Asia is an area of concern for the risk of introduction of mosquito species. In 2009, more than half of the imported cargo shipments came from the United States (53%), with about 30% and 13% coming from Asia and Europe respectively (BSP 2009b; Ferrier 2009; Guam Visitors Bureau 2009).

Mitigations

Mosquitoes can be introduced via ships as either eggs, larvae, or adults travelling inside boat cabins or shipping containers. Of the invasive pests and exotic mosquitoes that are intercepted, most are found in containers or commodities, such as tires or plants, rather than uncontained on maritime vessels. Hitch-hiking adult mosquitoes tend to die after a few days. The great distances between the Micronesia Region and the continents of Asia and North America further diminish the probability of adult mosquito survival (Joyce 1961). Additionally, modern ocean-going vessels have enclosed water supplies and covered lifeboats, and offer very little in the way of mosquito breeding possibilities.

Currently in Guam, as with the rest of the United States, commercial aircraft are not disinsected, nor are there specific surveillance activities in place for the detection of mosquitoes in aircraft (Jimenez et al. 2009). These circumstances coupled with the expected increase in the number of commercial and military flights to Guam mean that there is an increased risk for introduction of invasive mosquitoes.

Presently, the major risk is flights from Asian countries due to the abundance and diversity of mosquito fauna (WHO 1995; Gratz et al. 2000).

As for military planes, Military Customs Inspections inspectors are trained to look for prohibited animals and animal products, and will conduct inspection activities in planes arriving from foreign destinations for the presence of insects in cabin areas and spray when necessary. Air Force Joint Instruction (AFJI) 48-104, the Quarantine Regulations of the Armed Forces (DoD 1992), incorporate regulations to mitigate the risk of introduction and dissemination of arthropod vectors by movement of vessels, aircraft, and other transport of the Armed Forces arriving at or leaving installations in the United States and foreign countries, ports, or other facilities where arthropod vector-borne diseases are known to exist. The information on the materials and procedures for disinsectation can be found in the Military Entomology Operational Handbook (NAVFAC M0-310, Army TM 5-632, Air Force AFM 91-16) (U.S. Navy 1972, USAPHC 2010).

There may be specific issues related to contamination of equipment brought into Guam by the military related to exercises or deployments. The military has specific decontamination procedures designed to mitigate this risk.

Summary

The number of conveyances coming into Guam is expected to rise due to the relocation. Mosquito vectors have been identified hitchhiking on cargo in numerous studies, primarily focused on tires and equipment. However, the number of mosquitoes found is very low. In addition, it is not clear that infected mosquitoes have ever been the vehicle for introduction of an animal disease agent into a disease-free country, although there is reason to believe that infected mosquitoes on aircraft and on cargo may have spread arboviruses of human significance, including dengue virus and JEV (Mackenzie et al. 2004).

Because we expect an increase in conveyances coming into the Micronesia Region as a result of the relocation, the probability of introduction of vectors will likely increase concurrently. While vectors may be introduced, the likelihood that the introduced mosquito will be infected with an animal disease agent is reported in multiple studies to be less than 0.1% (Nasci and Mitchell 1996; Kramer and Bernard 2001; O'Leary et al. 2004; Reisen et al. 2004).

As described in elsewhere in the document, imports and people associated with the buildup are most likely to be coming from the United States rather than countries of concern for ticks carrying exotic livestock disease. But over time and in a broader consider, including both civilian and military imports, this may change to some degree. While there is evidence of ticks successfully establishing in tropical island ecosystems, introduction is most likely to occur as a result of importation of infested animals (George et al. 2002).

Conveyances Pathway Release Assessment

The increased risk of release of vector hazards into the Micronesia Region due to the military relocation through the conveyances pathway is very low.

A6.3.3.10.3 *Exposure Assessment: Conveyances Pathway*

Biological Factors

Increased risk for exposure of livestock or poultry to disease agents via mosquitoes introduced by this pathway would require an infected mosquito to find its way aboard a conveyance and survive to release a disease agent on Guam. Alternatively an adult mosquito could, in some instances, lay eggs on that conveyance, and pass the agent along to its offspring through its eggs. The eggs would hatch and complete the cycle to production of adult mosquitoes that will require exposure to a susceptible animal on Guam and in most cases, a competent alternative mosquito host present on the island to maintain infection. Fewer than a dozen mosquito species were reported in the Micronesia Region at the beginning of the 20th century, and no major disease vectors were present. However, in the course of the last century, this number increased four-fold with the introduction of exotic species, such as Aedes albopictus and Aedes aegypti (Reeves and Rudnick 1951) and numerous Culex species, which may be competent alternative hosts for the etiologic agents of several arboviral diseases of human and animal importance (Lounibos 2002), in particular WNV and JEV (Mitchell et al. 1993).

The risk for exposure of livestock or poultry to disease agents via introduced ticks is discussed elsewhere in this document.

Regional Factors

Mosquitoes released onto Guam may be able to bite and infect susceptible populations of wild birds such as pigeons and Eurasian tree sparrows (*Passer montanus*) that seem to be abundant on Guam and other known susceptible passerine birds, e.g. the Micronesian starling (*Aplonis opaca*) and the Marianas crow (*Corvus kubaryi*). There is evidence for the establishment of exotic vectors as a result of accidental introduction from antropogenic activities; however, circumstantial evidence of a disease outbreak via infected vectors was only in the case of malaria (Lounibos 2002). In the case of WNV spread is more likely to occur from introduction of an infected live bird transmitting the disease agent to an established competent mosquito vector, such as *Aedes albopictus, Ae. vexans* and *Ochlerotatus japonicus* (Turell et al. 2005).

Backyard and feral pigs serve as amplifying hosts for JEV and are present in sufficient numbers to establish an outbreak, as occurred in 1990 on Saipan (Paul et al. 1993).

Summary

Mosquitoes released on Guam will be able to bite and infect susceptible populations of wild birds, transmitting arboviruses, including WNV and JEV. Competent alternative mosquito vectors are present on Guam, Saipan, and potentially other islands of the Micronesia Region to sustain infection. Susceptible populations of domestic and feral pigs are present which may serve as amplifying hosts for JEV. Thus, we conclude that the factors necessary for exposure are present.

Conveyances Pathway Exposure Assessment

The risk of exposure of livestock or poultry to vector hazards into the Micronesia Region through the movement of conveyances is medium.

A6.3.3.10.4 ***Consequence Assessment: Conveyances Pathway***

Biological Consequences

The predominant impacts from the introduction of WNV and JEV would be to humans and to native wild bird populations, with minimal effects on poultry (Ghosh and Basu 2009; OIE 2010d). Experimental studies have shown that poultry rapidly develop an antibody response capable of neutralizing the virus. Infection in chickens is typically asymptomatic or with minimal clinical signs and pathology, and no mortality (Senne et al. 2000).

Some deaths have been reported in horses from WNV and JEV infection, though the number of clinical cases is very low compared to the total number of exposed animals (CFSPH 2007h; OIE 2010d). Because of the small number of horses in Guam and relatively low importance of this industry, and the availability of effective vaccines to protect horses against JEV and WNV, we conclude that the biological consequences for introduction of WNV or JEV to the livestock and poultry industries are negligible.

As in the continental United States, the major impact of WNV establishment would be to humans. Once established in a tropical environment and in the absence of preventive measures, spread would be expected to be rapid among human populations with no prior exposure or immunity, as would be the case in Guam and throughout the Micronesia Region (Hayes et al. 2005). In humans the ratio of asymptomatic to clinical infection is high and the majority of clinical illness would be limited to mild febrile disease; however about one of every hundred infected may develop severe neurological disease with mortality rates as high as 14% (Madden 2003).

Establishment of Japanese encephalitis on Guam would also be of consequence to humans, especially to children. Annually, up to 50,000 cases of Japanese encephalitis are reported worldwide and more than 15,000 deaths are reported in eastern and southern Asia. While asymptomatic infection can occur, approximately 30% of Japanese encephalitis cases are fatal and nearly half result in permanent neurological sequelae (Ghosh and Basu 2009). However, any such introduction might well be short lived. In 1990, a rare introduction of Japanese encephalitis on Saipan ended as the population of susceptible pigs which serve as amplifying hosts became infected and developed immunity, and Japanese encephalitis has not recurred (Paul et al. 1993).

Environmental Consequences

The spread of WNV in the continental United States has caused a marked decline in the number of particular bird species in entire regions, such as the American crow and eastern bluebirds (Rappole et al.

2000). Native bird populations on Guam have been severely diminished as a result of invasive species and feral cats (Poole 2009). WNV, as with END and HPAI viruses, could decimate remaining populations.

Economic Consequences

Release and establishment of WNV or JEV would be expected to result in little or no economic loss to the poultry industry or to the few remaining equine operations on Guam; however, significant cost would be incurred for human public health and mosquito vector surveillance, and for vector control to prevent spread throughout the region. A 2005 outbreak of WNV in Sacramento County, California (population 1.3 million) resulted in 163 reported human cases and a response that included emergency aerial spray to control vectors. Costs for aerial spray totaled just over $700,000 and when added to estimated medical costs and patients' loss in productivity, the total economic impact was estimated at $2.98 million (Barber et al. 2010).

Conveyances Pathway Consequence Assessment

The significance of the consequences to Guam of livestock or poultry exposure to hazards released into the Micronesia Region through the conveyances pathway is very low.

The significance of the consequences to the rest of the Micronesia Region of livestock or poultry exposure to hazards released into the Micronesia Region through the conveyances pathway is very low.

The significance of the consequences to the rest of the United States of livestock or poultry exposure to hazards released into the Micronesia Region through the conveyances pathway is very low.

Conveyances Pathway Risk Estimation

Because the increased risk of release of hazards into the Micronesia Region due to the military relocation through the conveyances pathway is very low, the risk of exposure of livestock and poultry is medium, and the significance of consequences of livestock and poultry exposure is very low, we conclude that the military relocation-associated overall risk for the conveyances pathway is very low.

A6.4 DISCUSSION AND CONCLUSIONS

A summary of our risk analysis results is presented in Table A7-16.

We found that any incremental increase in risk for most hazards, specifically related to the relocation, was relatively small in all pathways considered, yet highest in those that afforded opportunities to thwart existing mitigations via illegal movements. We found that in most cases there were measures in place to mitigate the likelihood of the hazard being introduced. However, these same mitigation measures could be bypassed by illegal means in certain pathways, or if the measures were inconsistently or ineffectively applied. Smuggling of poultry or the illegal importation of food and other animal products would bypass the regulations, as might the improper disposal of domestic and international garbage. These actions could result in the introduction and spread of foreign animal disease agents to susceptible domestic and feral animals. The impact of an outbreak could extend beyond Guam and the Micronesia Region, posing a risk for spread to the rest of the United States that could impact trade with other countries. These pathways should receive the most attention as plans proceed. Initial recommendations follow at the end of this document and are supplemented more extensively in preceding sections.

Table A7-16: Summary of Risk Analysis Results

	Release assessment			Consequence assessment			
Pathway	Legal introduction	Illegal introduction	Exposure assessment	Guam	Micronesia Region	United States[c]	Risk estimation
Livestock[a]	Negligible	Negligible	N/A[b]	N/A	N/A	N/A	Negligible
Poultry	Negligible	Very low	Medium	Low	Low	Medium	Low
Non-poultry birds	Negligible	Very low	Very low	Low	Low	Medium	Very low
Cats and dogs	Negligible	Negligible	N/A	N/A	N/A	N/A	Negligible
Other animals[d]	Low	Low	Low	Very low	Very low	Medium	Low
Humans	Negligible	Negligible	N/A	N/A	N/A	N/A	Negligible
Animal products	Negligible	Low	Medium	Low	Low	Medium	Low
Garbage	Negligible	Very low	Medium	Low	Low	Medium	Low
Other cargo	Very low	N/A	Medium	Very low	Very low	Very low	Very low
Conveyances	Very low	N/A	Medium	Very low	Very low	Very low	Very low

[a] Domesticated equids.
[b] Not applicable. We conducted exposure and consequence assessments only for those pathways for which the release assessment result was non-negligible.
[c] Rest of the United States, other than Guam.
[d] Reptiles.

In interpreting these results, it is important to note that we did not define a baseline risk, but focused only on that incremental change in risk attributable to the influx of people and the associated changes that will come during the course of the relocation. The inevitable outcome of this approach is the paradox that we may conclude a risk to be present or even significant, yet discount it from further consideration if there is not an increase in risk that we can attribute to the military relocation. For example, introduction of a disease hazard by the movement of people to and from Guam, who might unknowingly carry the hazard on their clothing or body, is always a possibility. Yet, if there is not an increase in people coming to Guam from areas at high risk for exposing them to the hazard as a consequence of the military relocation, that risk would not be considered further in this assessment. We also limited our consideration of the impacts to humans and pet dogs, cats, and non-poultry birds, to those consequences that arise from their association with livestock or poultry disease hazards. Thus, there are disease hazards of primary human health importance that are not considered here because they have no association with livestock or poultry health.

We based our risk assessment on available data and information that we believe to be accurate to the period during which it was collected but which could be subject to change. Data were lacking in a number of areas. In those cases, we supplemented with published reports from other parts of the world, where available. We assumed that mitigations, including inspection practices and regulatory enforcement, were consistently applied and that resources were adequate, at a minimum, to meet current demands. Finally, there are related aspects to our risk assessment, including wildlife hazards or those risks arising from introduction of invasive species that are not considered here, but are discussed in other sections of the document. We encourage the reader to review those sections as well.

A6.5 RECOMMENDATIONS

The introduction of many of the diseases of livestock and poultry considered in this risk assessment could have major consequences to animal and human health throughout the Micronesia Region and far reaching impact on trade to the rest of the United States. While federal, territorial, and military regulations serve to mitigate against introduction of hazards, the influx of people and goods associated with the military relocation will strain current systems for inspection and interdiction of illegal goods. We have reason to suspect that there may be current deficiencies in the ability of GCQA personnel to appropriately inspect cargo, passenger baggage, and conveyances. Further, with the expected arrival of increased numbers of pet dogs and cats, we suspect that current resources for inspection and follow-up will be overwhelmed.

Currently, there is no ongoing surveillance for livestock and poultry disease on Guam. Therefore, it is difficult to know what disease agents are already present in the Region and to identify the introduction of an exotic disease agent. A lack of a diagnostic laboratory in the Region also diminishes the ability to detect disease agents. Rapid detection is critical in order to mount a timely response to new disease introductions, especially in the case of the highly transmissible exotic diseases considered in this assessment.

Specific recommendations to mitigate the risk of release of livestock and poultry disease hazards include measures to address the need for additional resources and improvements in surveillance and communication, and to ensure adequate inspection and follow-up.

A6.5.1 Staffing and Infrastructure

Ensure sufficient staffing to accomplish all necessary inspection and quarantine activities in the Micronesia Region. Staffing levels will become further strained as a consequence of the military relocation as the workload at airports, maritime ports, and mail facility increases. Quarantine officers must be adequately trained in all aspects of their jobs and should receive periodic refresher training.

Ensure availability of necessary equipment. Equipment necessary for effective safeguarding must be available to quarantine officers. X-ray machines must be provided where needed. All equipment must be maintained in working order over the long term.

Provide detector dogs and handlers. An adequate number of teams must be available at airports for screening passenger baggage for animal products.

Ensure there are appropriate resources to implement response plans.

A6.5.2 Point-of-entry Activities (Cleaning, Inspection, Treatment)

Carry out inspection of all arriving conveyances, military and non-military, for illegal animals or animal products. In the case of military vessels, either PPQ specialists must be made available to inspect military vessels, or GCQA officers must be allowed to inspect military vessels.

Establish an effective mail inspection system on Guam. For international mail arriving via Hawai'i, either ensure adequate level of inspection in Hawai'i or else carry out inspection in Guam. Establish effective working relationships to ensure that safeguarding personnel can carry out their responsibilities. Safeguarding personnel must have sufficient access to the postal facility.

A6.5.3 Regulations, Guidelines, and Compliance

Systematically review all guidelines and SOPs relevant to livestock or poultry disease. Ensure that they are clear, complete and detailed. Develop guidelines or SOPs where they are lacking.

Enforce full compliance with all applicable existing federal and territorial regulations, guidelines, and SOPs, and harmonize military guidelines and SOPs with those requirements.

Develop a hazard response plan in coordination with military and civilian public health authorities for those diseases with serious animal health and zoonotic potential.

A6.5.4 Education and Training

Provide adequate education about the potential negative consequences of the introduction of an exotic livestock or poultry disease, especially with respect to smuggled animal products.

Facilitate training/education programs regarding changes in livestock and poultry hazards for inspectors.

Reinforce enforcement of existing regulations, such as these:

- Health certificates must accompany imported livestock and such livestock is subject to health inspection by the territorial veterinarian and quarantine if needed.
- Imported poultry and eggs must be quarantined, and inspected, and poultry must be vaccinated by the territorial veterinarian for Newcastle disease prior to entry to Guam in accordance with Title 9 of the Guam Administrative Rules and Regulations (9 GARR 1, Division 1, Chapter 1). Use USDA-APHIS-VS import permits for restricted animal products.
- Enforce Guam Administrative Rules and Regulations requiring a permit, health certificate, and inspection for imported reptiles (9 GARR 1, Division 1, Chapter 1).
- Enforce current Swine Health Protection regulations requiring cooking of certain types of waste prior to feeding to pigs (9 CFR § 166).

A6.5.5 Additional Safeguarding Practices

Develop a system of routine systematic surveillance for livestock and poultry diseases and vector hazards.

Develop situational monitoring for the occurrence of foreign animal diseases.

Develop procedures that will allow GCQA and GDOA to react to changing risks posed by arriving travelers, cargo, and conveyances, based on countries of origination or embarkation.

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Editors Note: The following sections (A7 through A25) consider some species which either are known invasive species or potential invasive species to micronesia and/or hawai'i. These sections should not be considered as comprehensive for all potential invasive species for the region. These lists should in fact be considered as generic and if fact they actually include species that are already established in parts of the region or which are native to sections of the region. There are various established resources which include information on invasive species for both Micronesia and Hawai'i and these resources should be utilized by policy makers and managers when considering best management practices (for example see the issg ias data set at: http://www.issg.org/).

A7 EXOTIC PLANT PESTS WITH THE POTENTIAL TO BE INTRODUCED INTO THE MICRONESIA REGION

This list contains some plant pests that would cause damage to agricultural crops and native plant species in the Micronesia and Hawai'i if permitted to establish. Structural wood pests, stored-grain pests, and pests of plant pollinators are also included. Shaded rows on the following pages indicate species associated with WPM.

Species	Distribution	Host(s)	References
ARTHROPODS			
Mites Mites not only cause direct feeding damage but also frequently vector plant pathogens. Mites are minute and thus difficult to detect. Due to high fecundity and short life cycles, they easily adapt to diverse environmental conditions and can rapidly develop resistance to pesticides (Jeppson et al. 1975, Ochoa 2005). Mites are mainly moved on infested plant materials.			
Acari: Eriophyidae			
Aceria guerreronis Keifer	Africa, Central and South America, India, Sri Lanka United States	*Cocos nucifera*	(Fernando et al. 2003, Navia et al. 2005, Lawson-Balagbo et al. 2007)
Aceria sheldoni (Ewing)	Africa, Argentina, Australia, Brazil, China, Hawai'i, Southern Europe, United States, Southeast Asia	*Citrus* spp.	(CAB 1980, Childers and Achor 1999, Hong et al. 2006)
Aceria tulipae (Keifer)	Brazil, China, Cuba, Egypt, Europe, India, Mexico, New Zealand, Thailand, United States	Poaceae, *Allium* spp., *Tulipa* spp.	(Somsen and Sill Jr. 1970, Perring 1996, Hong et al. 2006)
Aculops lycopersici (Massee)	Africa, Asia, Australia, Canada, Central and South America, China, Europe, Hawai'i, Melanesia, Mexico, United States	Solanaceae	(CABI 1987, Hong et al. 2006, CABI 2007)

Phyllocoptruta oleivora (Ashmead)	Africa, Australia, Caribbean, Central and South America, Cook and Fiji Islands, Hawai'i, Mexico, Middle East, United States, Southeast Asia, Southern Europe	*Citrus* spp.	(CAB 1970, Jeppson et al. 1975, Hong et al. 2006)
Acari: Laelapidae			
Tropilaelaps clareae Delfinado and Baker	South and Southeast Asia, Philippines	*Apis mellifera*	(ISSG 2010)
Acari: Tenuipalpidae			
Brevipalpus chilensis Baker	Argentina, Chile	*Actinidia chinensis*, *Ampelopsis* spp., *Annona cherimola*, *Citrus limon*, *Diospyros kaki*, *Ficus* spp., *Ligustrum* spp., *Pyrus communis*	(Jeppson et al. 1975, González 1989, Prado 1991, Navia and Mendonça 2005, Figueroa 2008)
Brevipalpus lewisi McGregor	Australia, Bulgaria, Egypt, Iran, Japan, Lebanon, Mexico, United States	*Citrus* spp., *Juglans* spp., *Pistacia* spp., *Punica granatum*	(Baker et al. 1975, Jeppson et al. 1975, Childers et al. 2003, Navia and Mendonça 2005, Namaghi 2010)
Raoiella indica (Hirst)	Caribbean, India, Malaysia, Mauritius, Middle East, Réunion, Philippines	Arecaceae, Musaceae, Zingiberaceae	(Peña et al. 2006, Vásquez et al. 2008, ISSG 2009)

	Venezuela		
Acari: Tetranychidae			
Amphitetranychus viennensis (Zacher)	Europe, Middle East	*Ficus carica*, *Plumeria* spp.	(Bolland et al. 1998, Navia and Mendonça 2005)
Tetranychus evansi Baker & Pritchard	Africa, Caribbean, Hawai'i, Mediterranean, South America, United States	Solanaceae, *Amaranthus* spp., *Ipomoea batatas*, *Passiflora foetida*, *Psidium guajava*	(Tsagkarakou et al. 2007, Migeon and Dorkeld 2010)
INSECTS			
Coleoptera: Bostrichidae These beetles are important pests of living trees and forest products (Liu et al. 2008). Bostrichids are often moved in WPM, timber, and furniture.			
Dinoderus minutus (F.)	Africa, Caribbean, China, CNMI, Germany, Guam, Israel, Japan, South America, Southeast Asia, United States	*Bambusa* spp., *Dendrocalamus* spp., *Manihot* spp., *Phyllostachys* spp.	(Chûjô 1958, Stone 1970, Buchelos 1991, CABI 2007, PIER 2010)
Dinoderus ocellaris Stephens	India, New Guinea, Philippines	*Bambusa* spp.	(Tanaka 1927, Atkinson 1936, Stone 1970, Spilman 1982, CABI 2007, Rajendran and Kumar 2008)
Heterobostrychus aequalis (Waterhouse)	Cuba, India, Indonesia, Madagascar, CNMI, Guam, Malaysia, New Guinea, Philippines, Sri Lanka, Suriname, United States	*Albizia* spp., *Bambusa* spp., *Canarium* spp., *Cassia* spp., *Dalbergia* spp., *Dendrocalamus* spp., *Endospermum* spp., *Leucaena* spp., *Mangifera* spp., *Morus* spp., *Poinciana* spp.,	(Chûjô 1958, Stone 1970, Woodruff and Fasulo 2006, Benker 2008)

		Pterocarpus spp., *Sterculia* spp., *Tectona* spp., *Terminalia* spp.	
Heterobostrychus brunneus (Murray)	Sub-Saharan Africa, United States	*Albizia* spp., *Bambusa* spp., *Canarium* spp., *Cedrela* spp., *Dendrocalamus* spp., *Endospermum* spp., *Leucaena* spp., *Mangifera* spp., *Pterocarpus* spp., *Sterculia* spp., *Tectona* spp., *Terminalia* spp.	(Stone 1970, Selander 1986, Pasek 2000, Haack 2006, Schabel 2006, PIER 2010)
Heterobostrychus hamatipennis (Lesne)	China, France, Hawai'i, India, Japan, Madagascar, Malaysia, Mauritius, Philippines, Thailand	*Acacia catechu*, *Bambusa* spp., *Bombax ceiba*, *Garuga pinnata*, *Lithocarpus calanthiformis*, *Paulownia tomentosa*	(Hutacharern and Tubtim 1995, Wang et al. 1998, Fassotte 2005, Halbert 2007, Aberlenc 2008, Benker 2008)
Lyctus africanus Lesne	Africa, India, Israel, Japan, Southeast Asia	*Bambusa* spp., *Dendrocalamus* spp.	(Stone 1970, Halperin and Geis 1999, Rajendran and Kumar 2008)
Sinoxylon anale Lesne	Australia, Brazil, China, India, Indonesia, New Zealand, Philippines, Saudi Arabia, Sri Lanka, Southeast Asia, United States, Venezuela	*Acacia* spp., *Albizia* spp., *Casuarina* spp., *Dalbergia* spp., *Delonix* spp., *Eucalyptus* spp.	(Stone 1970, Argaman 1987, Pasek 2000, Teixeira et al. 2002, Karnkowski 2006, CABI 2007, Krehan 2007)

Sinoxylon conigerum Gerstaecker	China, India, Israel, Italy, Japan, South America, Southeast Asia, Spain, Sub-Saharan Africa, United States, Vietnam	*Bambusa* spp., *Hevea* spp., *Manihot* spp.	(Stone 1970, Filho et al. 2006, Haack 2006, Karnkowski 2006, CABI 2007, Benker 2008)
Sinoxylon crassum Lesne	East Africa, India, Pakistan, Southeast Asia	*Acacia* spp., *Albizia* spp., *Bambusa* spp., *Cassia* spp.	(Stebbing 1914, Stone 1970, Singh and Bhandari 1987, Rathore 1995, Gul and Bajwa 1997, Pasek 2000, Krehan 2007)
Sinoxylon pugnax Lesne	Afghanistan, East Africa, India, New Guinea	*Prosopis* spp.	(Lesne 1904, Allen 2007b, CABI 2007, PIER 2010)
Coleoptera: Cerambycidae These beetles are extremely important wood boring pests of live trees. Adults feed on flowers, foliage, and bark; larvae destructively bore into wood (Gillott 1995). Cerambycids are often moved on nursery stock and in WPM.			
Anoplophora chinensis (Forster)	China, Hawai'i, Korea, Malaysia, Myanmar, Vietnam	*Citrus* spp., *Cryptomeria japonica*, *Ficus* spp., *Hibiscus* spp., *Mallotus* spp.	(CABI/EPPO 1997a, Benker 2008)
Ceresium flavipes (F.)	China, Hong Kong, Philippines, Southeast Asia, Taiwan	*Artocarpus* spp., *Casuarina* spp., *Citrus* spp., *Hevea* spp., *Streblus* spp.	(Samuelson and Gressitt 1965, Stone 1970, Allen 2001, Allen and Humble 2002)
Curtomerus flavus (F.)	Caribbean, Central and South America, Hawai'i, Japan, Marquesas Islands, Philippines, United States	*Acacia* spp., *Bidens* spp., *Eucalyptus* spp., *Leucaena leucocephala*, *Nicotiana tabacum*, *Psidium* spp., *Sapindus*	(Linsley 1963, Gressitt and Davis 1972, Sugiura et al. 2008, Peck 2009)

		spp.	
Psacothea hilaris (Pascoe)	China, Japan, Taiwan	*Ficus* spp., *Morus* spp.	(Allen and Humble 2002, CABI 2007, EPPO 2008)
Rhytidodera bowringii White	China	*Anacardium* spp., *Mangifera* spp.	(Stone 1970, FAO 2006b, NAPPO 2006, CABI 2007)
Stromatium barbatum (F.)	Bangladesh, East Africa, India, Myanmar, Pakistan, Sri Lanka	*Acacia* spp., *Bahuinia* spp., *Citrus* spp., *Coffea* spp., *Eriobotrya* spp., *Grevillea* spp., *Rosa* spp., *Tectona* spp.	(Stone 1970, CAB 1985, Singh and Bhandari 1987, Phukan et al. 1995, Thakur 1999, Pasek 2000)
Xylotrechus chinensis (Chevrolat)	China, Japan, Korea, Taiwan	*Morus* spp.	(Gressitt 1951, Benker 2008)
Xystrocera globosa (Olivier)	Australia, Caribbean, Egypt, Hawai'i, Israel, Madagascar, Mauritius, New Guinea, Southeast Asia	*Acacia* spp., *Acrocarpus* spp., *Adenanthera* spp., *Adina* spp., *Albizia* spp., *Bauhinia* spp., *Cassia* spp., *Duabanga* spp., *Grewia* spp., *Haematoxylon* spp., *Paraserianthes* spp., *Parkia* spp., *Salmalia* spp., *Samanea* spp., *Xylia* spp.	(Mathew 1987, Friedman et al. 2008)
Coleoptera: Curculionidae			
Hypothenemus hampei	Hawai'I, Africa, South and Central America	Rubiaceae	(Vega et al. 2009; Burbano et al. 2011)

Coleoptera: Chrysomelidae There are over 35,000 described species of Chrysomelids (leaf beetles). Adults feed on leaves and flowers, and larvae feed on leaves, roots, or stems (Gillott 1995). Leaf beetles are often moved in infested plant material, particularly in ornamental plants.			
Brontispa longissima Gestro	Australia, Cambodia, China Indonesia, Laos, Malaysia, The Maldives, Myanmar, New Guinea, Philippines, Singapore, Taiwan, Thailand, Vietnam	Arecaceae	(Sankaran 2007, ISSG 2009)
Diabrotica balteata Leconte	Central America, Mexico, South America, United States	Cucurbitaceae, *Ipomoea* spp., *Manihot esculenta*, *Phaseolus vulgaris*, Solanaceae	(Peña and Waddill 1982, CABI 2007)
Diabrotica undecimpunctata Mannerheim	Bermuda, Canada, Central America, Mexico, United States	Cucurbitaceae, *Ipomoea* spp., *Phaseolus vulgaris*	(Foster and Brust 1995, CABI 2007)
Diabrotica virgifera LeConte	Canada, Central America Europe, Mexico, United States	Cucurbitaceae, *Glycine max*, *Helianthus annuus*, *Zea mays*	(CABI/EPPO 1997d, EPPO 2006a, Ciosi et al. 2008, Gray et al. 2009, Meinke et al. 2009)
Microtheca ochroloma Stål	South America, United States	*Brassica* spp., *Raphanus sativus*, *Rosa* spp., *Zea mays*	(Balsbaugh Jr. 1978, Fasulo 2010)
Coleoptera: Curculionidae There are over 40,000 species in Curculionidae. Most larvae and adults feed on plant parts including fruits, nuts, stems, and roots. Many Curculionids are very serious plant pests. For example, the red palm weevil, *Rhynchophorus ferrugineus*, a devastating pest of various palm species, has been introduced into several parts of the world; it is not known to occur in Micronesia.			

Diaprepes abbreviatus (L.)	Caribbean, United States	*Carica papaya*, *Citrus* spp., *Ipomoea batatas*, *Psidium guajava*, *Saccharum officinarum*, *Solanum tuberosum*	(Ascunce et al. 2009, Weissling et al. 2009)
Metamasius callizona (Chevrolat)	Guatemala, Mexico, United States	Bromeliaceae, *Ananas comosus*	(Cooper 2008, Frank and Fish 2008, Larson and Frank 2009)
Rhynchophorus ferrugineus (Olivier)	Africa, Asia, Australia, India, Middle East, Spain	Arecaceae, especially *Cocos nucifera* and *Phoenix* spp.	(Kehat 1999, CABI 2007)
Rhynchophorus palmarum (L.)	Caribbean, Central and South America, Mexico	Arecaceae	(EPPO 2005a)
Coleoptera: Nitidulidae The small hive beetle (*Aethina tumida*) feeds on pollen and honey, burrowing through honey combs and causing damage to bee colonies. Small hive beetles can be transported in infested fruits, packages of bees, hive equipment, and soil (Neumann and Elzen 2004).			
Aethina tumida Murray	Africa, Australia, Canada, Egypt, Mexico, Portugal, United States	*Apis mellifera*, *Bombus* spp.	(Neumann and Elzen 2004)
Coleoptera: Scarabaeidae Scarabaeid adults can be serious foliage-feeding pests; larvae damage plant roots (Gillott 1995). These beetles may be introduced in infested propagative material.			
Oryctes rhinoceros (L.)	Asia, Australia, Fiji, Guam, Hawai'iIndonesia , Palau, Southeast Asia, New Guinea,	Arecaceae	(ISSG 2010)

	Tonga, Vanuatu, Wallis		
Papuana spp.	Papua New Guinea, Solomon Islands, Vanuatu, Fiji and Kiribati	*Colocasia, Musa, Canna, Xanthosoma, Solanum, Pandanus, Angiopteris, and Cocos*	(SPC 1987; Aloalii et al. 1980)
Cyclocephala pasadenae (Casey)	Hawai'i, Mexico, United States	Poaceae	(Bauernfeind 2001, Jameson et al. 2009, Ratcliffe 2009)
Coleoptera: Scolytidae Scolytids are very small wood boring beetles (Anderson and Burgin 2002). They complete almost their entire life cycle in the bark or the wood of trees (Rudinsky 1962), making them difficult to detect. Of the total tree mortality in the United States caused by insects, more than 60% is attributable to species of Scolytidae. Scolytidae often vector plant pathogenic fungi. Scolytidae are most frequently intercepted in WPM, but may also be moved in propagative materials and wooden handicrafts.			
Coccotrypes dactyliperda (F.)	Australia, Cuba, Egypt, Hawai'i, India, Israel, Japan, Mexico, Panama, South America, Southeast Asia, Sudan, United States	Arecaceae	(Wood 1982, Atkinson and Peck 1994, El-Sherif et al. 1998, Holzman et al. 2009)
Cyrtogenius brevior (Eggers)	Japan	*Dipterocarpus* spp., *Mangifera* spp.	(Bright and Skidmore 1997, Brockerhoff et al. 2003)
Hypocryphalus mangiferae Eggers	Brazil	*Mangifera* spp.	(Stone 1970, Haack 2001, CABI 2007)
Hypothenemus birmanus (Eichhoff)	Singapore	*Manilkara* spp.	(Stone 1970, Haack 2001, CABI 2007)
Xyleborinus saxeseni (Ratzeburg)	Australia, Ecuador, South Africa, United	*Eucalyptus* spp., *Juglans* spp., *Persea* spp.	(Stone 1970, Brockerhoff et al. 2003, HEAR 2004, CABI 2007, Haack and Petrice 2009)

	States		
Xyleborus affinis Eichhoff	Africa, Brazil, United States	*Dracaena* spp., *Juglans* spp. *Macadamia* spp., *Saccharum* spp.	(Stone 1970, Brockerhoff et al. 2003, HEAR 2004, CABI 2007)
Xyleborus glabratus Eichhoff	Bangladesh, India, Japan, Myanmar, Taiwan, United States	Lauraceae, including *Persea americana*	(Rabaglia et al. 2006, Fraedrich et al. 2007, Cognato 2008, Harrington et al. 2008, Mayfield et al. 2008, Goldberg and Heine 2010)
Xyleborus perforans (Wollaston)	Africa, Asia, New Guinea, Philippines, South America	*Citrus* spp., *Cocos* spp., *Eucalyptus* spp., *Mangifera* spp., *Persea* spp.	(Stone 1970, Brockerhoff et al. 2003)
Xyleborus similis Ferrari	Africa, Asia, Australia, FSM, New Guinea, United States	*Artocarpus* spp., *Durio* spp., *Ficus* spp., *Mangifera* spp., *Theobroma* spp.	(Stone 1970, Brockerhoff et al. 2003, HEAR 2004, Rabaglia et al. 2006, CABI 2007)
Xyleborus volvulus (F.)	United States	*Acacia* spp., *Bauhinia* spp., *Citrus* spp., *Cocos* spp., *Terminalia* spp.	(Stone 1970, Brockerhoff et al. 2003, CABI 2007)
Xylosandrus crassiusculus (Motschulsky)	Africa, Hong Kong, United States	*Coffea* spp., *Eucalyptus* spp., *Persea* spp.	(Stone 1970, Bright and Skidmore 1997, Brockerhoff et al. 2003, HEAR 2004, LaBonte et al. 2005, CABI 2007)
Xylosandrus morigerus (Blandford)	Asia, Europe, Africa, United States, Mexico, Central America, South America, Australia, Guam, CNMI, FSM	*Coffea* spp., *Dendrobium* spp., *Persea* spp., *Tectona* spp., *Theobroma* spp.	(Stone 1970, Bright and Torres 2006, CABI 2007)

Diptera: Tephritidae Larvae feed inside a large variety of fruit, causing serious crop damage. Fruit flies are introduced into new areas in infested fruit (White and Elson-Harris 1992).			
Bactrocera cucurbitae (Coquillett)	Asia, Guam, Hawai'i, Kenya, Mauritius, New Guinea, Tanzania	Cucurbitaceae, *Carica papaya*, *Phaseolus vulgaris*, *Vigna ungiculata*	(ISSG 2010)
Bactrocera dorsalis (Hendel)	Asia, French Polynesia, Hawai'i	*Annona squamosa*, *Capsicum* spp., *Solanum lycopersicon*, *Mangifera indica*, *Musa paradisiaca*, *Psidium guajava*	(USDA-APHIS-PPQ 1982, Allwood et al. 1999, SPC 2002, Iwaizumi 2004, Aketarawong et al. 2007, Chen et al. 2007)
Bactrocera frauenfeldi (Schiner)	Australia, FSM, Kiribati, Nauru, New Guinea, Palau, RMI, Solomon Islands	*Achras sapota*, *Annona muricata*, *Artocarpus* spp., *Averrhoa carambola*, *Barringtonia edulis*, *Carica papaya*, *Citrus* spp., *Diospyros* spp., *Eugenia uniflora*, *Fortunella japonica*, *Inocarpus fagifer*, *Mangifera indica*, *Persea americana*, *Psidium guajava*, *Syzygium malaccense*, *Terminalia* spp., *Trichosanthes cucumerina*	(Hollingsworth et al. 2003, GDOA 2005, Sengebau et al. 2005)

Bactrocera invadens Drew, Tsuruta, & White	Africa, Bhutan, Sri Lanka	*Annona* spp., *Carica papaya*, *Chrysophyllum albidum*, *Citrullus lanatus*, *Citrus* spp., *Cucumis* spp., *Diospyros montana*, *Dracaena steudneri*, *Eriobotrya japonica*, *Mangifera indica*, *Musa* spp., *Persea americana*, *Psidium guajava*, *Sclerocarya birrea*, *Spondias cytherea*, *Solanum lycopersicum*, *Strychnos mellodora*, *Terminalia catappa*	(Drew et al. 2005, Mwatawala et al. 2006, White 2006, Drew et al. 2007, Rwomushana et al. 2008)
Bactrocera latifrons (Hendel)	China, Hawai'i, India, Japan, Laos, Malaysia, Pakistan, Sri Lanka, Taiwan, Thailand	*Baccaurea motleyana*, *Capsicum annuum*, *Solanum* spp.	(White and Elson-Harris 1992, Shimizu et al. 2007)
Bactrocera occipitalis (Bezzi)	Brunei, Malaysia, Palau, Philippines	*Mangifera indica*, *Psidium guajava*	(Drew and Hancock 1994, CABI/EPPO 1997b, Iwaizumi 2004, GDOA 2005, Sengebau et al. 2005, Chen et al. 2007)
Bactrocera philippinensis Drew and Hancock	Palau, Philippines	*Artocarpus communis*, *Averrhoa carambola*, *Carica papaya*, *Citrus*	(Drew and Hancock 1994, CABI/EPPO 1997b, Iwaizumi 2004, GDOA 2005, Sengebau et al. 2005, Chen et al. 2007, USDA NRCS 2009)

		madurensis, *Mangifera indica*, *Pouteria duklitan*, *Psidium guajava*, *Syzygium malaccensis*	
Bactrocera scutellata (Hendel)	China, Japan, Malaysia, Taiwan, Thailand	Solanaceae, *Cucumis sativa*, *Cucurbita* spp., *Trichosanthes* spp.	(Ohno et al. 2006, CDFA 2009)
Bactrocera synnephes (Hendel)	China, Philippines, Taiwan, Thailand	*Diplocyclos palmatus*, *Luffa cylindrica*, *Melothria formosana*	(Chang et al. 2003, Ohno and Tamura 2008)
Bactrocera tryoni (Froggatt)	Australia, Cook Islands, French Polynesia, New Caledonia, Pitcairn	*Annona* spp., *Capsicum frutescens*, *Carica papaya*, *Citrus* spp., *Coffea arabica*, *Ficus* spp., *Mangifera indica*, *Morus* spp., *Musa acuminata*, *Opuntia ficus-indica*, *Passiflora* spp., *Persea americana*, *Phoenix dactylifera*, *Psidium* spp., *Solanum* spp.	(White and Elson-Harris 1992, ISSG 2009)
Bactrocera zonata (Saunders)	Egypt, India, Indonesia, Laos, Libya, Mauritius, Middle East, Sri	*Carica papaya*, *Citrus* spp., *Mangifera indica*, *Momordica*	(White and Elson-Harris 1992, White 2006, Duyck et al. 2008)

	Lanka, Thailand, Vietnam	*charantia*, *Phoenix dactylifera*, *Psidium guajava*, *Punica granatum*, *Terminalia catappa*	
Ceratitis capitata (Wiedemann)	Australia, Hawai'i, Mediterranean, North Africa, South America, United States	*Carica* spp., *Diospyros* spp., *Mangifera* spp., *Musa* spp., *Persea* spp.	(ISSG 2010)
Ceratitis rosa Karsch	Sub-Saharan Africa	*Capsicum frutescens*, *Carica papaya*, *Citrus* spp., *Coffea arabica*, *Ficus carica*, *Garcinia mangostana*, *Litchi chinensis*, *Mangifera indica*, *Persea americana*, *Psidium guajava*, *Solanum* spp.	(White and Elson-Harris 1992, Duyck et al. 2008)
Hemiptera: Aleyrodidae Aleyrodidiae (whiteflies) damage plants through direct feeding and also vector plant viruses. Whiteflies are introduced to new areas on infected plant material (Martin et al. 2000). After introduction into a new area whitefly populations often undergo rapid population growth (Byrne and Bellows Jr. 1991).			
Aleurotrachelus trachoides (Back)	Caribbean, FSM, Guyana, Peru, Réunion, Tahiti	*Annona* spp., *Bidens pilosa*, *Capsicum frutescens*, *Casuarina* spp., *Datura* spp., *Dioscorea* spp., *Duranta erecta*,	(Mound and Halsey 1978, Peña and Bennett 1995, SPC 2005)

		Ipomoea batatas, *Morinda citrifolia*, *Solanum* spp., *Tectona grandis, Piper metisticum* (host)	
Paraleyrodes pseudonaranjae Martin	Bermuda, China, Hawai'i, United States	*Annona glabra*, *Calophyllum inophyllum*, *Citrus* spp., *Mangifera indica*, *Morinda citrifolia*, *Rhododendron pulchrum*	
Trialeurodes vaporariorum (Westwood)	Africa, Australia, Canada, Central and South America, Caribbean, Mexico, Hawai'i, Europe, South Asia, United States	*Brassica oleracea*, *Citrus* spp., *Cucurbita* spp., *Diospyros* spp., *Hibiscus* spp., *Ipomoea* spp., *Lonicera* spp., *Nerium oleander*, *Passiflora* spp., *Persea americana*, *Pittosporum eugenioides*, *Psidium guajava*, *Rhododendron* spp., *Solanum* spp.	(Mound and Halsey 1978, Martin et al. 2000, McKee et al. 2009)
Hemiptera: Aphididae Aphids are small insects, often with broad host ranges, and move readily with imported horticultural commodities (Messing et al. 2007). Aphids cause direct feeding damage and vector many plant viruses.			
Acyrthosiphon ilka Mordvilko	Middle East, Mediterranean, Southern Russia	Asteraceae, Brassicaceae, Linaceae,	(Blackman and Eastop 2000)

		Papaveraceae, Thymelaeaceae	
Acyrthosiphon kondoi Shinji	Argentina, Asia, Australia, Chile, Hawai'i, New Zealand, United States	Fabaceae	(Rethwisch 1989, Blackman and Eastop 2000)
Aphis coreopsidis (Thomas)	North, Central, and South America	Asteraceae, Malvaceae	(Blackman and Eastop 1994)
Aphis menthaeradicis Cowen	United States	*Artemisia* spp., *Aster* spp., *Mentha* spp., *Taraxacum* spp.	(Blackman and Eastop 2000)
Aphis nasturtii Kaltenbach	Asia, Chile, Ethiopia, Europe, Kenya, North America, South Africa	Solanaceae, Brassicaceae, Polygonaceae	(Blackman and Eastop 2000)
Aulacorthum circumflexum (Buckton)	Hawai'i	*Pinopsida* spp., *Pteridophyta* spp.	(Beardsley Jr. 1979, Blackman and Eastop 2000)
Aulacorthum magnoliae (Essig & Kuwana)	China, India, Japan, Korea	Cucurbitaceae, *Citrus* spp.	(Blackman and Eastop 2000)
Aulacorthum solani (Kaltenbach)	Africa, Asia, Australia, Central America, Europe, South America, United States	*Glycine max*, *Solanum tuberosum*	(Beardsley Jr. 1979, Blackman and Eastop 2000)
Brachycaudus helichrysi (Kaltenbach)	Africa, Asia, Central America, Europe, New Zealand, South America, United States	Asteraceae, Boraginaceae, Cucurbitaceae, Fabaceae, Polygonaceae, Rosaceae, Saxifragaceae,	(Beardsley Jr. 1979, Blackman and Eastop 2000, CABI 2007)

		Scrophulariaceae	
Cavariella aegopodii (Scopoli)	Asia, Australia, Europe, Hawai'i	Apiaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000)
Cerataphis orchidearum (Westwood)	Africa, Asia, Central America, Hawai'i	Orchidaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000)
Dysaphis apiifolia (Theobald)	Africa, Australia, Central Asia, Europe, Middle East, North and South America	Apiaceae	(Blackman and Eastop 2000)
Dysaphis foeniculus (Theobald)	Africa, Australia, Mediterranean, Middle East, North and South America, South Asia	Apiaceae, Polygonaceae	(Blackman and Eastop 2000)
Dysaphis tulipae (Boyer de Fonscolombe)	India, Jordan, United Kingdom, United States	Araceae, Iridaceae, Liliaceae, Musaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000, CABI 2007)
Greenidea mangiferae Takahashi	Taiwan	*Euphoria longans*, *Mangifera indica*	(Blackman and Eastop 2000)
Greenidea psidii van der Goot	Asia, Central America, Hawai'i, United States	Clusiaceae, Juglandaceae, Loranthaceae, Lythraceae, Moraceae, Myrtaceae, Rhamnaceae, Rutaceae	(Beardsley 1995, Blackman and Eastop 2000, Halbert 2004, Pérez Hidalgo et al. 2009)
Hyadaphis coriandri (Das)	Africa, Central and South Asia, Mediterranean, Middle East, Peru, United	Amaranthaceae, Apiaceae, Fabaceae, Lamiaceae	(Blackman and Eastop 2000)

	States		
Hyadaphis foeniculi (Passerini)	Egypt, Europe, Middle East, South America, United States	*Daucus carota*, *Foeniculum vulgare*, *Petrosalinum* spp., *Solanum tuberosum*, *Viburnum* spp.	(Smith and Cermeli 1979, CABI 2007, Kavallieratos et al. 2007, Kaygin et al. 2009)
Hyperomyzus lactucae (L.)	Australia, Central and South Asia, Europe, Hawai'i, Japan, Mediterranean, Middle East, North and South America	*Sonchus* spp.	(Beardsley Jr. 1979, Blackman and Eastop 2000, CABI 2007)
Macrosiphoniella sanborni (Gillette)	Asia, Central America, Europe, South America, United States	Asteraceae	(Beardsley Jr. 1979, Blackman and Eastop 2000, CABI 2007)
Macrosiphum euphorbiae (Thomas)	Africa, Asia, Australia, Canada, Central America, Europe, Mexico, New Zealand, South America, United States	Solanaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000, CABI 2007)
Macrosiphum rosae (L.)	Africa, Asia, Australia, Canada, Europe, Mexico, New Zealand, South America, United States	Dipsacaceae, Onagraceae, Rosaceae, Valerianaceae	(Blackman and Eastop 2000, CABI 2007)
Melanaphis sacchari (Zehntner)	Australia, Central and South America, Hawai'i,	Poaceae	(Blackman and Eastop 2000, White et al. 2001)

	South Africa, Southeast Asia, United States		
Melanaphis sorghi (Theobald)	Africa, Asia, Middle East	*Saccharum* spp., *Sorghum* spp., *Zea mays*	(Blackman et al. 1990)
Metopolophium dirhodum (Walker)	Africa, Australia, Japan, North and Central America, West and Central Asia	Poaceae	(Blackman and Eastop 2000, CABI 2007)
Metopolophium festucae (Theobald)	Europe	Poaceae	(Blackman and Eastop 2000)
Myzus ascalonicus Doncaster	Canada, Europe, New Zealand, Russia, United States	Polyphagous on many vegetable crops including *Allium* spp., *Beta vulgaris*, *Fragaria* spp., *Solanum* spp.	(Hill 1983, CABI 2007, Verbeek et al. 2010)
Myzus ornatus Laing	Africa, Australia, Central America, Europe, Mediterranean, South America, United States	Asteraceae, Bignonaceae, Labiatae, Polygonaceae, Primulaceae, Rosaceae, Violaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000)
Neotoxoptera oliveri (Essig)	Africa, Australia, Bermuda, Brazil, Korea, Mexico, New Zealand, Panama, Pakistan, Portugal, United States	*Allium cepa*, *Stellaria media*, *Viola* spp.	(Blackman and Eastop 2000)
Ovatus	Africa, Europe,	Lamiaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000)

crataegarius (Walker)	Hawai'i, Mexico, United States		
Patchiella reaumuri (Kaltenbach)	Bulgaria, Balkan States, Hawai'i, Solomon Islands, Turkey, Western Europe	Araceae	(Blackman and Eastop 2000)
Pemphigus populitransversus Riley	Azores, North and South America, South Africa	Brassicaceae	(Blackman and Eastop 2000)
Rhopalosiphoninus latysiphon (Davidson)	Africa, Australia, Europe, Hawai'i, North and South America, South Asia	Apocynaceae, Convolvulaceae, Iridaceae, Liliaceae, Myrtaceae, Poaceae, Rosaceae, Solanaceae, Urticaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000)
Rhopalosiphoninus staphylaeae (Koch)	Africa, Australasia, Europe, North America, Peru	Iridaceae, Liliaceae	(Blackman and Eastop 2000)
Rhopalosiphum padi (L.)	Africa, Asia, Australia, Canada, Europe, Mexico, Hawai'i, New Zealand, Puerto Rico, South America, United States	Cyperaceae, Iridaceae, Juncaceae, Poaceae, Typaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000, CABI 2007)
Schizaphis graminum (Rondani)	Africa, Asia, North, Central and South America, Southern Europe	Poaceae	(Blackman and Eastop 2000)

Schizaphis rotundiventris (Signoret)	Africa, Asia, Australia, Hawai'i, Southern Europe, United States	Arecaceae, Cyperaceae	(Blackman and Eastop 2000)
Sipha flava (Forbes)	Azores, Western hemisphere	Arecaceae, Cyperaceae	(Beardsley et al. 1992, Blackman and Eastop 2000)
Sitobion luteum (Buckton)	Australia, Central and South America, Europe, Fiji, Hawai'i, India, Madagascar, Mauritius, Singapore, Tahiti, United States	Orchidaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000)
Sitobion miscanthi (Takahashi)	Australia, Cook Islands, Fiji, Hawai'i, Southeast Asia, Tahiti, Tonga	Poaceae, Polygonaceae	(Beardsley Jr. 1979, Blackman and Eastop 2000, CABI 2007)
Tetraneura nigriabdominalis (Sasaki)	Africa, Asia, Australia, Europe, New Zealand, South America, United States	Poaceae	(Blackman and Eastop 2000)
Tetraneura ulmi (L.)	Eastern Siberia, Europe, North America, West and Central Asia	Poaceae	(Blackman and Eastop 2000)
Therioaphis trifolii (Monell)	Asia, Australia, Hawai'i, Japan, Mexico, South Africa, South America, United States	*Astragalus* spp., *Lotus* spp., *Medicago* spp., *Melilotus* spp., *Onobrychis* spp., *Ononis* spp., *Trifolium* spp.	(Beardsley Jr. 1979, Blackman and Eastop 2000, CABI 2007)

Toxoptera odinae (van der Goot)	Asia, Sub-Saharan Africa	Anacardiaceae, Araliaceae, Caprifoliaceae, Ericaceae, Pittosporaceae, Rubiaceae, Rutaceae	(Blackman and Eastop 2000)
Wahlgreniella nervata (Gillette)	Africa, England, Hawai'i, North and South America, Pakistan	*Rosa* spp.	(Beardsley Jr. 1979, Blackman and Eastop 2000)
Hemiptera: Coccidae Coccidae (soft scale insects) often live in concealed places on plants and are frequently transported on commodities and plant materials (Miller et al. 2002). Many scale insects are major agricultural pests and have causeed serious problems when introduced into new areas (Miller et al. 2005).			
Ceroplastes actiniformis Green	Brazil, Canary Islands, Egypt, India, Indonesia, Israel, Sri Lanka	Polyphagous	(Miller and Miller 2003, Ben-Dov et al. 2009)
Ceroplastes brevicauda Hall	Africa	*Citrus* spp., *Coffea* spp.	Ben-Dov et al. (2009) (Miller and Miller 2003)
Ceroplastes cirripediformis Comstock	Caribbean, Hawai'i, Indonesia, Mexico, South America, Southern Europe, United States	*Citrus* spp., *Ipomoea batatas*, *Mangifera indica*, *Passiflora edulis*, *Psidium guajava*, *Solanum melongena*	(Ben-Dov et al. 2009)
Ceroplastes destructor Newstead	Africa, Australia, India, New Guinea, New Zealand	*Citrus* spp., *Coffea arabica*, *Diospyros kaki*, *Psidium guajava*	(Miller and Miller 2003, CABI 2007, Ben-Dov et al. 2009)
Ceroplastes floridensis Comstock	Africa, Australia, Caribbean, Central and	Polyphagous on tropical fruits in at least 69 plant	(Ben-Dov et al. 2009)

	South America, Europe, Hawai'i, United States, West, South, and Southeast Asia	families	
Ceroplastes grandis Hempel	South America	*Citrus* spp., *Diospyros kaki*, *Psidium guajava*, *Punica granatum*	(Miller and Miller 2003, Ben-Dov et al. 2009)
Ceroplastes japonicus Green	Central and East Asia, England, France, Italy, Russia	*Citrus* spp.	(Miller and Miller 2003, Ben-Dov et al. 2009)
Ceroplastes pseudoceriferus Green	South and East Asia	*Citrus* spp., *Mangifera indica*, *Psidium guajava*	(Miller and Miller 2003, Ben-Dov et al. 2009)
Eulecanium tiliae (L.)	Canada, Europe, South Asia, United States	Polyphagous	(Miller and Miller 2003, Ben-Dov et al. 2009)
Milviscutulus mangiferae (Green)	Africa, Australia, Central and South America, Hawai'i, Israel, Mexico, Caribbean, Asia, United States	Orchidaceae, *Ananas* spp., *Artocarpus* spp., *Carica papaya*, *Citrus* spp., *Cocos nucifera*, *Eugenia* spp., *Ficus* spp., *Mangifera indica*, *Persea americana*, *Psidium guajava*	(Miller and Miller 2003, CABI 2007, Ben-Dov et al. 2009)
Parthenolecanium persicae (F.)	Asia, Australia, Europe, FSM, Hawai'i, North and South America	*Citrus* spp., *Diospyros kaki*, *Persea americana*, *Ficus carica*, *Magnolia grandiflora*, *Mangifera indica*, *Rosa* spp.	(Miller and Miller 2003, Ben-Dov et al. 2009)

Philephedra tuberculosa Nakahara & Gill	Africa, Caribbean, Central and South America, Mexico, United States	*Annona* spp., *Carica papaya*, *Citrus* spp., *Mangifera indica*, *Persea americana*, *Pouteria sapota*, *Psidium guajava*	(Miller and Miller 2003, Ben-Dov et al. 2009)
Protopulvinaria pyriformis (Cockerell)	Caribbean, Central and South America, Israel, Mexico, Southern Europe, United States	*Carica papaya*, *Citrus* spp., *Hibiscus sinensis*, *Mangifera indica*, *Musa cavendishi*, *Passiflora* spp., *Persea americana*, *Plumeria* spp., *Psidium guajava*	(Miller and Miller 2003, Ben-Dov et al. 2009)
Pulvinaria floccifera (Westwood)	Australia, Canada, Caribbean, Europe, Mexico, South Africa, South America, Southeast Asia, United States	*Citrus* spp., *Nerium* spp., *Psidium guajava*	(Ben-Dov et al. 2009)
Saissetia miranda (Cockerell & Parrott)	Caribbean, Central and South America, Hawai'i, India, Indonesia, Mexico, South Africa, South Pacific Islands, United States	*Citrus* spp., *Cocos nucifera*, *Mangifera indica*, *Nerium oleander*, *Persea americana*, *Plumeria* spp., *Psidium guajava*	(Ben-Dov et al. 2009)
Saissetia neglecta De Lotto	Caribbean, Central and South America,	*Annona muricata*, *Citrus* spp., *Coffea arabica*,	(Ben-Dov et al. 2009)

	Mexico, United States, Vanuatu	*Mangifera indica*, *Manihot esculenta*, *Manilkara zapota*, *Musa* spp., *Psidium guajava*, *Tamarindus indica*	
Vinsonia stellifera (Westwood)	Africa, Australia, Caribbean, Netherlands, New Guinea, South America, Southeast Asia, Taiwan, United States	*Citrus* spp., *Cocos nucifera*, *Eugenia jambos*, *Garcinia mangostana*, *Mangifera indica*, *Musa* spp., *Persea americana*, *Plumeria acutifolia*	(Ben-Dov et al. 2009)
Hemiptera: Diaspididae There are over 2,500 species of Diaspididae (armored scales) worldwide (Gillott 1995). These insects damage trees and shrubs and are moved to new areas in infested propagative material.			
Aulacaspis tubercularis Newstead	Africa, Asia, Australia, Central America, India, South America, United States	*Citrus* spp., *Cocos nucifera*, *Cucurbita* spp., *Mangifera indica*, *Persea americana*, *Pittosporum undulatum*	(Miller et al. 2005, CABI 2007)
Auscalaspis yasumatsu Takagi	Caribbean, CNMI, France, Guam, Hong Kong, New Zealand, Palau, Singapore, Taiwan, United States	Cycadaceae, Stangeriaceae, Zamiaceae	(ISSG 2010)
Aonidiella aurantii (Maskell)	Africa, Australia, Caribbean, FSM, Melanesia,	*Acacia* spp., *Agave* spp., *Ambrosia*	(Miller et al. 2005, CABI 2007, Ben-Dov et al. 2009)

	Mexico, Middle East, South America, South Asia, United States, Western Europe	*artemisiifolia*, *Artocarpus* spp., *Bambusa* spp., *Brassica nigra*, *Capsicum frutescens*, *Carica papaya*, *Casuarina* spp., *Citrus* spp., *Cocos nucifera*, *Cucurbita pepo*, *Cycas* spp., *Diospyros kaki*, *Ficus* spp., *Hibiscus* spp., *Jasminum* spp., *Mangifera indica*, *Musa sapientum*, *Nerium oleander*, *Pandanus tectorius*, *Persea americana*, *Poinsettia* spp., *Psidium guajava*	
Chrysomphalus aonidum (L.)	Africa, Australia, Caribbean, Central and South America, China, Europe, FSM, Hawai'i, Melanesia, Mexico, Middle East, South Asia, Taiwan, Vietnam, United States	*Acacia* spp., *Annona* spp., *Artocarpus* spp., *Citrus* spp., *Cocos nucifera*, *Cycas* spp., *Diospyros kaki*, *Dodonaea viscosa*, *Garcinia* spp., *Gardenia* spp., *Hibiscus* spp., *Heliconia* spp., *Ficus* spp., *Mangifera indica*, *Musa* spp.,	(Miller et al. 2005, Ben-Dov et al. 2009)

		Nerium oleander, *Opuntia* spp., *Pandanus* spp., *Persea americana*, *Phoenix dactylifera*, *Plumeria* spp., *Psidium guajava*, *Punica granatum*	
Diaspidiotus perniciosus (Comstock)	Africa, Canada, Europe, Hawai'i, South America, Southeast Asia, United States	*Actinidia chinensis*, *Cannabis sativa*, *Citrus* spp., *Diospyros kaki*	(Miller et al. 2005, Ben-Dov et al. 2009)
Diaspis boisduvalii Signoret	Africa, Asia, Australia, Canada, Caribbean, Central and South America, Europe, Hawai'i, Mexico, Palau, United States	*Agave* spp., *Ananas comosus*, *Cattleya* spp., *Citrus* spp., *Cocos* spp., *Garcinia mangostana*, *Heliconia* spp., *Mangifera indica*, *Musa* spp., *Pandanus* spp., *Persea americana*, *Phoenix* spp., *Strelitzia* spp., *Vanda* spp.	(Miller et al. 2005, Ben-Dov et al. 2009)
Fiorinia theae Green	Caribbean, Central and South America, Mexico, South and East Asia	*Camellia* spp., *Citrus* spp., *Olea* spp., *Spondias* spp.	(Miller et al. 2005, Ben-Dov et al. 2009)
Gymnaspis aechmeae Newstead	Argentina, Caribbean, Costa Rica, Europe,	Bromeliaceae, *Ananas comosus*, *Cymbidium* spp.	(Miller et al. 2005, Ben-Dov et al. 2009)

	Hawai'i, United States		
Lepidosaphes ulmi (L.)	Australia, Canada, China, Europe, Hawai'i, India, Middle East, North Africa, South Africa, South America, Taiwan, United States	*Citrus* spp., *Cocos nucifera*, *Diospyros kaki*, *Ginkgo* spp., *Persea* spp., *Ficus carica*, *Nerium oleander*, *Olea europaea*, *Punica granatum*	(Miller et al. 2005, CABI 2007, Ben-Dov et al. 2009)
Lindingaspis rossi (Maskell)	Africa, Australia, Hawai'i, Mexico, New Zealand, New Caledonia, Philippines, Samoa, South America, South and East Asia, Southern Europe, United States	*Citrus* spp., *Cocos nucifera*, *Cycas* spp., *Eucalyptus* spp., *Garcinia* spp., *Macadamia ternifolia*, *Mangifera indica*, *Nerium oleander*	(Miller et al. 2005, Ben-Dov et al. 2009)
Parlatoria oleae (Colvée)	Australia, Mexico, Northern Africa, South America, Southern Asia, Southern Europe, United States	*Acacia* spp., *Citrus* spp., *Dianthus* spp., *Diospyros kaki*, *Eriobotrya japonica*, *Hibiscus syriacus*, *Jasminum* spp., *Mangifera indica*, *Nerium* spp., *Olea europaea*, *Oryza sativa*, *Phoenix* spp., *Punica granatum*	(Miller et al. 2005, Ben-Dov et al. 2009)
Pinnaspis aspidistrae (Signoret)	Africa, Canada, Caribbean, Central and South America,	*Acacia* spp., *Annona* spp., *Citrus* spp., *Cocos nucifera*,	(Miller et al. 2005, CABI 2007, Ben-Dov et al. 2009)

	Europe, FSM, Hawai'i, Melanesia, Mexico, Philippines, United States	*Cordyline terminalis*, *Cymbidium* spp., *Cycas* spp., *Dracaena* spp., *Heliconia* spp., *Hibiscus rosasinensis*, *Jatropha integerrima*, *Mangifera indica*, *Musa paradisiaca*, *Pandanus odoratissimus*, *Persea* spp., *Piper* spp., *Plumeria acutifolia*, *Portulaca lutea*, *Psidium guajava*, *Solanum* spp.	
Unaspis citri (Comstock)	Africa, Australia, Caribbean, Central and South America, FSM, Hawai'i, Melanesia, Mexico, Southeast Asia, United States	*Acacia* spp., *Ananas* spp., *Annona muricata* spp., *Citrus* spp., *Cocos* spp., *Euonymus* spp., *Hibiscus* spp., *Mangifera* spp., *Musa* spp., *Persea americana*, *Psidium guajava*	(Miller et al. 2005, Ben-Dov et al. 2009)
Hemiptera: Keriidae Kerridae (lac scales) are mainly tropical and subtropical in distribution (Gillott 1995) and can be spread to new areas in infested propagative material. They can be serious pests of various plant species.			
Paratachardina lobata (Chamberlin)	Christmas Island, India, Sri Lanka, United States	*Acacia* spp., *Annona* spp., *Artocarpus*	(Howard et al. 2004, Ben-Dov et al. 2009)

		heterophyllus, *Bambusa vulgaris*, *Casuarina* spp., *Citrus* spp., *Dimocarpus longan*, *Diospyros* spp., *Garcinia* spp., *Gardenia* spp., *Litchi sinensis*, *Mangifera indica*, *Manilkara* spp., *Persea* spp., *Psidium* spp., *Solanum* spp.	
Paratachardina pseudolobata Kondo & Gullan	United States	*Mangifera indica*	(Ben-Dov et al. 2009, ISSG 2009)
Hemiptera: Miridae Many mirids cause severe feeding damage to vegetables, fruits, flowers, and forage crops (Gillott 1995). They are often moved in infested plant materials.			
Lygus hesperus Knight	Canada, United States	*Daucus carota*, *Solanum lycopersicum*	(Scott 1977, CABI 2007)
Lygus lineolaris Palisot de Beauvois	Canada, Central America, Mexico, United States	Polyphagous. Hosts include *Brassica* spp., *Cucumis sativus*, *Dahlia* spp., *Phaseolus vulgaris*, *Prunus* spp., *Solanum* spp.	(Young 1986, CABI 2007)
Hemiptera: Ortheziidae Orthziidae can live on almost any host plant part, including the roots (Triplehorn and Johnson 2005). These insects can be moved to new areas on infested plant materials.			
Insignorthezia	Africa, Australia,	*Artemisia* spp.,	(Ben-Dov et al. 2009, ISSG 2009)

insignis (Browne)	Canada, Caribbean, Central and South America, China, Europe, Hawai'i, India, Indonesia, Japan, Malaysia, Mexico, Sri Lanka, Taiwan, United States	*Citrus* spp., *Coffea* spp., *Euphorbia* spp., *Geranium* spp., *Ipomoea* spp., *Lantana* spp., *Oxalis* spp., *Solanum* spp., *Viola* spp.	
Hemiptera: Pseudococcidae Pseudococcidae (mealybugs) often attain high population densities, killing their host plants by depleting sap, injecting toxins, transmitting viruses, and/or excreting honeydew (Williams and Granara de Willink 1992). They are moved on infested plant materials.			
Balanococcus poae (Maskell)	New Zealand	Poaceae	(Miller et al. 2002, Ben-Dov et al. 2009)
Dysmicoccus grassii (Leonardi)	Caribbean, Central and South America, France, Italy Malaysia, Mexico, Nigeria	*Ananas comosus*, *Annona squamosa*, *Artocarpus* spp., *Carica papaya*, *Coffea arabica*, *Mangifera indica*, *Musa* spp., *Passiflora edulis*, *Persea* spp., *Punica granatum*, *Sechium edule*, *Theobroma cacao*	(Ben-Dov et al. 2009)
Dysmicoccus sp. nr. *bispinosus*	Caribbean, Central America, Mexico, Puerto Rico, South America	*Acacia* spp., *Coffea* spp., *Citrus* spp., *Dieffenbachia* spp., *Inga* spp., *Musa* spp., *Psidium guajava*,	(Williams and Granara de Willink 1992, Rung et al. 2007)

		Solanum spp.	
Dysmicoccus texensis (Tinsley)	Central America, Mexico, South America, Trinidad and Tobago, United States	*Acacia* spp., *Coffea* spp.	(Williams and Granara de Willink 1992, Santa-Cecília et al. 2002, Miller et al. 2005, Bigger 2009)
Exallomochlus hispidus (Morrison)	Southeast Asia	*Annona muricata*, *Artocarpus heterophyllus*, *Citrus maxima*, *Cocos nucifera*, *Dimocarpus longan*, *Durio* spp., *Garcinia mangostana*, *Manilkara zapota*, *Nephelium lappaceum*, *Psidium guajava*, *Saccharum officinarum*, *Theobroma cacao*	(Miller et al. 2002, Ben-Dov et al. 2009)
Ferrisia malvastra (McDaniel)	Australia, Caribbean, Hawai'i, India, Israel, Mexico, New Guinea, South Africa, South America, United States	*Ambrosia artemisifolia*, *Arachis hypogaea*, *Brassica rapa*, *Citrus paradisi*, *Gossypium hirsutum*, *Macadamia* spp., *Manihot esculenta*, *Persea americana*, *Phaseolus vulgaris*, *Punica granatum*, *Solanum* spp., *Tectona grandis*	(Ben-Dov et al. 2009)

Geococcus coffeae Green	Africa, Australia, Caribbean, Central and South America, FSM, Hawai'i, Mexico, New Guinea, Southeast Asia, United States, Western Europe	*Ananas comosus*, *Dioscorea* spp., *Acacia koa*, *Citrus* spp., *Coffea arabica*, *Colocasia esculenta*, *Mangifera indica*, *Musa* spp., *Nerium oleander*, *Theobroma cacao*	(Miller et al. 2002, Ben-Dov et al. 2009)
Phenacoccus gossypii Townsend & Cockerell	Caribbean, Japan, Mexico, South America, Southern Europe, United States	*Capsicum annuum*, *Gossypium* spp., *Helianthus* spp., *Lantana* spp., *Mangifera indica*, *Phaseolus vulgaris*, *Solanum lycopersicum*	(Ben-Dov et al. 2009)
Phenacoccus parvus Morrison	Africa, Australia, Caribbean, Central and South America, India, Indonesia, Israel, Mexico, New Caledonia, Thailand, United States	*Actinidia deliciosa*, *Capsicum* spp., *Cucumis sativus*, *Lantana camara*, *Mangifera indica*, *Musa* spp., *Psidium guajava*, *Saccharum officinarum*, *Solanum* spp.	(Ben-Dov et al. 2009)
Phenacoccus solani Ferris	Caribbean, Central and South America, Hawai'i, India, Italy, Kiribati, North America, RMI, Southern Africa, West and	*Artemisia heterophylla*, *Aster* spp., *Brassica oleracea*, *Centaurea diffusa*, *Chenopodium* spp., *Chrysanthemum*	(Ben-Dov et al. 2009)

	Southeast Asia	*morifolium*, *Citrus aurantifolia*, *Dendrobium* spp., *Euphorbia* spp., *Helianthus* spp., *Lantana camara*, *Narcissus* spp., *Raphanus sativus*, *Solanum* spp., *Viola* spp.	
Planococcus ficus (Signoret)	Caribbean, Middle East, South America, South Asia, Southern Africa, Southern Europe, United States	*Bambusa* spp., *Ficus* spp., *Mangifera indica*, *Nerium oleander*, *Persea americana*, *Phoenix dactylifera*, *Punica granatum*, *Theobroma cacao*	(Ben-Dov et al. 2009)
Planococcus kraunhiae (Kuwana)	China, Japan, Korea, Philippines, Taiwan, United States	*Actinidia* spp., *Agave americana*, *Artocarpus lanceolata*, *Casuarina stricta*, *Citrus* spp., *Coffea arabica Cucurbita moschata*, *Diospyros kaki*, *Ficus carica*, *Musa basjoo*, *Nerium indicum*, *Pyrus ussuriensis*	(Ben-Dov et al. 2009)
Planococcus minor (Maskell)	Australia, Caribbean, Central America, FSM, Guam, Mexico, South	*Acacia* spp., *Aleurites moluccana*, *Ananas comosus*, *Annona* spp.,	(Miller et al. 2002, Ben-Dov et al. 2009)

	America, Southeast Asia, Taiwan	*Artocarpus* spp., *Brassica* spp., *Capsicum* spp., *Citrus* spp., *Cocos nucifera*, *Coffea* spp., *Colocasia esculenta*, *Cucumis* spp., *Cucurbita* spp., *Heliconia* spp., *Hibiscus* spp., *Ipomoea* spp., *Leucaena* spp., *Manihot esculenta*, *Mangifera indica*, *Mimosa* spp., *Musa* spp., *Pandanus* spp., *Passiflora edulis*, *Persea americana*, *Plumeria rubra*, *Psidium guajava*, *Saccharum officinarum*, *Solanum* spp., *Tectona grandis* spp., *Theobroma cacao*	
Pseudococcus calceolariae (Maskell)	Africa, Australia, Caribbean, China, Europe, Indonesia Mexico, United States, South America	*Brassica* spp., *Citrus* spp., *Helianthus* spp., *Hibiscus* spp., *Nerium oleander*, *Persea indica*, *Solanum* spp., *Theobroma*	(CABI 2007, Ben-Dov et al. 2009)

		cacao, *Trifolium* spp.	
Pseudococcus cryptus Hempel	Caribbean, Central and South America, FSM, Hawai'i, Middle East, Palau, Southeast Asia	*Ananas sativa*, *Annona muricata*, *Artocarpus* spp., *Bambusa* spp., *Cocos nucifera*, *Coffea* spp., *Citrus* spp., *Garcinia mangostana*, *Litchi chinensis*, *Mangifera indica*, *Moringa oleifera*, *Musa* spp., *Pandanus* spp., *Passiflora foetida*, *Persea americana*, *Psidium guajava*, *Punica granatum*	(Ben-Dov et al. 2009)
Pseudococcus jackbeardsleyi Gimpel & Miller	Canada, Caribbean, Central and South America, FSM, Hawai'i, Mexico, Southeast Asia, Taiwan, United States	*Ananas comosus*, *Annona* spp., *Carica papaya*, *Cereus* spp., *Coccinia grandis*, *Cocos* spp., *Citrus* spp., *Coffea arabica*, *Cucumis melo*, *Cucurbita* spp., *Ficus* spp., *Gossypium* spp., *Ipomoea* spp., *Lantana camara*, *Litchi chinensis*, *Mangifera indica*, *Musa* spp., *Persea* spp., *Psidium guajava*, *Punica*	(Ben-Dov et al. 2009)

		granatum, *Solanum* spp., *Zea mays*, *Zingiber officinale*	
Pseudococcus landoi (Balachowsky)	Caribbean, Central America, Mexico, South America	*Artocarpus altilis*, *Coffea* spp., *Heliconia* spp., *Manihot esculenta*, *Musa* spp., *Passiflora* spp., *Phaseolus lunatus*, *Schinus terebinthifolius*, *Theobroma cacao*, *Yucca elephantipes*	(Ben-Dov et al. 2009)
Pseudococcus longispinus (Targioni Tozzetti)	Africa, Asia, Australia, Caribbean, Central and South America, Europe, Hawai'i, Mexico, New Zealand, United States	*Acacia* spp., *Ananas comosus*, *Annona muricata*, *Artocarpus* spp., *Averrhoa carambola*, *Carica papaya*, *Citrus* spp., *Cocos nucifera*, *Coffea* spp., *Colocasia esculenta*, *Cycas* spp., *Ficus carica*, *Garcinia mangostana*, *Hibiscus* spp., *Jasminum* spp., *Mangifera indica*, *Manihot esculenta*, *Musa* spp., *Nephelium lappaceum*, *Nerium oleander*,	(CABI 2007, Ben-Dov et al. 2009)

		Opuntia spp., *Pandanus* spp., *Persea americana*, *Plumeria rubra*, *Psidium guajava*, *Solanum* spp.	
Pseudococcus viburni (Signoret)	Canada, Caribbean, Central and South America, Europe, Hawai'i, Mexico, Middle East, New Zealand, South Africa, Southeast Asia, United States	*Allium sativum*, *Ananas comosus*, *Annona* spp., *Brassica* spp., *Carica papaya*, *Citrus* spp., *Cucurbita* spp., *Diospyros kaki*, *Ficus* spp., *Eugenia jaboticaba*, *Helianthus* spp., *Litchi cinensis*, *Mangifera indica*, *Manihot esculenta*, *Nerium oleander*, *Opuntia* spp., *Passiflora* spp., *Solanum* spp., *Tamarix* spp., *Theobroma cacao*, *Zingiber officinale*	(CABI 2007, Ben-Dov et al. 2009)
Puto barberi (Cockerell)	Caribbean, Venezuela	*Bougainvillea glabra*, *Cajanus* spp., *Citrus* spp., *Coffea arabica*, *Geranium* spp., *Hibiscus* spp., *Lantana camara*, *Manihot*	(Miller et al. 2002, Ben-Dov et al. 2009)

		esculenta, *Persea americana*, *Physalis micondroi*, *Psidium guajava*, *Tamarix* spp., *Theobroma cacao*	
Rhizoecus americanus (Hambleton)	Caribbean, Central and South America, Italy, Mexico, Thailand, United States	*Chrysanthemum* spp., *Coffea arabica*, *Dieffenbachia* spp., *Euphorbia* spp., *Ficus nitida*, *Hibiscus rosa-sinensis*, *Lantana* spp., *Melaleuca leucadendron*, *Musa* spp., *Paspalum* spp., *Phoenix loureirii*, *Physalis pubescens*	(Ben-Dov et al. 2009)
Rhizoecus cacticans (Hambleton)	Australia, Canary Islands, Central and South America, Europe, United States	*Aloe* spp., *Bromus* spp., *Caesalpinia pulcherrima*, *Coffea* spp., *Cyperus rotundus*, *Fragaria* spp., *Opuntia* spp.	(Ben-Dov et al. 2009)
Rhizoecus dianthi Green	Australia, Canada, Europe, New Zealand, United States	*Chrysanthemum* spp., *Dianthus* spp., *Lantana* spp., *Pelargonium* spp., *Solanum sodomaeum*, *Yucca afoifolia*	(Ben-Dov et al. 2009)
Rhizoecus falcifer Kunckel	Australia, Caribbean,	*Chrysanthemum frutescens*, *Citrus*	(Ben-Dov et al. 2009)

d'Herculais	Europe, Mexico, North Africa, South Africa, Suriname, United States	*sinensis*, *Coffea* spp., *Convolvulus* spp., *Cynodon dactylon*, *Geranium* spp., *Hibiscus* spp., *Iris* spp., *Matthiola* spp., *Passiflora edulis*, *Phoenix* spp., *Prunus persica*, *Solanum* spp., *Theobroma cacao*	
Ripersiella hibisci (Kawai & Takagi)	Caribbean, China, Hawai'i, Japan, Taiwan, United States	*Carex* spp., *Hibiscus rosa-sinensis*, *Nerium oleander*, *Phoenix* spp.	(Miller et al. 2002, Ben-Dov et al. 2009)
Vryburgia brevicruris (McKenzie)	Australia, Europe, Israel, United States	Asclepiadaceae, *Gerbera* spp., *Solanum tuberosum*, *Taraxacum officinale*, *Trifolium* spp.	(Ben-Dov et al. 2009)
Hemiptera: Psyllidae The toxic saliva of psyllids may cause galling and stunting of plants (Gillott 1995). These small insects also transmit viruses and phytoplasmas. *Diaphorina citri* vectors '*Candidatus* Liberibacter asiaticus', the phytoplasma that causes Huanglongbing (citrus greening) in *Citrus* spp. (Gottwald et al. 2007).			
Diaphorina citri Kuwayama	Australia, Central and South America, Guam, Hawai'i, Southeast Asia, United States	*Citrus* spp.	(Grafton-Cardwell et al. 2006, ISSG 2010)
Hemiptera: Triozidae Triozidae (jumping plant lice) are small insects that feed on plants, causing galling and stunting (Gillott 1995). The potato psyllid, *Bactericera cockerelli*, feeds on			

plants in 20 different plant families, favoring solanaceous plants (Abdullah 2008). Some Triozid species (especially the one included in the assessment) vector disease caused fastitous bacteria (Candidatus Liberibacter solanacearum). There are multiple strains/biotypes of both the Triozid, and the vectored bacteria (Pers Comm. Barbour).			
Bactericera cockerelli (Sulc)	Central America, Mexico, New Zealand, United States, Europe	Polyphageous, favoring Solanaceae	(Abdullah 2008)
Hymenoptera: Formicidae At least 90 ant species have been introduced into the Pacific Region, many by human activities (McGlynn 1999); they have had devastating impacts, reducing agricultural productivity and biodiversity (O'Dowd et al. 2003, Krushelnycky et al. 2005, Lester et al. 2009, Savage et al. 2009) and affecting human health. Red imported fire ants (*Solenopsis invicta*) sting people, often causing severe allergic reactions, and can make public areas, such as parks, unsafe for people (ISSG 2010). Ants are often moved on nursery stock and in many other items, including WPM, shipping containers, soil, construction materials, and vehicles.			
Acromyrmex octospinosus (Reich)	Caribbean, South America		(ISSG 2009)
Lasius neglectus Van Loon, Boomsma, & Andrásfalvy	Europe, Georgia, Kyrgyzstan, Turkey, Uzbekistan		(Seifert 2000, Schultz and Seifert 2005, ISSG 2009)
Linepithema humile (Mayr)	Australia, Bermuda, Hawai'i, Japan, Mexico, New Zealand, South Africa, South America, United Arab Emirates, United States, Western and Southern Europe		(Suarez et al. 2001, Holway et al. 2002, Krushelnycky et al. 2005)
Monomorium pharaonis (L.)	Africa, Asia, Australia, Europe, Galápagos Islands, Hawai'i, North, Central and South		(ISSG 2009)

	America		
Myrmica rubra (L.)	Australia, Canada, Europe, United States		(Groden et al. 2005, CABI 2007, ISSG 2009)
Solenopsis invicta Buren	Australia, Caribbean, New Zealand, South America, United States		(Vinson 1997, Holway et al. 2002, Morrison et al. 2004b)
Solenopsis richteri Forel	South America, United States		(ISSG 2009)
Solenopsis papuana Emery	American Samoa, Fiji, New Zealand, Hawai'i, United States	*Cocos*, *Colocasia*	(SPREP 2000, ISSG 2009)
Tapinoma melanocephalum (Fabricius)	Australia, Brazil, Canada, Caribbean, Costa Rica, Japan, United States		
Wasmannia auropunctata (Roger)	Africa, Caribbean, Central and South America, Galápagos Islands, Hawai'i, New Caledonia, North America, Solomon Islands, Tahiti, Vanuatu		(Holway et al. 2002, Wetterer and Porter 2003)
Lepidoptera: Bedellidae Native species in Hawai'I and also found in Fiji			
Bedellidae spp.	Hawai'I and Fiji	Ipomoea	(Englberger, personal communication)
Lepidoptera: Gelechiidae There are over 4,000 species of Gelechiidae. Larvae cause damage by boring into plant stems, seeds, fruit, flowers, and tubers (Gillott 1995). These small moths			

are often moved to new areas in infested plant material.			
Tuta absoluta (Meyrick)	North Africa, South America, Southern Europe	Solanaceae	(EPPO 2005b; CABI/EPPO 2009)
Lepidoptera: Gracillariidea The family Gracillariidea contains species of small moths, the larvae of which are leaf miners (Gillott 1995). *Marmara gulosa* larvae make serpentine mines in the rind of citrus fruits, making the fruit unsellable in the fresh market (Kirkland 2009).			
Marmara gulosa Guillén and Davis	United States	*Capsicum annuum*, *Citrus* spp., Cucurbitaceae, *Persea americana*, *Prunus* spp., *Vitis* spp.	(Kirkland 2009)
Lepidoptera: Limacodidae Limacodidae (nettle caterpillars) often have stinging hairs or spines, which may cause allergies in humans. Some species feed on palms (Barlow 1982) while other species are abundant in hardwood forests. Limacodiae can be moved to new areas on infested plant material.			
Darna pallivitta (Moore)	China, Hawai'i, Indonesia, Malaysia, Taiwan, Thailand	Arecaceae, Poaceae, *Adenostemma* spp., *Breynia* spp., *Cordyline terminalis*, *Ficus* spp., *Macadamia integrifolia*	(Robinson et al. 2001, Nagamine and Epstein 2007, Conant et al. 2008, Jang et al. 2009)
Lepidoptera: Noctuidae Noctuid larvae may cause severe damage to many plant species (Barlow 1982). Noctuids are moved to new areas on infested plant material and can be attracted to cargo and conveyances during night loading.			
Autographa californica Speyer	Malaysia, United States	*Medicago sativa*, *Mentha piperita*, *Solanum lycopersicum*	(Pearson et al. 1988, CABI 2007)
Copitarsia corruda	Colombia,	*Alstroemeria*	(Pogue and Simmons 2008, Gómez et al. 2009)

Pogue & Simmons	Ecuador, Peru	spp., *Ammi* spp., *Asparagus* spp., *Aster* spp., *Brassica* spp., *Callistephus* spp., *Iris* spp., *Limonium* spp., *Lysimachia* spp.	
Lepidoptera: Papilionidae The lime swallowtail, *Papilio demoleus*, is a pest of citrus nursery stock. Larvae are capable of defoliating entire nursery groves (Lewis 2009). Larvae can be moved on citrus nursery stock and adults may be deliberately introduced through the hobby trade.			
Papilio demoleus L.	Australia, Caribbean, Indonesia, Middle East, Southern Asia	Rutaceae, Fabaceae	(Guerrero et al. 2004, Eastwood et al. 2006, Lewis 2009)
Lepidoptera: Tineidae Tineid larvae are concealed feeders that often mine into plant parts (Gillott 1995). Tineoid moths can be moved to new areas on infested plant materials.			
Opogona sacchari (Bojer)	Africa, Brazil, Caribbean, China, Central America, Europe, Hawai'i, United States	*Alpinia* spp., *Ananas comosus*, *Bambusa* spp., *Begonia* spp., *Bougainvillea* spp., *Cordyline* spp., *Dieffenbachia* spp., *Dracaena* spp., *Euphorbia pulcherrima*, *Gloxinia* spp., *Heliconia* spp., *Musa* spp., *Philodendron* spp., *Saccharum officinarum*	(CABI/EPPO 1997f, Nishida 2002, Wang et al. 2008a)

Lepidoptera: Tortricidae Larvae of tortricids cause damage by mining into fruits, seeds, and bark, or by defoliating plants (Gillott 1995). Tortricids can be moved to new areas in infested plant material. The light brown apple moth (*Epiphyas postvittana*) is a significant horticultural and agricultural pest in both its native and introduced ranges and is highly polyphagous with at least 500 host plant species in 121 families.			
Epiphyas postvittana (Walker)	Australia, Hawai'i, Ireland New Zealand, United Kingdom, United States	Polyphagous, including fruits and cut flowers	(Suckling and Brockerhoff 2010)
Lepidoptera: Yponomeutidae Yponomeutidae are small moths. Larvae may be miners, web builders, or exposed feeders (Gillott 1995). *Acrolepiopsis* species mine into the leaves of *Allium* spp., which severely weakens the plant (CABI 2007).			
Acrolepiopsis assectella (Zeller)	Algeria, Asia, Canada, Europe, Hawai'i	*Allium* spp.	(CABI 2007, CABI/EPPO 2007, Jenner et al. 2010)
Acrolepiopsis sapporensis (Matsumura)	East Asia, Hawai'i	*Allium* spp.	(Landry 2007)
Thysanoptera: Phlaeothripidae Thrips damage plants by direct feeding and by vectoring plant viruses. Thrips are extremely difficult to detect in consignments, particularly in bulky shipments (Lewis 1997). Many of the thrips associated with grasses (Poaceae) are readily transported in straw as well as with grass seeds (Mound and Teulon 1995). The habit of crawling into confined spaces makes some species enter packaged goods (Palmer et al. 1989).			
Holopothrips tabebuia Cabrera & Segarra	Caribbean, United States	*Amphitecna latifolia*, *Schefflera actinophylla*, *Tabebuia* spp.	(Gilman and Watson 1994, Cabrera and Segarra 2008, Michel et al. 2008)
Chaetanaphothrips signipennis (Bagnall)	Africa, Australia, Brazil, Fiji, Hawai'i, Honduras, India, Indonesia, New Guinea, Panama, Philippines, Sri	*Anthurium palmatum*, *Alocasia* spp., *Citrus* spp., *Cordyline terminalis*, *Dracaena* spp.,	(Lewis 1973, CAB 1981, Denmark and Osborne 1985, Hara et al. 2002, Hussain and Annamalai 2006)

	Lanka, United States	*Maranta leuconeura*, *Musa* spp., *Phaseolus vulgaris*, *Solanum lycopersicum*, *Strelitzia reginae*	
Frankliniella cephalica (Crawford)	Caribbean, Central America, Japan, Mexico, United States	*Amaranthus spinosus*, *Ambrosia artemisifolia*, *Bidens* spp., *Citrus* spp., *Commelina diffusa*, *Euphorbia* spp., *Heterotheca subaxillaris*, *Ipomoea* spp., *Lantana camara*, *Mangifera indica*, *Morrenia odorata*, *Taraxacum officinale*, *Youngia japonica*	(Jeppson 1989, Lamberts and Crane 1990, Nakahara 1997, Masumoto and Okajima 2004, Childers and Nakahara 2006, Ohnishi et al. 2006)
Frankliniella intonsa (Trybom)	Canada, Europe, Israel, New Zealand, South and East Asia, Turkey, United States	Solanaceae	(Nakahara 1997, CABI/EPPO 1999a, Nakahara and Foottit 2007)
Frankliniella occidentalis (Pergande)	Australia, Canada, Caribbean, Central and South America, Europe, Hawai'i, Japan, Korea, Malaysia, Middle East, Mexico,	Cucurbitaceae, *Allium cepa*, *Citrus* spp., *Daucus carota*, *Fragaria* spp., *Gossypium* spp., *Phaseolus* spp., *Solanum lycopersicum*	(CABI/EPPO 1997e, 1999b, CABI 2007, Funderburk et al. 2009)

	New Zealand, Sri Lanka, Southern Africa, United States		
Scirtothrips dorsalis Hood	Australia, Hawai'i, New Guinea, Solomon Islands, South Africa, South and East Asia, United States	Fabaceae, *Allium cepa*, *Actinidia chinensis*, *Camellia sinensis*, *Capsicum* spp., *Citrus* spp., *Fragaria* spp., *Gossypium hirsutum*, *Hevea brasiliensis*, *Hydrangea* spp., *Mangifera* spp., *Nelumbo* spp., *Ricinus* spp., *Rosa* spp.	(CABI/EPPO 1997i, Silagyi and Dixon 2006, Funderburk et al. 2009)
MOLLUSKS Snails and slugs can cause considerable damage to agriculture and horticulture (Godan 1983) by causing direct feeding damage, and by vectoring or indirectly facilitating the entry of plant pathogens. They can also vector pathogens to humans. Mollusks are often intercepted on WPM. They are also likely to be introduced on agricultural and horticultural commodities, containers and conveyances, vehicles and equipment, items that were stored outdoors, and in potting media (Cowie 2001).			
Achatina fulica	FSM (except Chuuk and Yap), RMI, Palau, Guam, CNMI, American Samoa, French Polynesia, Hawai'i, New Caladonia, Papua New Guinea, Samoa, Vanuatu and Wallis and Fortuna	A wide variety fruit and vegetable crops	(SPC 1999)

Allopeas clavulinum (Potiez and Michaud) [Subulinidae]	American Samoa, East Africa, Fiji, Hawai'i, Japan, United States	Polyphagous	(Auffenberg and Stange 1988, SPREP 2000, Cowie et al. 2008)
Allopeas micra (d'Orbigny) [Subulinidae]	American Samoa, Europe, Galápagos Islands, Hawai'i, United States	Polyphagous	(Auffenberg and Stange 1988; SPREP 2000; Delivering Alien Invasive Species Inventories for Europe 2009)
Arion ater (L.) [Arionidae]	Canada, Europe, United States	Polyphagous	(Godan 1983)
Arion hortensis Férussac [Arionidae]	Australia, Europe, Russia	Polyphagous	(Godan 1983)
Arion intermedius Normand [Arionidae]	Australia, Azores, Canada, Chile, Europe, Hawai'i, New Zealand, North Africa, South Africa, United States	*Coleus* spp., *Datura* spp., *Iris* spp., *Solanum tuberosum*, *Tulipa* spp.	(Godan 1983, Cowie 2001, Glen and Moens 2002, Quinteiro et al. 2005, Cádiz and Gallardo 2007, Mc Donnell et al. 2009)
Arion lusitanicus (Mabille) [Arionidae]	Southern Europe	*Beta vulgaris*, *Brassica* spp., *Fragaria ananassa*, *Lactuca sativa*	(Grimm and Paill 2001, Kozłowski 2005, Weidema 2006, Kozłowski 2007)
Arion rufus (L.) [Arionidae]	Canada, Europe, United States	Polyphagous	(Godan 1983)
Beckianum beckianum (Pfeiffer) [Subulinidae]	Caribbean, Central and South America, Hawai'i, United States	Polyphagous	(SPREP 2000, DPI 2003, Cowie et al. 2008)
Bradybaena fruticum (Mabille) [Bradybaenidae]	Europe	Polyphagous	(Godan 1983, Staikou et al. 1990)
Candidula	Australia,	Polyphagous	(Godan 1983, Baker 1986a)

intersecta (Poiret) [Hygromiidae]	Europe, Mediterranean		
Cathaica fasciola (Draparnaud) [Bradybaenidae]	China	Polyphagous	(Barker 2002)
Cepaea hortensis (Müller) [Helicidae]	Europe, United States	Polyphagous	(Godan 1983, Kozlowski et al. 2006)
Cepaea nemoralis (L.) [Helicidae]	Canada, Europe, United States	Polyphagous	(Godan 1983, Delivering Alien Invasive Species Inventories for Europe 2009)
Cernuella cisalpina (Rossmässler) [Hygromiidae]	Europe, Mediterranean, United States	Polyphagous	(Mack 2003, Delivering Alien Invasive Species Inventories for Europe 2009)
Cernuella (Xerocincta) neglecta (Draparnaud) [Hygromiidae]	Australia, Europe, Mediterranean	Polyphagous	(Godan 1983, Baker 1986a)
Cernuella virgata (Da Costa) [Hygromiidae]	Australia, Europe, Israel, Mediterranean, Turkey	Polyphagous	(Pomeroy 1967, Godan 1983, Baker 1986a, AFPMB 2008, Roll et al. 2009)
Cochlicella acuta (Müller) [Cochlicelidae]	Australia, Bermuda, Europe, Mediterranean, United States	Grains	(Godan 1983, Baker 1986a)
Cochlicella barbara (L.) [Cochlicelidae]	Australia, Bermuda, Europe, Japan, Mediterranean, South Africa	Polyphagous	(Godan 1983, Baker 1986a, AFPMB 2008)
Cochlicella conoidea (Draparnaud) [Cochlicelidae]	France, Italy, Morocco, Portugal, Spain	Polyphagous	(Godan 1983, AFPMB 2008)

Cochlicella ventrosa (Férussac) [Cochlicelidae]	Australia	Polyphagous	(Pomeroy 1967, Godan 1983)
Cryptomphalus aspersus (Müller) [Helicidae]	Australia, Central and South America, Hawai'i, Mediterranean, United States, Western Europe	Polyphagous	(Godan 1983, Smith 1989, Cowie 2001, Cowie et al. 2008)
Cryptozona belangiri (Deshayes) [Ariophantidae]	India	Polyphagous	(Godan 1983, Srivastava 1992)
Cryptozona bistrialis (Beck) [Ariophantidae]	India	Polyphagous	(Godan 1983, Raut and Ghose 1984, Srivastava 1992)
Cryptozona semirugata (Beck) [Ariophantidae]	India	Polyphagous	(Godan 1983, Srivastava 1992)
Deroceras caruanae (Pollonera) [Agriolimacidae]	Australia, Europe, North and South America, South Africa	Polyphagous	(Godan 1983, Smith 1989)
Deroceras laeve (Müller) [Agriolimacidae]	Africa, Europe, Fiji, Hawai'i, New Caledonia, United States	Polyphagous	(Godan 1983, Smith 1989, Cowie 1997, Cowie 2001)
Deroceras reticulatum (Müller) [Agriolimacidae]	Australia, Central and South America, Europe, Hawai'i, United States	Polyphagous	(Godan 1983, Smith 1989, Cowie 2001)
Eobania vermiculata (Müller) [Helicidae]	Europe, Mediterranean, South Africa, United States	Polyphagous	(Godan 1983, Delivering Alien Invasive Species Inventories for Europe 2009)

Helicella itala (L.) [Hygromiidae]	Europe	Polyphagous	(Godan 1983, Nordsieck 2009)
Helicella neglecta (Draparnaud) [Hygromiidae]	Australia	Polyphagous	(Pomeroy 1967, Godan 1983)
Helix aperta (Born) [Helicidae]	Australia, Europe, United States	Polyphagous	(Godan 1983, Smith 1989)
Helix cincta (Müller) [Helicidae]	Greece, Israel, Italy, Romania, Turkey	Polyphagous	(Delivering Alien Invasive Species Inventories for Europe 2009, Roll et al. 2009)
Helix lucorum (L.) [Helicidae]	France, Greece, Italy, Turkey, Ukraine	Polyphagous	(Godan 1983, Delivering Alien Invasive Species Inventories for Europe 2009)
Hygromia cinctella (Draparnaud) [Hygromiidae]	Europe, Mediterranean	Polyphagous	(Godan 1983, Delivering Alien Invasive Species Inventories for Europe 2009)
Lehmannia marginata (Müller) [Limacidae]	Europe, Japan	Polyphagous	(Godan 1983, Tanaka et al. 2001)
Lehmannia valentiana (Férussac) [Limacidae]	Australia, Central and South America, Europe, Hawai'i, Israel, Japan, United States	Polyphagous	(Godan 1983, Cowie 2001)
Limacus flavus (L.) [Limacidae]	Cook Islands, Europe, Hawai'i, United States, Vanuatu	Polyphagous	(Godan 1983, Cowie 2001)
Limax cinereoniger (Wolf) [Limacidae]	Australia, Europe	Polyphagous	(Godan 1983, Shoaib and Cagan 2004)
Limax maximus (L.) [Limacidae]	Australia, Africa, Europe, Hawai'i, United States	Fruit crops	(Godan 1983, Cowie 1997)
Limax tenellus	Europe, Hawai'i,	Polyphagous	(Godan 1983, Cowie 2001, Suominen et al. 2003)

(Müller) [Limacidae]	United States		
Microxeromagna armillata (Lowe) [Hygromiidae]	Australia, Europe, Israel, Mediterranean, Turkey	Polyphagous	(Zhao et al. 2004, Delivering Alien Invasive Species Inventories for Europe 2009)
Monacha cantiana (Montagu) [Hygromiidae]	Europe	Polyphagous	(Godan 1983, Schultes 2009)
Monacha cartusiana (Müller) [Hygromiidae]	France, Greece, Israel, Italy, Spain	Polyphagous	(Godan 1983, AFPMB 2008)
Monacha syriaca (Ehrenberg) [Hygromiidae]	Greece, Italy, Turkey	Polyphagous	(Godan 1983, AFPMB 2008)
Opeas mauritianum (Pfeiffer) [Subulinidae]	Hawai'i, Mauritius, United States	Polyphagous	(Tryon et al. 1906, Godan 1983, SPREP 2000)
Opeas pumilum (Pfeiffer) [Subulinidae]	South America, United States	Polyphagous	(Godan 1983, Auffenberg and Stange 1988)
Otala lactea (Müller) [Helicidae]	Europe, United States	Polyphagous	(Godan 1983, Mienis 1999)
Otala punctata (Müller) [Helicidae]	Europe, United States	Polyphagous	(Godan 1983, Mienis 1999)
Oxychilus alliarius (Miller) [Oxychilidae]	Europe, Hawai'i, United States	Polyphagous	(Godan 1983, Cowie 1997, Cowie 2001)
Oxychilus cellarius Müller [Oxychilidae]	Canada, Europe, Hawai'i, South Africa, United States	Polyphagous	(Godan 1983, Cowie 1997, Giusti and Manganelli 1997)
Oxychilus draparnaudi (Beck)	Europe, Africa, United States	Greenhouse crops	(Godan 1983, Giusti and Manganelli 1997)

[Oxychilidae]			
Parmarion martensi Simroth [Ariophantidae]	American Samoa, Cambodia, Hawai'i, Indonesia, Japan, Malaysia, Singapore, Taiwan, Vietnam	Polyphagous	(Liao and Wang 1999, Cowie 2001, Hollingsworth et al. 2007)
Rumina decollata (L.) [Subulinidae]	Europe, Mexico, United States	Polyphagous	(Godan 1983, Delivering Alien Invasive Species Inventories for Europe 2009)
Succinea tenella Morelet [Succineidae]	Asia, Europe, Hawai'i, United States	Polyphagous	(Hayes et al. 2007, Cowie et al. 2008)
Theba pisana (Müller) [Helicidae]	Australia, Bermuda, Canary Islands, Europe, Mediterranean, South Africa, United States	Vegetables and *Citrus* spp.	(Godan 1983, Baker 1986a, Cowie et al. 2009)
Trochoidea elegans (Gmelin) [Hygromiidae]	Europe, Mediterranean	Polyphagous	(Godan 1983, Delivering Alien Invasive Species Inventories for Europe 2009)
Trochoidea pyramidata (Draparnaud) [Hygromiidae]	Europe	Polyphagous	(Godan 1983, Delivering Alien Invasive Species Inventories for Europe 2009)
Xerolenta obvia (Menke) [Hygromiidae]	Europe, Turkey	Polyphagous	(Shoaib and Cagan 2004, Nordsieck 2009)
Xeropicta derbentina (Krynicki) [Hygromiidae]	Greece, Italy, Turkey	Polyphagous	(AFPMB 2008)
Xerotricha conspurcata (Draparnaud) [Hygromiidae]	Europe, Mediterranean, United States	Polyphagous	(Delivering Alien Invasive Species Inventories for Europe 2009)

Zonitoides arboreus (Say) [Gastrodontidae]	Canada, Caribbean, China, Hawai'i, Israel, Mexico, Philippines, South America, United States	Orchidaceae	(Godan 1983, Cowie 1997, Roll et al. 2009)
Zonitoides nitidus (Müller) [Gastrodontidae]	Asia, Europe, North America	Orchidaceae	(Godan 1983, Porcelli and Parenzan 1988)

NEMATODES

Nematodes are estimated to cause agricultural losses that exceed 100 billion dollars annually worldwide (Veech and Dickson 1987, Koenning et al. 1999). Soilborne plant parasitic nematodes feed on plant roots causing yellowing, stunting, root deformation, resulting in reduced crop yields and plant death (Perry and Moens 2006). Some nematodes damage above ground plant parts. *Bursaphelenchus cocophilus* infects coconut (*Cocos nucifera*) roots, stems, and leaves, causing red ring disease which can result in crop losses as high as 80 to 98% (Dean 1979). The most likely pathways of introduction for nematodes include plant roots and tubers, growing media, WPM, and articles contaminated with soil (Chen et al. 2004, Perry and Moens 2006). The baggage and footwear of international travelers have also been shown to be pathways for introduction of pest nematodes (Hockland et al. 2008).

Bursaphelenchus aberrans Fang et al.	China, Thailand	Unknown – described from WPM	(Tomiczek et al. 2003, Gu et al. 2006)
Bursaphelenchus arthuri Burgermeister, Gu and Braasch	Korea, Taiwan	Unknown – described from WPM	(Gu et al. 2006)
Bursaphelenchus chengi Li et al.	Taiwan	Unknown – described from WPM	(Li et al. 2008)
Bursaphelenchus cocophilus (Cobb) Baujard	Caribbean, Central and South America, Mexico	Arecaceae, *Attalea cohune*, *Cocos nucifera*, *Elaeis guineensis*, *Phoenix* spp., *Roystonea regia*	(Brammer and Crow 2001, Griffith et al. 2005, GDOA 2005)
Bursaphelenchus macromucronatus Gu, Zheng, Braasch	India, Taiwan	Unknown – described from WPM	(Gu et al. 2008b)

& Burgermeister			
Bursaphelenchus obeche Braasch, Zhen, Burgermeister & Lin	Unknown	Unknown – described from WPM	(Gu et al. 2008a)
Bursaphelenchus sinensis Palmisano, Ambrogioni, Tomiczek & Brandstetter	China	Unknown – described from WPM	(Palmisano et al. 2004)
Bursaphelenchus singaporensis Gu, Zhang, Braasch & Burgermeister	East Asia	Unknown – described from wWPM	(Gu et al. 2006)
Meloidogyne mayaguensis Rammah & Hirschmann	Brazil, Caribbean, United States, West and South Africa	*Apium graveolens*, *Beta vulgaris*, *Bidens pilosa*, *Brassica oleracea*, *Capsicum annuum*, *Citrullus lanatus*, *Cucurbita* spp., *Nicotiana tabacum*, *Petroselynum crispum*, *Psidium guajava*, *Solanum* spp.	(SON 2003a, De Waele and Elsen 2008, Randig et al. 2009)
Pratylenchus coffeae (Zimmermann) Filipjev & Schuurmans Stekhoven	Africa, Australia, Caribbean, Central and South America, Fiji, Hawai'i, Kiribati, New Guinea, Niue, Mexico, Palau, Samoa, Solomon	*Citrus* spp., *Colocasia esculenta*, *Dioscorea* spp., *Ipomoea batatas*, *Manihot esculenta*, *Momordica charantia*, *Musa*	(Bridge 1988, Campos et al. 1990, Inserra et al. 1990, CABI/EPPO 2000, Kavitha et al. 2008)

	Islands, Southern Europe, Southeast Asia, Tonga, United States, Vanuatu	spp., *Theobroma cacao*, *Zingiber officinale*	
Zygotylenchus guevarai (Tobar Jiménez) Braun & Loof	Europe, Pakistan, South Africa, Tunisia, United States Uzbekistan	*Apium graveolens*, *Capsicum annuum*, *Cucumis melo*, *Daucus carota*, *Gossypium hirsutum*, *Lactuca scariola*, *Phaseolus vulgaris*, *Pisum sativum*, *Solanum* spp., *Vicia* spp., *Zea mays*	(SON 2003b, Stinner et al. 2010)
FUNGI and STRAMENOPILES More than 10,000 species of fungi and stramenopiles (fungal-like organisms) cause plant diseases (Agrios 2005), often resulting in lesions, cankers, stunting, necrosis, rots, deformation, dieback, reduced yields, and plant death. Some fungi also produce mycotoxins, which make plants toxic to people and animals (Agrios 2005). Fungi can be moved to new areas on infected plant materials, and with contaminating soil (McCullough et al. 2006).			
Armillaria fuscipes Petch	Africa, India	*Acacia* spp., *Cordia* spp.	(USDA-APHIS and USDA-FS 2000, Farr and Rossman 2010)
Armillaria gallica Marxm. & Romagn.	Europe, Japan, South Africa, United States	*Diospyros* spp.,*Galeola* spp., *Prunus* spp.,*Umbellularia* spp.	(USDA-APHIS and USDA-FS 2000, Farr and Rossman 2010)
Armillaria sinapina Bérubé & Dessur.	Canada, Hawai'i, Japan, United States	*Acacia* spp.,*Corynocarpus* spp.	(USDA-APHIS and USDA-FS 2000, Farr and Rossman 2010)
Armillaria tabescens (Scop.) Emel	Europe, Fiji, India, Japan, United States	*Acacia* spp., *Aleurites* spp., *Casuarina* spp.,	(USDA-APHIS and USDA-FS 2000, Ramsden et al. 2002, Farr and Rossman 2010)

		Citrus spp., *Cycas* spp., *Ixora* spp., *Musa* spp., *Persea* spp.	
***Apiospora montagnei* Sacc. [Anamorph:** *Arthrinium arundinis* (Corda) Dyko & B. Sutton]	Central America, China, New Guinea, Philippines, United States	Poaceae, *Bambusa* spp., *Elaeis* spp.	(Khan 1961, Farr and Rossman 2010)
Ceratocystis albifundus M.J. Wingf., De Beer & M.J. Morris	South Africa, Tanzania, Uganda	*Acacia* spp., *Protea* spp., ***Terminalia*** spp.	(Farr and Rossman 2010)
Ceratocystis fimbriata Ellis & Halst	Asia, Africa, Central and South America, United States	*Acacia* spp., *Citrus* spp., *Cocos* spp., *Hevea* spp., *Mangifera* spp.	(CMI 1983, Wingfield et al. 1993)
Ceratocystis moniliformis (Hedgc.) C. Moreau	Australia, Canada, Chile, China, Japan, Philippines, South Africa, United States	*Calamus* spp., *Erythrina* spp., *Hevea* spp.	(Wingfield et al. 1993, Farr and Rossman 2010)
Colletotrichum lindemuthianum (Sacc. & Magn.) Scribn. (= *Gloeosporium lindemuthianum* Sacc. & Magnus)	Africa, Asia, Australia, Canada, Caribbean, Central and South America, Europe, Mexico, New Zealand, United States	*Allium cepa*, *Cucumis melo*, *Glycine* spp., *Oryza sativa*, *Phaseolus* spp., *Philodendron bipinnatifidum*, *Vigna* spp.	(Vasey and Galloway 1889, Bancroft 1910, Lloyd 1918, Mordue 1971, Farr and Rossman 2010)
Daedaleopsis flavida (Lev.) Roy and Mitra	India	*Bambusa* spp., *Cocos* spp., *Diospyros* spp., *Mangifera* spp., and other	(De 1994)

		hardwoods	
Ganoderma applanatum (Pers.) Pat.	Africa, Australia, Chile, Europe, Japan, United States	*Acacia* spp., *Casuarina* spp., *Citrus* spp., *Cocos* spp., *Diospyros* spp., *Persea* spp., *Tamarindus* spp.	(USDA-FS 1993, Schwarze and Ferner 2003, Farr and Rossman 2010)
Ganoderma boninense Pat.	Japan	*Cocos* spp., *Elaeis* spp., *Livistona* spp.	(Sinclair and Lyon 2005, Farr and Rossman 2010)
Ganoderma resinaceum Boud.	Canada, Europe, Pakistan, Russia, West Indies	*Dalbergia* spp., *Mangifera* spp.	(Schwarze and Ferner 2003, Farr and Rossman 2010)
Ganoderma zonatum Murrill.	Caribbean, Congo, Tanzania, United States	*Acacia* spp., *Citrus* spp., *Cocos* spp., *Grevillea* spp., *Persea* spp., *Phoenix* spp., *Saba* spp.	(Sinclair and Lyon 2005, Farr and Rossman 2010)
Gibberella subglutinans (E. Edwards) P.E. Nelson, Toussoun & Marasas] [Anamorph: *Fusarium subglutinans* (Wollenw. & Reinking) P.E. Nelson, Toussoun & Marasas]	China, India, Mexico, Philippines, South Africa, South America, United States	*Acacia* spp., *Ananas* spp., *Cocos* spp., *Dracaena* spp., *Musa* spp.	(Farr and Rossman 2010)
Heterobasidion annosum (Fr. : Fr.) Bref [Anamorph: *Spiniger meineckellus* (A. Olson) Stalpers]	Africa, Europe, Fiji, Japan, Pakistan, United States	*Chamaecyparis* spp., *Citrus* spp., *Diospyros* spp.	(Ramsden et al. 2002, Kohl 2007, Farr and Rossman 2010)

Inonotus hispidus (Bull.: Fr.) P. Karst.	China, Europe, Japan, Mexico, United States	*Albizia* spp., *Citrus* spp., *Rosa* spp., *Sophora* spp.	(Sinclair and Lyon 2005, Farr and Rossman 2010)
Inonotus rheades (Pers.) Bondartsev & Singer.	Australia, Brazil, China, New Zealand, United States	*Acacia* spp.	(USDA-FS FPL 2003, Farr and Rossman 2010)
Lasiodiplodia crassispora Burgess & Barber	Australia, South Africa, Venezuela	*Santalum* spp., *Syzygium* spp., and other hardwoods	(Burgess et al. 2006, Farr and Rossman 2010)
***Nectria cinnabarina* (Tode: Fr.) Fr. [Anamorph:** *Tubercularia vulgaris* Tode : Fr.]	China, Europe, Japan, Russia, United States	*Acacia* spp., *Citrus* spp., *Sambucus* spp., *Sophora* spp.	(Farr and Rossman 2010)
Neonectria coccinea (Pers.: Fr.) Rossman & Samuels [Anamorph: *Cylindrocarpon candidum* (Link) Wollenw.]	Malaysia, Japan, Europe, South Africa, United States	*Acacia* spp., *Cocos* spp., *Sambucus* spp.	(Spaulding 1961, Farr and Rossman 2010)
Neonectria ditissima (Tul. & C. Tul.) Samuels & Rossman [Anamorph: *Cylindrocarpon heteronemum* (Berk. & Broome) Wollenw.]	Brazil, Canada, Japan, Mexico, New Zealand, South Africa, South America, United States	*Acacia* spp., *Citrus* spp., *Persea* spp., *Swietenia* spp.	(Spaulding 1961, Farr and Rossman 2010)
Oidium caricae Noack	Africa, Australia, Bermuda, Central and South America, China,	*Carica* spp.	(Ploetz et al. 1994, Farr and Rossman 2010)

	Cuba, Europe, Hawai'i, India, Mexico, New Caledonia, Taiwan, United States		
Ophiostoma quercus (Georgev.) Nannf. [Anamorph: *Pesotum roboris* (Georgescu, Teodoru & Badea) Grobbelaar, Z.W. de Beer & M.J. Wingf.]	China, Europe, Japan, Russia, South Africa, United States	*Acacia* spp.	(Farr and Rossman 2010)
Ophiostoma stenoceras (Robak) Melin & Nannf.	Europe, Indonesia, New Zealand, South Africa, South America, United States	*Acacia* spp.	(Farr and Rossman 2010)
Perenniporia medulla-panis (Jacq.) Donk	Chile, Japan, New Zealand, United States	*Acacia* spp.	(Sinclair and Lyon 2005, Farr and Rossman 2010)
***Pestalotiopsis versicolor* (Speg.) Steyaert**	Africa, China, Mexico, South America, Virgin Islands	*Achras* spp., *Ananas* spp., *Artocarpus* spp., *Coccoloba* spp., *Cocos* spp., *Elaeis* spp., *Pandanus* spp., *Persea* spp.	(Sinclair and Lyon 2005, Farr and Rossman 2010)
Phellinus conchatus (Pers. Fr.) Quél.	Canada, China, Japan, New Zealand, South Africa, United States	*Acacia* spp., *Casuarina* spp.	(USDA-APHIS and USDA-FS 2000, Farr and Rossman 2010)
Phellinus lamaensis (Murrill) R. Heim	China, New Zealand, New	*Agathis* spp., *Araucaria* spp.,	(USDA-APHIS and USDA-FS 2000, Farr and Rossman 2010)

	Caledonia, Palau, New Guinea	*Hevea* spp.	
Phellinus linteus (Berk. & M.A. Curtis) S. Teng.	China, Japan, Pakistan, United States, West Indies	*Cinnamomum* spp., *Cordia* spp., *Diospyros* spp.	(USDA-APHIS and USDA-FS 2000, Farr and Rossman 2010)
Phellinus pachyphloeus (Pat.) Pat.	Africa, Australia, New Zealand, Philippines, Southern Asia	*Metrosideros* spp., *Podocarpus* spp.	(USDA-APHIS and USDA-FS 2000, Farr and Rossman 2010)
Phellinus rimosus (Berk.) Pilát	Australia, China, India, Japan, Mexico, Puerto Rico, South Africa	*Acacia* spp., *Casuarina* spp., *Vatica* spp.	(USDA-APHIS and USDA-FS 2000, Farr and Rossman 2010)
Phytophthora heveae Thompson	Australia, Brazil, China, Côte d'Ivoire, Guatemala, India, Malaysia, Philippines, Taiwan, United States	*Areca catechu*, *Bertholletia excelsa*, *Caesalpinia pulcherrina*, *Cocos nucifera*, *Hevea* spp., *Mangifera indica*, *Persea americana*, *Psidium guajava*, *Theobroma cacao*	(Stamps 1978, Chang and Shu 1988, Zhang et al. 1995, Zeng et al. 2009, Farr and Rossman 2010)
Phytophthora megakarya Brasier & Griffin	Africa	*Irvingia* spp., *Theobroma cacao*	(Stamps 1984, Guest 2007, Paulin et al. 2008, Farr and Rossman 2010)
Seiridium cardinale (W. Wagener) B. Sutton & I. Gibson	Europe, New Zealand, South Africa, South America, United States	*Chamaecyparis* spp., *Protea* spp.	(Sinclair and Lyon 2005, Farr and Rossman 2010)
Seiridium unicorne (Cooke & Ellis) B. Sutton [Teleomorph:	Africa, India, Japan, United States	*Chamaecyparis* spp., *Ixora* spp.	(Sinclair and Lyon 2005, Farr and Rossman 2010)

Lepteutypa cupressi (Nattrass, C. Booth & B. Sutton) H.J. Swart]			
BACTERIA and PHYTOPLASMAS Bacteria and phytoplasmas are microscopic organisms that may infect plants, causing leaf spots, blights, cankers, soft rots, reduced crop yield, and plant death (Agrios 2005). Bacterial plant diseases are often severe in tropical climates. As infected plants may be asymptomatic for a long time, it is often impossible to detect the presence of bacteria or phytoplasmas by visual inspection. Bacteria and phytoplasmas are most likely to be spread to new areas on infected plant material and in soil contaminations.			
Acidovorax avenae subsp. *citrulli* (Schaad et al.) Willems et al.	Australia, Indonesia, United States	*Citrullus lanatus*, *Cucumis melo*	(Saddler 1994, Hopkins et al. 2000)
Erwinia papayae Gardan et al.	Caribbean, Malaysia	*Carica papaya*	(Gardan et al. 2004, Maktar et al. 2008)
Ralstonia solanacearum race 1 (Smith) Yabuuchi et al.	Africa, Australia, Europe, Canada, Caribbean, Central and South America, FSM, Guam, Hawai'i, Mexico, New Zealand, Southeast Asia, United States	*Nicotiana* spp., *Solanum* spp.	(CABI/EPPO 1997h, Cerkauskas 2004, Elphinstone 2005, Hacisalihoglu et al. 2007, Vanitha et al. 2009)
Ralstonia solanacearum race 2, biovar 1 (Smith) Yabuuchi et al.	Africa, Asia, Caribbean, Central America, Guam, Mexico, South America, United States	*Heliconia* spp., *Musa* spp.	(CABI/EPPO 1997h, Eyres et al. 2005)
Xanthomonas campestris (Pammel)	Africa, Asia, Canada, Caribbean, Central and South America Europe, Hawai'i,	*Persea americana*	(Hayward and Waterston 1965, CAB 1978, Pegg et al. 2002)

	Mexico, United States		
Xanthomonas campestris pv. *celebensis* (Gäumann)	India, Indonesia	*Heliconia* spp., *Musa* spp.	(Bradbury 1986, Eden-Green 1994, Supriadi 2003, Mackie et al. 2007)
Xanthomonas campestris pv. *mangiferaeindicae* (Patel et al.)	Australia, Brazil, India, Japan, Kenya, New Caledonia, Pakistan, Réunion, South Africa, Southeast Asia, Sudan Taiwan, United Arab Emirates	*Anacardium occidentale*, *Mangifera indica*, *Schinus terebinthifolius*, *Spondias dulcis*	(Bradbury 1986, Gagnevin and Pruvost 2001)
Xanthomonas campestris pv. *manihotis* (Berthet & Bondar)	Africa, Cuba, India, Panama, Southeast Asia, South America	*Manihot esculenta*	(Bradbury 1986, Lozano 1986)
'*Candidatus* Liberibacter asiaticus'	China, Indonesia, Belize, Cuba, Iran, Solomon Islands, South America, United States	*Citrus* spp.	(Da Graca 1991, Gottwald et al. 2007)
Palm lethal yellowing (proposed name: '*Candidatus* Phytoplasma palmae')	Belize, Benin, Cameroon, Caribbean, Ghana, Guyana, Honduras, Mexico, Nigeria, Togo, United States	Arecaceae	(CABI/EPPO 1997g, Harrison and Elliott 2009)
Sweet potato little leaf	Australia, Japan, New Caledonia, Korea, New Guinea, Niue,	*Cucurbita maxima*, *Ipomoea batatas*, *Solanum lycopersicum*,	(Jackson et al. 1984, Saqib et al. 2006)

	Palau, Solomon Island, Taiwan, Tonga, Vanuatu	*Vigna unguiculata*	

VIRUSES and VIROIDS

Viral diseases of plants are second only to fungal infections in terms of economic significance worldwide (Hadidi et al. 1998). Viruses and viroids are often vectored by insects such as aphids, whiteflies, and thrips, but can also be vectored by nematodes and fungi. Virus and viroid infections in plants lead to discoloration, deformation, stunting, reduced vigor, crop losses, and plant death (Hull 2002). If plants become infected with a virus or viroid, the destruction of infected plants is often the only way to control the outbreak (Agrios 2005). The most likely pathway of introduction is infested plant material or the introduction of vector organisms.

Avocado sunblotch viroid (ASBV)	Australia, Argentina, Ghana, Israel, Mexico, Peru, South Africa, Spain, United States, Venezuela	*Persea americana*	(Dale et al. 1982, Ploetz et al. 1994, Darvas et al. 1996, Flores et al. 2000, Pegg et al. 2002, Acheampong et al. 2008, De La Torre et al. 2009)
Banana bract mosaic virus (BBrMV)	Central and South America, India, Philippines, Samoa, Sri Lanka, Vietnam	*Musa* spp.	(Magnaye and Valmayor 1995, Brunt et al. 1996, Thomas and Magnaye 1996, Rodoni et al. 1997)
Banana bunchy top virus (BBTV)	Guam, Hawai'I, southeast Asia, Philippines, Taiwan, numerous islands in the south Pacific, India, and Africa	*Musa* spp.	(Ferreira et al. 1997; Per. Comm. Englberger)
Bean pod mottle virus (BPMV)	Canada, United States	*Desmodium paniculatum*, *Glycine max*, *Phaseolus vulgaris*	(Brunt et al. 1996, Glesler et al. 2002, Zhang et al. 2009)
Cadang-cadang viroid (CCCVd)	Philippines, Solomon Islands	*Cocos nucifera*, *Corypha elata*, *Elaeis guineensis*	(CABI/EPPO 1997c, Randles 2003, Agrios 2005)

Cassava green mottle virus (CGMV)	Solomon Islands	*Manihot esculenta*	(Lennon et al. 1987, Frison and Feliu 1991, Brunt et al. 1996)
Cocoa swollen shoot virus (CSSV)	Côte d'Ivoire, Ghana, Nigeria, Sierra Leone, Sri Lanka, Togo	*Adansonia digitata*, *Ceiba pentandra*, *Cola chlamydantha*, *Cola gigantea*, *Sterculia tragacantha*, *Theobroma cacao*	(Brunt 1970, Brunt et al. 1996, ICTVdB Management 2006)
Colocasia bobone disease virus (CBDV)	New Guinea, Solomon Islands	*Colocasia esculenta*	(Jackson 1978, Zettler et al. 1989, Onwueme 1999, Yang et al. 2003)
Papaya droopy necrosis virus (PDNV)	United States	*Carica papaya*	(Ploetz et al. 1994, Aires Ventura et al. 2004)
Papaya mosaic virus (PapMV)	South America, United States, and India	*Carica papaya*	(Pers. Comm. Englberger)
Papaya yellow crinkle virus (PYCV)	Australia	*Carica payaya*	(Gibb et al. 1996)
Pepino mosaic virus (PepMV)	Canada, Chile, Europe, Peru, United States	*Solanum muricatum*, *Solanum lycopersicum*	(Fakhro et al. 2005, EPPO 2006b, Córdoba-Sellés et al. 2007)
Pepper mild mottle virus (PMMoV)	Argentina, Australia, Europe, Japan, United States	*Capsicum* spp.	(Brunt et al. 1996, Lamb et al. 2001, Zhang et al. 2006a)
Pepper yellow leaf curl virus (PepYLCIV)	Indonesia	*Ageratum conyzoides*, *Capsicum* spp., *Glycine max*, *Helianthus annuus*, *Nicotiana* spp., *Solanum*	(De Barro et al. 2008, Hidayat et al. 2009)

		spp., *Vigna* spp.	
Tomato spotted wilt virus (TSWV)	Africa, Asia, Australia, Canada, Central and Sounth America, Europe, Mexico, New Zealand, United States	*Ananas comosus*, *Arachis hypogaea*, *Bidens pilosa*, *Capsicum annuum*, *Datura stramonium*, *Helianthus annuus*, *Lactuca sativa*, *Phaseolus vulgaris*, *Solanum* spp., *Zinnia elegans*	(Zitter et al. 1989, Brunt et al. 1996)
Tomato yellow leaf curl virus (TYLCV)	Africa, Caribbean, Hawai'i, Middle East, United States	*Capsicum annuum*, *Solanum lycopersicum*, *Solanum melongena*	(Navot et al. 1991, Moriones and Navas-Castillo 2000, Melzer et al. 2010)

WEEDS

Agricultural losses due to weeds surpass those caused by any other class of agricultural pest (Pimentel et al. 2001). Weeds may also have enormous ecological impacts by reducing biodiversity, altering fire regimes and hydrological cycles, changing soil chemistry and biology, and promoting siltation or erosion of stream banks and sand dunes. Weeds may also affect human and animal health when they are toxic or cause allergies. Intentional importation of plants for horticultural purposes has been identified as the most important facilitator in the spread of weeds (invasive plants) (Dehnen-Schmutz et al. 2007).

Antigonon leptopus	American Samoa, Fiji, French Polynesia, Guam, Kiribati, RMI, Nauru, CNMI, Palau, Samoa, United States		http://www.issg.org/database/species/distribution.asp?si=203&fr=1&sts=&lang=EN
Bryophyllum daigremontianum (Raym.-Hamet & Perrier) (Crassulaceae)	Australia, Bangladesh, Fiji, Galápagos Islands, Madagascar, New Caledonia, New Zealand,		(McKenzie and Armstrong 1986, Hannan-Jones et al. 2005, Foxcroft et al. 2008, Nahar et al. 2008, USDA NRCS 2009, PIER 2010)

	Niue, RMI, South Africa, United States		
Callisia repens (Jacq.) L. (Commelinaceae)	Caribbean, Central and South America, China, Hawai'i, Mexico, RMI, South Africa, United States		(Velde 2003, Foxcroft et al. 2008, Weber et al. 2008, USDA ARS 2009, Frohlich and Lau 2010)
Centaurea diffusa Lam. (Asteraceae)	Canada, Europe, Mediterranean, United States, Western Asia		(Zouhar 2001a, USDA NAL 2010)
Cirsium arvense (L.) Scop. (Asteraceae)	Australia, Canada, India, Japan, Mediterranean, Middle East, New Zealand, Southeastern Europe, Southern Africa, South America, United States		(Holm et al. 1977, Zouhar 2001b, Kaufman and Kaufman 2007, USDA NAL 2010)
Clidemia hirta	Palau, American Samoa, Fiji, Indonesia, Samoa, United States		http://www.issg.org/database/species/distribution.asp?si=53&fr=1&sts=
Coccina grandis	Hawai'I, Fiji, French Polynesia, Guam, RMI, FSM, CNMI, Samoa, Tonga, United States		http://www.ctahr.hawaii.edu/invweed/WeedsHI/W_Coccinia_grandis.pdf; http://www.issg.org/database/species/distribution.asp?si=348&fr=1&sts=&lang=EN
Elymus repens (L.) Gould (Poaceae)	Canada, United States		(Snyder 1992, USDA NAL 2010)

Epipremnum pinnatum	Southeast Asia, United States, Hawai'I, Australia, Fiji, Guam, FSM, RMI, Palau		http://www.cabi.org/isc/?compid=5&dsid=50410&loadmodule=datasheet&page=481&site=144
Jasminum dichotomum Vahl, *J. fluminense* Vell. (Oleaceae)	Africa, Hawai'i, United States		(IFAS 2007, Kaufman and Kaufman 2007, USDA NRCS 2009)
Lygodium japonicum (Thunb. ex Murr.) Sw. (Lygodiaceae)	Australia, Caribbean, Hawai'i, India, Southeast Asia, United States		(Wilson 2002, Munger 2005, USDA NAL 2010)
Miconia calvescens De Candolle (Melastomataceae)	Hawai'i, French Polynesia, and South America		(Meyer 1996, Medeiros et al. 1997)
Mikania micrantha	American Samoa, Australia, Fiji, French Polynesia, Guam, FSM, CNM, Palau, Papua New Guinea, New Caledonia, Philippines, Thailand, and numerous other Pacific islands		http://www.issg.org/database/species/distribution.asp?si=42&fr=1&sts=
Mimosa diplotricha	Hawai'i, Australia, Other Pacific Islands		http://www.fao.org/forestry/13377-0977cb34791475aa6a7a360640f09778.pdf
Persicaria perfoliata (L.) Gross (= *Polygonum*	Canada, East Asia, India, Japan, Philippines,		(Kaufman and Kaufman 2007, Stone 2010, USDA NAL 2010)

perfoliatum L.) (Polygonaceae)	United States		
Piper auritum	Hawai'i, Samoa, Tonga, Florida		(http://www.hear.org/pier/species/piper_auritum.htm; SPC 2001)
Solidago canadensis L., *S. gigantea* Aiton (Asteraceae)	Australia, Canada, China, Europe, New Zealand, United States		(Lu et al. 2007, Moroń et al. 2009)
Spathodea campanulata	Southeast Asia, Africa, United States, Mexico, Hawai'i, the Caribbean, South and Central America, Australia, Fiji, Guam, CNMI, RMI, Palau		http://www.cabi.org/isc/?compid=5&dsid=51139&loadmodule=datasheet&page=481&site=144
Syngonium podophyllum Schott (Araceae)	American Samoa, Australia, Central and South America, FSM, Galápagos Islands, Hawai'i, Solomon Islands, South Africa, United States,		(Morgan et al. 2004, Foxcroft et al. 2008, Brunel 2009, PIER 2010)
Tamarix spp. (Tamaricaceae)	Asia, Canada, Europe, United States		(Zavaleta 2000, Kaufman and Kaufman 2007)
Thunbergia grandiflora	Florida, Hawai'i, Australia, Singapore		(Starr et al. 2003)
Tradescantia pallida Rose (Commelinaceae)	Australia, Central America, South Africa, United		(Lampe 1986, Foxcroft et al. 2008, Chimpan and Şipoş 2009, USDA ARS 2009)

	States		

A8 SPECIES ACCOUNTS

A8.1 Amphibians

A8.1.1 *Bufo gargarizans*

Common names: Asiatic toad, common giant toad

Synonymous scientific names: *Bufo asiaticus, Bufo bufo gargarizans, Bufo bufo miyakonis*

Adult description: 56 to 102 mm (2 to 4 in) in length; females larger; spines on the large dorsal tubercles; dark gray to olive to brown dorsal color; three light longitudinal bands; black band extends from parotid to the flank, turning into spots posteriorly; grayish or yellowish venter

Tadpole description: no information found in the literature

Reproduction: reproduces in lakes, ponds, swamps, puddles, riverbeds, ditches, and stagnant to slow-flowing water; lays paired strings of 1,200 to 7,400 eggs; metamorphose in summer; sexually mature in 3 to 4 years

Habitat: vegetative cover, in rock crevices, tree hollows, cultivated areas; common in human-inhabited areas; limited by high temperatures and low humidity

Human health impacts: secrete toxins that can cause severe illness or death if ingested

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: predation on native fauna

Pathways: biocontrol; intentional, for education

Control measures: no information found in the literature

References: Brubacher et al. 1999; Lever 2003; Liu et al. 2005; Kraus 2009; AmphibiaWeb 2010; Yu et al. 2010

A8.1.2 *Bufo melanostictus*

Common names: Asian black-spotted toad, Asian common toad, Asian eyebrow-ridge toad, black-lipped toad, black-spined toad, common Indian toad, Indian toad, keeled-nosed toad, South Asian garden toad, southeast Asian common toad, spectacled toad

Synonymous scientific names: *Ansonia kamblei, Bufo scaber, Bufo tienhoensis, Duttaphrynus melanostictus, Rana dubia*

Adult description: females more than 150 mm (6 in) in length; several distinct cranial crests; distinct tympanum; double tubercles under third finger only; elliptical parotid; dark spines on tubercles of flanks; 8 to 9 large tubercles along sides of dorsum; gray dorsum with brown to reddish spots; speckled, whitish ventrum; males have an orange or yellow throat during the breeding season

Tadpole description: 26 to 27 mm (1 in) in length; dark coloration; bufonid body; broad dorsal fin but narrow ventral fin; finely serrated beak; inhabit side pools or puddles; metamorphosis in approximately 25 days

Reproduction: breeds during the rainy season or throughout the year, depending on location; breeds in any available water; males call from shallow pools; male-male competition; lays paired strings of eggs; metamorphosis occurs in about 25 days

Habitat: Habitat generalist; ponds, paddy fields, low hills, mountains, coastal plains; under stones, logs, dense vegetation, crevices

Human health impacts: secrete toxins that can cause severe illness or death if ingested; may be a host for the causative agent of human angiostrongyliasia

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: consumes agricultural pests

Pathways: boat, cargo

Control measures: no information found in the literature

References: Jorgensen et al. 1986; Ding 1988; Saidapur and Girish 2001; Lever 2003; Keomany et al. 2007; Kraus 2009; AmphibiaWeb 2010; Frost 2010

A8.1.3 ***Eleutherodactylus coqui:*** established in Hawai'i, individuals have been detected and removed from Guam on multiple occasions.

Common names: coqui frog, Puerto Rican coqui

Synonymous scientific names: *Eleutherodactylus martinicensis, Eleutherodactylus portoricensis*

Adult description: males approximately 34 mm (1.3 in) snout to vent length; females approximately 41 mm (1.6 in) snout to vent length; well-developed pads at the end of the toes; variable coloration with the upper body usually being a grey or grey-brown uniform color; may also have an "M" shape between the shoulders; two broad, light-colored bars running from the snout through the eye to the axilla of the rear legs that is bordered with black spots; a light bar on top of the head between the eyes; underside is usually light-colored and stippled with brown

Reproduction: breeds year-round; internal fertilization; lays 1 to 2 dozen eggs; do not need water, may construct nests on the ground or use cavities of birds; males care for the clutches; direct development

Habitat: Habitat generalist; agricultural areas, natural and planted forests, riparian zones, wetlands, urban areas

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: lowering of property values and tourism due to the high noise level associated with calls

Ecological impacts: increased nutrient cycling, predation on invertebrates causing declines, prey source to potentially support invasive snake populations

Pathways: cargo, intentional, nursery trade

Control measures: bans on importation, hand capture, caffeine, citric acid, cargo restrictions and inspections, citric acid spray for imported plants, public education

References: Bartlett and Bartlett 1999; Campbell and Kraus 2002; Campbell et al. 2002; Kraus and Campbell III 2002; Beard et al. 2003b; Kaiser and Burnett 2006; Christy et al. 2007a; Christy et al. 2007c; Tuttle et al. 2008; Kraus 2009; AmphibiaWeb 2010; ISSG 2010

A8.1.4 ***Eleutherodactylus planirostris:*** established on Guam and in Hawai'i

Common names: greenhouse frog

Synonymous scientific names: *Eleutherodactylus ricordii, Euhyas planirostris, Lithodytes ricordii*

Adult description: males about 19 mm (0.7 in) in length; females may be greater than 25 mm (1 in) in length; rust, orange, or brown skin, dark, with warts and a whitish or gray venter; either mottled markings or light longitudinal stripes; possible dark triangle between the eyes; enlarged finger pads; elongate toe pads which point toward the tips of the toes

Reproduction: breeds from late spring to early autumn in Florida; males call from the ground or plants and herbs; reproduces in debris or damp holes; lays 1 to 2 dozen eggs; direct development

Habitat: Habitat generalist; ubiquitous, diverse habitats; woodlands, scrub, yards, gardens, greenhouses and nurseries; beneath boards or natural objects, in crevices

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: prey source to potentially support invasive snake populations

Pathways: cargo, nursery trade

Control measures: caffeine, hydrated lime (no longer allowed), public education

References: Stevenson 1976; Bartlett and Bartlett 1999; Campbell and Kraus 2002; Kraus and Campbell III 2002; Christy et al. 2007a; Christy et al. 2007c; Kraus 2009; ISSG 2010

A8.1.5 ***Fejervarya cancrivora:*** established on Guam

Common names: Asian brackish frog, crab-eating frog, mangrove frog, rice field frog

Synonymous scientific names: *Limnonectes cancrivora*, *Rana cancrivora*

Adult description: information not found

Reproduction: reproduces in any available water

Habitat: Habitat generalist; mangrove forests, estuarine habitats, swamps, wet coastal areas; swales; human-inhabited areas, including rice fields, gardens, and urban areas; can tolerate some salinity

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: prey source to potentially support invasive snake populations

Pathways: aquaculture contaminant, food

Control measures: no information found in the literature

References: Zhigang et al. 2004; Christy et al. 2007a; Christy et al. 2007c; Kraus 2009

A8.1.6 Fejervarya limnocharis

Common names: alpine cricket frog, field frog, rice frog

Synonymous scientific names: *Limnonectes limnocharis, Rana limnocharis*

Adult description: 39 to 43 mm (1.5 to 1.7 in) in length; pointed snout projects beyond the mouth; obtuse canthus; width of upper eyelid is wider than the internarial distance, which is longer than the interorbital width; distinct tympanum; fingers pointed, toes with obtuse or swollen tips and slightly webbed; males with mottled brown, loose upper throat and w-shaped marking; gray brown or olive skin; dark "v" between the eyes; yellow stripe down the dorsal midline; white venter

Tadpole description: 26 to 27 mm (1 in) in length; long, oval body; convex venter; tail about twice the body length and pointed; dorsal fin broader in the middle, while ventral fin follows the line of the tail; dark tip on tail

Reproduction: breeds during the rainy season; males call from edges of flowing water; lays batches of eggs adhered to grass

Habitat: habitat generalist; wetlands, plains, alpine; dense vegetation bordering canals, streams, torrents, ponds, puddles, and rice fields; can tolerate some salinity

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: prey source to potentially support invasive snake populations

Pathways: aquaculture contaminant, biocontrol, research, pet trade

Control measures: no information found in the literature

References: Hutchins et al. 2003a; van Dijk et al. 2004a; Lee et al. 2006; Christy et al. 2007a; Christy et al. 2007c; Kraus 2009; Wu and Kam 2009; AmphibiaWeb 2010

A8.1.7 Hyla cinerea

Common names: American green tree frog, Carolina tree frog, green tree frog, marsh tree frog

Synonymous scientific names: *Calamita cinereus, Calamita lateralis, Hyla blochii, Hyla carolinensis, Hyla lateralis, Hyla semifasciata, Rana bilineata, Rana lateralis*

Adult description: 44.5 to 63.5 mm (1.8 to 2.5 in) in length; females larger; slender body; legs one and a half times the head and body length; pointed head, flat between the eyes; large eyes extend laterally; skin fold over the bronze-colored tympanum to the shoulder; slight webbing of toes; large disks on fingers and toes; bold yellow green to gray green on the dorsum with a white or yellow line along the sides of the head and body; similar colored bands on the posterior of the arm and anterior and posterior of the legs; lower jaw dark; whitish venter; pale yellow throat; can change color from light to dark

Tadpole description: 4.5 to 5.5 mm (0.2 in) in length at hatching; 60 mm (2.4 in) in length at metamorphosis; color changes throughout development; blotches eventually form the lateral bands; in later stages body is green, venter is yellow to buff, and the long tail is mottled yellow; arched dorsal fin; bulging eyes

Reproduction: reproduces in floating or emergent vegetation; lays eggs in clutches of 478 to 3,946 eggs; metamorphose in 24 to 45 days

Habitat: habitat generalist; coastal lowlands, ponds, lakes, swamps, marshes, sloughs, dry streambeds, cultivated areas; water margins; perches on broad leaves

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: vector of a disease of weedy plants

Pathways: aquaculture contamination, cargo, nursery trade, pet trade

Control measures: no information found in the literature

References: Dickerson 1969; Garton and Brandon 1975; Stevenson 1976; Layne Jr. et al. 1989; Wygoda and Williams 1991; Wygoda and Garman 1993; Lever 2003; Gunzburger 2006; Kraus 2009; AmphibiaWeb 2010; Frost 2010

A8.1.8 Kaloula picta

Common names: painted narrow-mouth toad, slender-digit chorus frog

Synonymous scientific names: *Callula picta, Plectropus pictus*

Adult description: males 32.8 to 51.2 mm (1.3 to 2 in) in length, with an average of 39.6 mm (1.6 in); females 34.7 to 56.1 mm (1.4 to 2.2 in) in length, with an average of 42.2 mm (1.7 in); females larger on average; dorsal tubercles present; prominent, pointed outer metatarsal tubercle; lateral glandular ridge; glandular venter; stratified coloration on flank and posterior thigh; may have spots on the lower back

Reproduction: breeds May through February, beginning with the rainy season, and peaks July through October; males call from the water; reproduces in ephemeral pools; lays 812 to 4,029 eggs; one clutch per female per year; eggs hatch within 13 to 15 hours; 3.1-3.3 mm (0.1 in) in length at hatching; metamorphose in 18 days

Habitat: forests, shrublands, grasslands, wetlands, tropics; most common in human-inhabited areas, including agricultural lands, ditches, artificial ponds, gardens, and urban areas; burrows or hides in logs, dropped coconuts, or stones

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: boat, cargo

Control measures: no information found in the literature

References: Cendaña and Fermin 1940; Diesmos et al. 2002; Diesmos et al. 2004a; Christy et al. 2007a; Christy et al. 2007c; Kraus 2009; Frost 2010

A8.1.9 Kaloula pulchra

Common names: Asian painted frog, banded bullfrog, beautiful kaloula, Malayan narrow-mouthed frog, Malaysian narrow-mouth toad, Malaysian painted frog, ox frog, painted balloon frog, painted bullfrog, painted burrowing frog, painted microhylid frog, piebald digging frog

Synonymous scientific names: *Callula macrodactyla, Callula pulchra, Kaloula aureata, Kaloula macrocephala*

Adult description: 54 to 75 mm (2.1 to 3 in) in length; females larger; robust body with short, thick hind legs; rounded snout; two spades on feet for digging; lacks a cervical vertebrae; generally smooth skin; dark grey, light brown or pinkish skin with a large brown spot over much of the back; two large, irregular light-colored bands running from the eye to the groin; snout tan; whitish to yellow brown venter with brown spots; males have a black throat; inflates body when threatened

Reproduction: breeds during the rainy season or year-round, depending on climate; males call while floating in the water; reproduces in small pools or ponds; rapid larval growth

Habitat: habitat generalist; wetlands, riverbanks, dry forests; burrow or hide in vegetation; human-inhabited areas, including agricultural, residential, and urban areas; commensal, no longer found in undisturbed habitats

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: possible predation on native fauna, due to its generalist habits; potential carrier of chytridiomycosis; possible competition with native anurans

Pathways: aircraft, boat, cargo, intentional, pet trade

Control measures: no information found in the literature

References: Heyer 1973; Hutchins et al. 2003a; Kuangyang et al. 2004b; Hou et al. 2006; Christy et al. 2007a; Christy et al. 2007c; Tyler and Chapman 2007; Page et al. 2008; Kraus 2009; AmphibiaWeb 2010; Frost 2010

A8.1.10 Limnodynastes tasmaniensis

Common names: marbled frog, spotted grass frog, spotted marsh frog

Synonymous scientific names: *Limnodynastes peronii var. tasmaniensis, Limnodynastes tasmanicus*

Adult description: maximum 48 mm (1.9 in) in length; generally Rana-like appearance; green to olive-gray back with dark blotches; white venter; dark line from snout to arm; dark spots anteroventral to the eye; light ridge from the upper jaw to the top of the foreleg; usually a white stripe along the midline of the dorsum; smooth to slightly rough skin; very little webbing on toes

Tadpole description: dark dorsum with gold spots on the ventrum of the tail

Reproduction: breeds year-round, with peaks August through March; males call from vegetation on edges of shallow water; aquatic; reproduces in grassy ditches, small pools, grassy marshes, and shallow ponds; lays foam nests of 90 to 1,350 eggs adhering to vegetation; metamorphose in 3 to 5 months or less; sexually mature at 80 to 100 days after metamorphosis

Habitat: habitat generalist; streams, lakesides, marshes, shrublands; under logs, stones, or debris

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: known to carry chytridiomycosis, a possible threat to native anurans

Pathways: cargo

Control measures: no information found in the literature

References: Moore 1961; Hutchins et al. 2003a; Hero et al. 2004b; Kraus 2009; AmphibiaWeb 2010; Frost 2010

A8.1.11 Litoria aurea

Common names: golden bell frog, golden frog, golden tree frog, green frog, green and golden bell frog, green and golden swamp frog

Synonymous scientific names: *Auletris jacksoniensis, Hyla aurea, Hyla jacksoniensis, Hyla jacksonii, Rana aurea, Ranoidea aurea, Ranoidea jacksoniensis, Ranoidea resplendens, Ranoidea ulongae*

Adult description: about 55 to 108 mm (2 to 4.3 in) in length; females larger; glandular stripe from the mouth to the base of the forearm; fleshy webbing on toes and disks on fingers and toes; cream or yellow fold extending from the eye almost to the groin; fold on chest; sides and abdomen have a rough texture; prominent, gold tympanum; smooth, bright green dorsum with brown blotches; white venter; males have a yellowish throat

Tadpole description: large at metamorphosis; high tail fin; heavily pigmented

Reproduction: breed in mid-spring to summer, peaking October-March; males call from water; lays a mat of 2,400 to 11,600 eggs; hatch in 2 to 3 days; metamorphose in about 2, but up to 11, months

Habitat: habitat generalist; ponds, lakes, streams, grassy marshes, swamps, low-lying grasslands, forest clearings, agricultural lands; prefers isolated, still, shallow, and pristine waters; perches in emergent vegetation

Human health impacts: carries the pathogen which causes eosinophilic meningitis (EM) in humans

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: predation on native skinks and other vertebrates; known to carry chytridiomycosis, a possible threat to native anurans

Pathways: biocontrol, cargo, intentional, pet trade, possibly as food for ducks

Control measures: no information found in the literature

References: Moore 1961; Pyke and White 1996, 2001: Lever 2003: Hero et al. 2004d: Vörös et al. 2008: Kraus 2009: AmphibiaWeb 2010: Frost 2010: ISSG 2010

A8.1.12 Litoria caerulea

Common names: Australian green tree frog, Australian tree frog, blue frog, great green tree frog, green tree frog, smiling frog, White's tree frog

Synonymous scientific names: *Calamita cyanea, Calamites coreulea, Hyla caerulea, Hyla coerulea, Hyla cyaneus, Litoria irrorata, Pelodryas caeruleus, Pelodryas irrorata, Rana austrasiae, Rana caerulea, Rana coerulea*

Adult description: about 72.4 to 97.7 mm (2.8 to 3.8 in) in length; dorsum solid, leaf green to greenish brown; white venter with greenish throat; anterior and posterior of the thigh is tan or yellow-green; occasionally white spots on the dorsum; large glandular ridge of skin between the eye and shoulder; prominent tympanum; fingers slightly webbed, toes heavily webbed

Reproduction: breeds October to January in Australia; males call from hiding spots near water; reproduces in ponds; lays clusters of 100 to 200 eggs, with 2,000 to 3,000 eggs total; metamorphose in 6 weeks

Habitat: habitat generalist; deserts, woodlands, grasslands, shrublands, rain forests; often in human-inhabited areas, near buildings or objects holding water; perches on or hides in various objects; does not need a water body, can withstand severe droughts

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: known to carry chytridiomycosis, a possible threat to native anurans

Pathways: biocontrol, cargo, intentional, pet trade

Control measures: no information found in the literature

References: Moore 1961; Main and Bentley 1964; Buttemer 1990; Christian and Parry 1997; Bartlett and Bartlett 1999; Lever 2003; Hero et al. 2004e; Berger et al. 2005; Kraus 2009; AmphibiaWeb 2010; Frost 2010

A8.1.13 Litoria chloris

Common names: Australian red-eyed tree frog, north coast green tree frog, red-eyed green tree frog, red-eyed tree frog, southern orange-eyed tree frog

Synonymous scientific names: *Dryomantis chloris, Hyla chloris*

Adult description: about 52.7 to 65 mm (2 to 2.6 in) in length; distinct tympanum with a ridge from the eye across the dorsal side of the membrane; rounded canthus; webbed fingers and toes with large disks; leaf green dorsum; white to bright yellow venter; purplish or brown posterior of thigh; inner portion of hands is yellow, whereas the outer portion is green; red eyes

Tadpole description: medium sized; coloration is light grey to dark brown; may have gold along the sides

Reproduction: breeds during heavy rains in spring and summer, October to February; males call from the ground or shallow pools beside streams; reproduces in flooded spots, mountain streams, and grasslands; lays single egg or clumps of eggs within vegetation; each female lays over 1,000 eggs per year; sexually mature in 2 to 3 years

Habitat: coastal rain forests, wet sclerophyll forests, and human-inhabited areas, especially in objects holding water; perches high in trees

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, intentional

Control measures: no information found in the literature

References: Moore 1961; Hero et al. 2004c; Morrison et al. 2004a; FAN 2006; Kraus 2009; AmphibiaWeb 2010; Frost 2010

A8.1.14 Litoria ewingii

Common names: Australian brown tree frog, brown tree frog, Ewing's tree frog, southern brown tree frog, whistling tree frog

Synonymous scientific names: *Hyla ewingi, Hyla inguinalis, Rawlinsonia calliscelis, Rawlinsonia ewingi, Rawlinsonia parvidens*

Adult description: 26 to 50 mm (1 to 2 in) in length; short legs and a broad head; toes with small disks and very slight webbing; distinct tympanum; grey to dark brown, smooth dorsum; brown to black patch on back extending from between the eyes to the cloaca, often with a light stripe down the midline; white stripe extending from the snout, through the eye and tympanum, to the base of the forelegs; whitish venter; ventral side of thighs bright orange

Reproduction: breeds year-round; males call from the ground or short emergent or floating vegetation; reproduces in still water of various water bodies; lays clumps of eggs, with 500 to 700 eggs total, attached to vegetation below the water surface; metamorphosis varies from 7 to 8 weeks to 6 to 7 months

Habitat: habitat generalist; moist environments; streams, lakesides, woods, shrublands, rain forests, alpine lakes and meadows, and human-inhabited areas, including gardens, pasturelands, and urban areas

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: known to carry chytridiomycosis, a possible threat to native anurans

Pathways: biocontrol, cargo, intentional, pet releases

Control measures: no information found in the literature

References: Moore 1961; Lever 2003; Hero et al. 2004a; Pauza and Driessen 2008; Kraus 2009; AmphibiaWeb 2010; Frost 2010

A8.1.15 Litoria fallax: Established on Guam

Common names: dwarf tree frog, Eastern dwarf tree frog, Eastern sedgefrog

Synonymous scientific names: *Dryomantis fallax, Dryomantis glauerti, Hyla bicolor glauerti, Hyla glauerti, Hylomantis fallax, Litoria glauerti*

Adult description: information not found

Reproduction: breeds during heavy rains of summer; lays clumps of eggs attached to vegetation below the water surface

Habitat: vegetation on margins of swamps, streams, lagoons, ponds, and farm dams; dense populations

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: prey source to potentially support invasive snake populations

Pathways: aircraft, cargo, escape

Control measures: no information found in the literature

References: Lever 2003; Christy et al. 2007a; Christy et al. 2007c; Kraus 200;, AmphibiaWeb 2010; Frost 2010

A8.1.16 Microhyla pulchra: Established on Guam

Common names: beautiful pygmy frog, Guangdong rice frog, marbled pygmy frog, painted chorus frog, painted frog, yellow-legged narrow-mouthed frog, yellow-legged pigmy frog

Synonymous scientific names: *Diplopelma pulchrum, Engystoma pulchrum, Microhyla hainanensis, Microhyla major, Microhyla melli, Microhyla pulchrum, Ranina symmetrica, Scaptophryne labyrinthica*

Adult description: about 32 mm (1.3 in) in length; slender with a prominent snout; distance between the upper eyelids does not exceed the interorbital space; lacks disks on digits but has some webbing on toes; large subarticular tubercles; generally smooth, olive, grey, or pinkish brown dorsum; a thin, dark bar between the eyes; dark band extending from the eye to the flank; nested v-shaped markings on the back, with the arms of the v's often breaking up into spots; barred markings on legs; yellowish white venter, with mottling on the throat and chest

Reproduction: breeds during the rainy season, April to October; reproduces in ephemeral pools, ponds, and paddy fields; metamorphose in about 23 days

Habitat: habitat generalist; common in forest edges; ponds, mud, brackish marshes, grasslands, and human-inhabited areas including gardens, fields and plantations

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: prey source to potentially support invasive snake populations

Pathways: aquaculture contaminant

Control measures: no information found in the literature

References: Boring 1934; van Dijk et al. 2004b; Christy et al. 2007a; Christy et al. 2007c; Kraus 2009; Frost 2010

A8.1.17 Osteopilus septentrionalis

Common names: Cuban tree frog, giant tree frog

Synonymous scientific names: *Hyla dominicensis, Hyla septentrionalis*

Adult description: males 27 to 89 mm (1 to 3.5 in) , and some up to 100 mm (4 in) in length; females 52 to 165 mm (2 to 6.5 in) in length; usually warts on dorsum; rounded snout; prominent tympanum; pale green, gray, light brown, or reddish brown to bronze skin; dark reticulations or elongate markings, possibly with lighter cream or yellow markings on the flanks; venter whitish; gray throat common in males; large finger disks with basal webbing; skin on top of head co-ossified with the skull, forming a casque

Tadpole description: 32 mm (1.3 in) in length; large; ovoid body; small, anteroventral mouth; caudal fins high with pointed tip; black body with grayish caudal musculature; black or brown spots on fins

Reproduction: breeds throughout the rainy season although males are reported to breed on only a single day; population increases dramatically post-breeding; males call from elevated sites, such as in bushes or trees; reproduce in ephemeral ponds, flooded areas, ditches, swimming pools, and fountains; lays clusters of 25 to 75 eggs, up to more than 200 eggs total

Habitat: habitat generalist; low to moderate elevations; humid habitats; under objects or in plants; human-inhabited areas, including urban areas, city parks, swimming pools, and gardens

Human health impacts: skin secretions may cause irritation to mucous membranes in humans; mating calls may be annoying

Economic impacts: clogged drains; water contamination; cause of short circuits in transformers

Ecological impacts: predation of native frogs

Pathways: boat, cargo, intentional, nursery trade, pet trade, vehicle, on/in construction materials

Control measures: early detection, exclusion, hand capture with euthanasia, plant fumigation

References: Allen and Neill 1953; Stevenson 1976; Carmichael and Williams 1991; Bartlett and Bartlett 1999; Townsend et al. 2000; Savage 2002; Bomford et al. 2005; Owen 2005; Smith 2005; Platenberg and Boulon Jr. 2006; Vargas Salinas 2006; Varnham 2006; Anguilla National Trust 2007; Campbell 2007; Johnson 2007; Hedges et al. 2008; Kraus 2009; Perry 2009; Frost 2010; ISSG 2010

A8.1.18 Polypedates leucomystax

Common names: Asian brown tree frog, banana frog, bamboo tree frog, common tree frog, four-lined tree frog, golden foam-nest frog, golden tree frog, jar tree frog, Java whipping frog, Malayan house frog, perching frog, striped tree frog, white-lipped tree frog

Synonymous scientific names: *Hyla leucomystax, Hyla quadrilineata, Hyla sexvirgata, Polypedates rugosus, Polypedates teraiensis, Rhacophorus maculatus leucomystax*

Adult description: males 50 mm (2 in) in length; females 80 mm (3 in) in length; dorsum various shades of brown; markings range from spots to longitudinal stripes; is able to change color, from light during the day to darker at night

Tadpole description: about 6 to 14 mm (0.2 to 0.6 in) in length; lateral eyes

Reproduction: can breed year-round, depending on climate, but peaks during the rainy season; aquatic; males call from water margins and/or perches in vegetation; reproduces in ephemeral pools; lays a foam nest of 100 to 400 eggs, attached to vegetation; metamorphose in 28 to 33 days

Habitat: habitat generalist; wetlands, forests, edge habitats, beaches, and human-inhabited areas, including agricultural lands, ditches, urban areas, garden ponds, and buildings; commensal

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: possible competition with endemic anuran species

Pathways: aircraft, boat, cargo

Control measures: no information found in the literature

References: Heyer 1973; Diesmos et al. 2004b; Christy et al. 2007a; Christy et al. 2007c; Kraus 2009; Kuraishi et al. 2009; AmphibiaWeb 2010; Frost 2010

A8.1.19 Polypedates megacephalus: Established on Guam

Common names: Hong Kong whipping frog, hour-glass-marked tree frog, spot-legged tree frog, white-lipped tree frog

Synonymous scientific names: *Polypedates maculates* var. unicolor, *Rhacophorus leucomystax megacephalus*

Adult description: 40 to 66 mm (1.6 to 2.6 in) in length; x-shaped markings or 4 longitudinal stripes

Reproduction: breeds March to September (in native range); reproduces in shallow, still water with aquatic vegetation; lays foam nests of 300 to 400 eggs, in vegetation overhanging water

Habitat: habitat generalist; wetlands, ponds, marshes, tropical forests, grasslands, shrublands, bamboo groves, and cultivated fields, orchards; dense vegetation;

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: prey source to potentially support invasive snake populations

Pathways: aquaculture contaminant

Control measures: no information found in the literature

References: Lazell et al. 1999; Lau et al. 2004; Lee et al. 2006; Christy et al. 2007a; Christy et al. 2007c; Wu et al. 2007; Kraus 2009; Frost 2010

A8.1.20 Pseudacris regilla

Common names: Cascade mountain tree frog, northern pacific tree frog, Oregon wood frog, Pacific chorus frog, Pacific hyla, Pacific tree frog, Pacific tree-toad, western Oregon tree frog

Synonymous scientific names: *Hyla regilla*, *Hyla scapularis*, *Pseudacris pacifica*

Adult description: males 25.5 to 48 mm (1 to 1.9 in) in length; females 25 to 47 mm (1 to 1.9 in) in length; toes with large disks and webbing; gray to green to brown dorsum; black stripe extending from the snout, through the eye, to the shoulder; commonly a triangular mark on the head and dark spots across the back and legs; bands or blotches on legs; able to change colors in different environments; males have a wrinkled throat

Tadpole description: 45 to 55 mm (1.8 to 2.2 in) in length at metamorphosis; deep-bodied with a tail twice the body length; black, yellowish brown, or dark brown coloration with black spots; whitish venter with a bronze tint

Reproduction: breeds January to July; aquatic; males call from ponds; male-male competition; reproduces in still or slow-moving waters, often with vegetation; lays clusters of 9 to 80 eggs, with 400 to 750 eggs total, often attached to submerged vegetation; each female may lay more than 3 clutches per year; eggs hatch in 1 to 5 weeks; metamorphose in about 2 to 2.5 months; sexually mature in less than 1 year to 2 years

Habitat: habitat generalist; springs, oases, rivers, ponds, marshes, sloughs, forests, grasslands, deserts, and human-inhabited areas, including ditches, plant nurseries, livestock water tanks, and other agricultural areas; most time spent on the ground under vegetation or other cover

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: known to carry chytridiomycosis, a possible threat to native anurans; may compete with California tree frogs

Pathways: agricultural trade, cargo, intentional, nursery trade, pet trade

Control measures: no information found in the literature

References: Dickerson 1969; Fellers et al. 2001; Rorabaugh et al. 2004; Christy et al. 2007a; Christy et al. 2007c; Kraus 2009; AmphibiaWeb 2010; Frost 2010; Somma 2010b

A8.1.21 Rana catesbeiana

Common names: American bullfrog, bullfrog

Synonymous scientific names: *Lithobates catesbeianus*, *Rana catesbeana*, *Rana catesbyana*

Adult description: the largest frog in North America; about 101.6 to 165.1 mm (4 to 6.5 in) in length, with a record of 203.2 mm (8 in); skin is various shades of green to dark black; lighter venter; sides of face and lips bright green; may have dark spots on forelimbs and/or bands on hind limbs; yellow throats common in males, whereas females have white throats; has a ridge from the eye down to the top of the foreleg; the longest toe extends beyond the webbing of the foot

Tadpole description: up to 76.2 mm (3 in) in length; stippled olive with lateral lines and a lighter venter

Reproduction: males call from sides of water on floating vegetation; male-male competition during the breeding season; aquatic; reproduces in vegetation-choked shallows; lays rafts of up to 20,000 eggs; hatch in 3 to 5 days; metamorphose in 2 months to 2 years, depending on climate

Habitat: habitat generalist; ponds, lakes, swamps, large ditches, wetlands, canals, slow rivers and oxbows, rice fields, garden ponds; can withstand high salinity

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: consumes agricultural pest insects; damage to aquaculture;

Ecological impacts: predation on native fauna, especially other herptiles; competition with native anurans, in both larval and adult stages; possible disease transmission to native fauna

Pathways: aquaculture contaminant, biocontrol, farming/hunting for human consumption, intentional, lab release, pet trade, natural dispersal

Control measures: Early detection; shooting; use of spears, bow and arrow, clubs, nets, traps; angling; electrofishing; hand capture; fencing; collection of egg masses; draining ponds and excavating sediments; public education; bans on importation

References: Bartlett and Bartlett 1999; Lever 2003; Kraus 2009; Santos-Barrera et al. 2009; AmphibiaWeb 2010; ISSG 2010

A8.1.22 Rana guentheri: Established on Guam

Common names: Guenther’s amoy frog, Guenther’s frog, Guenther’s red-and-black frog, barking frog

Synonymous scientific names: *Hylarana guentheri*, *Rana elegans*, *Sylvirana guentheri*

Adult description: males 65 to 74 mm (2.6 to 2.9 in) in length; females 61 to 74 mm (2.4 to 2.9 in) in length; flat head with protruding snout; noticeable maxillary glands at the corners of the mouth; fold extending from the tympanum to the shoulder; flattened dorsolateral folds extending from the eye to the hip; robust limbs, with hind limbs up to 1.5 times the total body length; lacks disks on fingers and toes; smooth skin, excepting the posterior; dark mustard to olive or red brown dorsum; yellowish brown to brown dorsum; black marks along the longitudinal folds; lateral black spots; stripes on outside of legs and dark spots on posterior of legs; white venter; metallic platinum to gold upper lip

Tadpole description: dorsolateral eyes; narrow mouth; relatively high tail fin; speckled grayish green coloration; pointed, speckled brown tail

Reproduction: breeds May to June; reproduces in still water bodies; lays clutches of 2,000 to 3,000 eggs; females lay once per year; metamorphose in 45 to 60 days

Habitat: habitat generalist; lowlands, shrublands, grasslands, riverbanks, ponds, marshes, pools, ditches, and paddy fields; disturbed habitats; hides in aquatic vegetation

Human health impacts: carries the pathogen which causes eosinophilic meningitis (EM) in humans

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: prey source to potentially support invasive snake populations

Pathways: aquaculture contaminant

Control measures: no information found in the literature

References: Alicata 1991; Lazell et al. 1999; Kuangyang et al. 2004a; Christy et al. 2007a; Christy et al. 2007c; Lv et al. 2008; Kraus 2009; AmphibiaWeb 2010; Frost 2010

A8.1.23 Rana nigromaculata

Common names: dark-spotted frog, black-spotted pond frog

Synonymous scientific names: *Pelophylax nigromaculatus*, *Pelophylax nigromaculata*, *Rana esculenta*

Adult description: vomerine teeth; posterior part of tongue free and forked; toes webbed; horizontal pupil; dorsal coloration grey, grayish-olive, olive to green with large dark spots which are sometimes absent; numerous longitudinal wrinkles between the dorso-lateral folds; light middorsal line and two lines on dorso-lateral folds usually present; no temporal spot; belly white, sometimes with small amount of dark spots on throat; males differ from females by having white vocal sacs behind the mouth angles and nuptial pads on the first finger

Tadpole description: no information found in the literature

Reproduction: occurs soon after emerging from hibernation; axillary amplexus; 600 to 5,000 eggs/clutch; metamorphosis depends on latitude and altitude but occurs between May and August; sexually mature at 2 years

Habitat: habitat generalist; meadows; deserts; forests; shrublands; grasslands; wetlands; pastures; gardens; urban areas; artificial ponds; prefers stagnant water; hibernate in winter

Human health impacts: carrier of the Spirometra tapeworm that causes human sparganosis

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: food, aquaculture, pet trade

Control measures: no information found in the literature

References: Kuzmin et al. 2004; Li et al. 2009; AmphibiaWeb 2010; Frost 2010

A8.1.24 Rana sylvatica

Common names: wood frog

Synonymous scientific names: *Lithobates sylvaticus*, *Rana maslini*, *Rana pennsylvanica*, *Rana temporaria*

Adult description: 37 to 83 mm (1.5 to 3.3 in) in length; females larger; large dorsolateral folds extending from the eye to the cloaca, with the lateral edge darker than the medial edge; additional, shorter folds along the back; webbed toes; gray to tan to bright reddish brown or golden dorsum; dark marking possible on back and sides; some populations have a white line down the dorsal midline; wide, dark marking from the snout to the tympanum; white, sometimes mottled, venter with a dark pectoral mark

Tadpole description: 50 to 60 mm (2 to 2.4 in) in length at metamorphosis; larger individuals are cannibalistic

Reproduction: breeds after first rains of late winter to early spring, varies from January to June by latitude; aquatic; reproduces in ephemeral pools or ponds; eggs deposited communally; lays clutches of 500 to 1,500 eggs each; metamorphose in 65 to 130 days; males sexually mature at 1 to2 years, females at 2 to 3 years

Habitat: habitat generalist; forests, tundra, subalpine woodlands, willow stands, moist meadows, swamps, and human-inhabited areas; can be far from water sources; terrestrial hibernator

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: may be a carrier for ranavirus and Batrachochytrium dendrobatidis that can infect and kill other amphibians

Pathways: biocontrol, cargo, research

Control measures: no information found in the literature

References: Light 1991; Ouellet et al. 2005; Harp and Petranka 2006; Muir et al. 2007; Kraus 2009; AmphibiaWeb 2010; Frost 2010

A8.1.25 Rhinella marina

Common names: cane toad, giant toad, marine toad

Synonymous scientific names: *Bufo agua*, *Bufo marinus*, *Bufo strumosus*, *Chaunus marinus*, *Rana marina*

Adult description: heavy body with short legs; up to 150 mm (6 in) in length; weight of females up to 1.5 kg (3.3 pounds); females larger; toes are webbed but fingers are not; large cranial crests; has tarsal folds; tan, brown, dark brown, dull green, or black skin with warts; mottled coloration in females; venter mottled whitish color; large parotid glands

Tadpole description: 10 to 25 mm (0.4 to 1 in) in length; ovoid body; subterminal mouth; short tail with pointed caudal fin; dark brown or black body and tail

Reproduction: breeds throughout the rainy season (April to November in Costa Rica); males call from edges of water bodies; strong male-male competition in populations with high densities; reproduce in shallow water with little cover; lays paired strings of 2,500 to 12,500 eggs; hatch in 36 hours to 4 days; metamorphose in 14 to 80 days

Habitat: all lowland and premontane zones, particularly disturbed areas; subtropical forests close to fresh water, rainforests, man-made ponds, gardens, drain pipes, debris, under cement piles and boards, houses, and disturbed areas; able to withstand a high level of salinity; can withstand a broad temperature range

Human health impacts: secrete toxins (bufotenine toxin) from parotid glands that can cause serious illness or death and human fatalities have occurred; reservoirs for Leptospira interrogans that causes Weil’s disease (infectious jaundice) in humans; calls may disturb sleep

Economic impacts: toxify livestock water sources where they breed and die

Ecological impacts: will eat most anything; competition with native species

Pathways: biocontrol, cargo, seafreight (container/bulk), intentional, natural dispersal, pet trade, vehicles, water currents, zoo trade

Control measures: public education, exclusion; research being conducted: use of parasites and viral vectors, pheromones

References: Hinckley 1963; Pernetta and Watling 1979; Brandt and Mazzotti 1990; Catling et al. 1999; Crossland 2000; Lever 2001; Christy et al. 2007a; Kraus 2009; ISSG 2010

A8.2 Birds: an important species for Micronesia which in not included in this list is the Eurasian Tree Sparrow which is established on various islands within Micronesia including Guam. Various other species could readily be added to this list.

A8.2.1 Columba livia: established on numerous islands in the region and the broader Pacific

Common names: common pigeon, domestic pigeon, feral pigeon, rock dove

Synonymous scientific names: no information found in the literature

Adult description: 29 to 36 cm (11.6 to 14.4 in), 194 to 398 g (6.84 to 14.04 oz); variable species, generally blue-grey with green and purple sheen on neck; wings with two black bars; white rump; cere whitish; bill black; the description above refers to the wild form; are many patterns among feral birds from white, red, and black.

Reproduction: most of the year; as many as five broods per year; two eggs per brood; eggs are smooth, white, and glossy; nests on ledges and flat surfaces; new nests are built on top of old nests; nests consist of twigs, roots, pine needles, straw, and grass stems; incubation length is 18 days; hatchlings are altricial; fledging occurs in 25 to 45 days

Habitat: Cities, towns, villages, farms, and cliffs.

Human health impacts: carry up to 60 human pathogens including viruses, bacteria, fungi, and protozooans; reasonable evidence that they are responsible for the spread of several noxious diseases including: psittacosis or ornithosis, cryptococcal meningitis, histoplasmosis, toxoplasmosis, encephalitis, Q fever, chlamydia, campylobacter, diarrheagenic *E. coli*, WNV, *Enterocytozoon bieneusi*, fleas that cause allergies

Economic impacts: nuisance in most of the larger cities in the world because of their fouling of buildings, statues, etc. with droppings; contaminate grain for human consumption; nests clog drainpipes; occasionally interfere with crops; compete with domestic fowl for food.

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: escaped or run wild, intentional.

Control measures: exclusion, habitat modification, hazing, repellents, toxicants, fumigants, trapping, shooting, contraception

References: Long 1981; Lever 1987; Johnston 1992; Williams and Corrigan 1994; To et al. 1998; Stein and Raoult 1999; Trávniček et al. 2002; Haag-Wackernagel and Moch 2004; Haag-Wackernagel and Śpiewak 2004; Gibbs et al. 2006; Graczyk et al. 2007; Avery et al. 2008; Magnino et al. 2009; Salant et al. 2009; Silva et al. 2009; Haag-Wackernagel and Bircher 2010; Rosario et al. 2010

A8.2.2 Dicrurus macrocercus: Established on Guam and Rota

Common names: black drongo, drongo, king crow

Synonymous scientific names: no information found in the literature

Adult description: 22.5 to 31 cm (11 to 12.4 in); 38 to 59 g (1.34 to 2.08 oz); black with a bluish gloss; red eyes; usually white spot on nape; prominent rictal bristles; tail deeply forked; bill black.

Reproduction: breed mainly February to August; amount of eggs variable; 2 to 5 eggs.

Habitat: open country, marshes, roadsides, cultivated areas, cities, and towns

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: thought to be responsible for decline of some small passerines in the Marianas

Pathways: intentional, natural spread

Control measures: no information found in the literature

References: Long 1981

A8.2.3 Francolinus francolinus

Common names: black francolin, black partridge, Indian black francolin

Synonymous scientific names: none

Adult description: females lighter than males; mostly black below and rufous brown above; crown to nape rufous brown; eye region is black; cheeks and ear-coverts are white; prominent broad chestnut collar on dorsal surface of neck surrounded by white-spotted black feathers; feathers of nape distinctly mottled black and white; back is brown; lower back, rump, chin, throat, and area below the ear-coverts are black; breast is black with oval white spots on sides and flanks; lower breast and thighs are black to reddish brown with large white spots or bars; center of abdomen and vent are lighter chestnut with whitish bars.

Reproduction: may produce two clutches in India; generally nests in well-concealed areas; ground-nesting; nest consists of a shallow scrape or depression on the bare ground which may or may not be lined sparingly with grass, stems, twigs, leaves, or feathers; eggs are short-subelliptical to short oval and are smooth and glossy; egg coloration dependent on habitat but are pale olive brown to chocolate brown and often have white specks of calcareous deposits; clutch size is usually 6 to 8 eggs; incubation lasts approximately 18 days; hatchlings are precocial.

Habitat: habitat generalist; dry grasslands, open pasturelands, dry scrubland and savanna, well-vegetated habitats, and areas adjacent to fields

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: alternative prey source for BTS

Pathways: introduced as a game bird, natural spread

Control measures: no information found in the literature

References: Long 1981; Conry 1988b; Islam 1999; Birdlife International 2009a

A8.2.4 Lonchura malacca

Common names: tricolored munia, black-headed munia, chestnut-breasted munia, chestnut mannikin, black-headed mannikin

Synonymous scientific names: none

Adult description: upper parts brown; rump reddish brown; head, neck, and breast black, underparts brown with a black or white patch in the center of the abdomen; vent, thighs, and under tail-coverts black; upper tail-coverts and tail yellow to orange-red; bill silver-grey or slaty blue

Reproduction: nest is a ball of coarse grass lined with finer grass and contains a lateral entrance hole at the end of a short spout; nest in low bushes, trees, or grass tussocks; clutch size is 4 to 8 eggs

Habitat: forests, shrublands, wetlands, arable lands, plantations.

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: damage rice

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: pet trade, natural spread

Control measures: hazing, glue-coated perches

References: Reidinger and Libay 1979; Long 1981; Birdlife International 2009b

A8.2.5 Padda oryzivora: established in Hawai'I and an incipient population on Guam

Common names: Javan finch, Java sparrow, rice or paddy bird

Synonymous scientific names: no information found in the literature

Adult description: 14.5 to 16 cm (5.8 to 6.4 in); head, chin, upper throat, band behind ear-coverts; upper tail-coverts and tail black; sides of face to ear-coverts and under tail-coverts white; remainder grey; belly and lower flanks vinous; bill pink; pure-white form can occur.

Reproduction: may breed seasonally or year-round depending on location; colonial; nests are bell-shaped or domed with a side entrance and are located 1 to 18 m (3.3 to 60 feet) above ground in natural and artificial crannies; eggs are white, oval, and matte; clutch size: 3 to 8 eggs; may produce a second brood; both sexes incubate; incubation lasts 13 to 15 days; hatchlings are altricial; fledging occurs in 15 to 17 days

Habitat: rice fields, villages, cities, mangroves, open country, and scrub; largely in association with man.

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: destroy agricultural crops, especially rice fields.

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: intentional, escaped, imported, religious, ship

Control measures: no information found in the literature

References: Long 1981; Lever 1987; Islam 1997

A8.2.6 Passer domesticus: established in Hawai'i

Common names: English sparrow, European sparrow, house sparrow

Synonymous scientific names: no information found in the literature

Adult description: 14.3 to 15.5 cm (5.72 to .2 in). 25 to 37 g (0.88 to 1.3 oz); crown, nape, and lower back dark grey; lores black; nape through eye brown; white stripe over eye; back brown streaked black; wings brown with a single white bar on middle coverts; throat and breast black; cheeks and sides of neck white; belly whitish or grayish; tail dull brown; bill black. Female: generally lacks as much black on throat; upper parts dusky brown; bill brown.

Reproduction: breed all year; 2 to 3 or more broods per year; breeding times depend on area; clutch size usually 2 to 7 eggs; eggs are glossy and smooth and are oval to long-oval in shape; the eggs are white to greenish white or bluish white with dots or spots of grays or browns particularly around the larger end; nests consist of dried vegetation and are often found in enclosed spaces; incubation lasts 10 to 14 days; hatchlings are altricial; fledging occurs at 14 days.

Habitat: open forest, wooded country, grasslands, cultivated areas, parks, gardens, cities, towns, and everywhere there is human settlement.

Human health impacts: cause contamination with droppings, and help spread human disease, such as toxoplasmosis, WNV, chlamydiosis, coccidiosis, salmonellosis, transmissible gastroenteritis, shistosomiasis, and trichomoniasis.

Economic impacts: does harm in arable areas and lands adjacent to these areas, damage wheat and other cereals, damage vegetable crops, dig up newly sewn seeds, eat fruit crops, block drain and water pipes with nesting materials, distribute poultry cestodes and nematodes

Ecological impacts: displace some indigenous insectivorous birds

Pathways: biocontrol, intentional, ships, cargo vessels, grain boats, followed horses and their food, natural spread

Control measures: exclusion, removal of roosting sites, hazing, repellents, toxicants, trapping, shooting, and changes in agricultural practices.

References: Long 1981; Pascual et al. 1999; Komar et al. 2005; Lowther and Cink 2006; Une et al. 2008; Gondim et al. 2010

A8.2.7 Passer montanus

Common names: tree sparrow

Synonymous scientific names: no information found in the literature

Adult description: 11.6 to 15 cm (4.64 to 6 in.); 17 to 27 g (0.6 to 0.95 oz); crown and back of head chestnut; lores, line beneath eye to above ear-coverts, chin and throat black; ear-coverts white, with black patch; neck almost surrounded by white collar; upper parts brown, streaked black; underparts whitish or ashy; rump, upper tail-coverts and tail buffish brown, wing with two white bars; bill brown or grayish.

Reproduction: Breed December to June (September to January in Australia); often colonial; 2 to 3 clutches per year; nests are domed and consist of loosely intertwined stems of grass, straw, and roots surrounding a cup lined with soft material (feathers, fur, flower parts, waste paper, cloth, string, green leaves); nest has a side entrance; nests in cavities or dense foliage; clutch size is 4 to 7 eggs; eggs are subelliptical, slightly glossy, and smooth; eggs are white to pale gray and are heavily marked with spots, blotches, or speckling of dark brown, purple, or gray (usually heavier on broad end); incubation is approximately 12 days; hatchlings are altricial; fledging occurs around 14 days.

Habitat: wooded regions, open fields, grasslands, parks, gardens, orchards, villages, and towns.

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: damage crop fields; cause damage when grain is drying, being threshed, fed to domestic animals and stored in open grain bins; spoil grain with their manure; cause damage to fruit crops; damage young vegetable seedlings and leaves; cause damage to houses by nesting in them; compete for food with domestic poultry

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: intentional, ship, boat, steamboat

Control measures: no information found in the literature

References: Long 1981; Lever 1987; Barlow and Leckie 2000

A8.2.8 Pycnonotus jocosus: Established in Hawai'I, Fiji, and Majuro

Common names: Red-eared Bulbul, Red-whiskered Bulbul

Synonymous scientific names: no information found in the literature

Adult description: 17.3 to 22 cm (6.92 to 8.8 in); 23 to 42 grams (0.81 to 1.48 ounces); upper parts brown, with crested blackish crown a red patch behind eye; cheeks and throat white; a broken blackish or dark brown band from breast around sides of neck; underparts grayish white; under tail-coverts red; tail brown, tipped white; bill black.

Reproduction: variable, January to August; 2 to 3 broods per season; nests are cup-shaped and consist of rootlets, twigs, dead leaves, and grasses bound by cobwebs on the outside; the nest cup is lined with hair, soft fibers, rootlets, and fine materials; clutch is 2 to 5 eggs; eggs are short oval in shape, and are smooth with little or no gloss; eggs are pale pink to reddish white marked with numerous reddish-brown blotches, spots, and streaks with secondary markings of pale, inky purple; spots on the eggs may form a ring or cap around the broad end; incubation lasts 10 to 14 days; hatchlings are altricial; fledging occurs in approximately 12 days.

Habitat: forest edges, secondary growth, woodland, cultivation, parklands, gardens, and villages.

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: Not great pests in native range; in non-native range reported damage fruits, vegetables, and flowers; may spread seeds of invasive plants and facilitate germination of those seeds by passage through the gut

Ecological impacts: compete with mockingbirds for berries in Florida

Pathways: Natural spread, escaped, intentional, unauthorized release, ship

Control measures: repellents

References: Long 1981; Lever 1987; Cummings et al. 1994; Islam and Williams 2000; Mandon-Dalger et al. 2004; Linnebjerg et al. 2009

A8.2.9 Streptopelia bitorquata dusimieri

Common names: Java ring dove, Javan collared dove, Javan turtledove, Javanese collared dove, Philippine turtle-dove

Synonymous scientific names: *Streptopelia bitorquata*

Adult description: 30 cm (12 in); forehead, crown, and nape grey; broad black, white-edged, half collar on hindneck; remainder of neck and upper mantle pinkish, often with rusty tinge; breast mauvish pink; belly and under tail-coverts white or grayish-white; flanks grayish; back brown; primaries and secondaries blackish, remainder of wing blue-grey; rump dark grey-brown; central tail-feathers brown, outer feathers pale grey with basal third dark grey, under tail grayish white with basal third black; bill blackish or dark grey, red at nape.

Reproduction: April to August (eastern Java); Eggs: 2

Habitat: habitat generalist; forest edges, open country with trees, villages, fields, and cultivation.

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: intentional

Control measures: no information found in the literature

References: Long 1981; USGS 2005b

A8.3 Mammals

A8.3.1 Clethrionomys rutilus

Common names: red-backed vole, red-backed mouse, northern red-backed vole, northern red-backed mouse

Synonymous scientific names: *Myodes rutilus*

Adult description: head and body 80 to 110 mm (3.2 to 4.3 in) in length; tail 23 to 44 mm (0.9 to 1.7 in) in length; weight 14.2 tp 42.6 g (0.5 to 1.5 oz); sides of body yellow; upper parts bright reddish to rufous; ear brown; dorsum red, or dark brown to blackish; tail densely furred; under tail yellow; feet whitish or buff.

Reproduction: breed from April to October; gestation is 17 to 20 days; litter size is 1 to 8 pups; produce 3 to 4 litters per year; young are born naked and helpless; young weaned at 3 to 4 weeks; mature at 3 to 4 months

Habitat: habitat generalist; forest and taiga, grassland, tundra, woodland, forest, buildings, around decaying stumps.

Human health impacts: reservoir for tularemia, Lyme disease

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: may damage trees

Pathways: plants and nursery trade, with firewood

Control measures: exclusion, habitat modification, zinc phosphide, anticoagulants, trapping

References: Nakao et al. 1994: O'Brien 1994: Berdal et al. 1996: Long 2003: Tobin and Fall 2004: Linzey et al. 2008

A8.3.2 Didelphis marsupialis

Common names: American opossum, black-eared opossum, southern opossum, Virginia opossum

Synonymous scientific names: *Didelphis virginiana*

Adult description: head and body 300 to 584 mm (11.8 to 23 in) in length; tail 255 to 535 mm (10 to 21 in) in length; weight 136 to 504 g (4.8 to 17.8 oz); females smaller than males; fairly heavy-bodied; pointed muzzle with pink nose pad; face is white with black patches around eyes; short, black legs with white toes; coloration varies regionally, ranging between grey, black, brown, reddish, and rarely white; prehensile tail; fur-lined pouch on abdomen of females

Reproduction: breeds year-round with peaks in January to March and May to July; 1 to 2 litters per year; gestation 8 to 13 days; 4, 8 to 18, or 25 young per litter, but must find mammae to survive; young develop in pouch for 2 months; weaned at 90 to 100 days; males sexually mature at 8 months, females at 6 months

Habitat: habitat generalist; forest, brush areas, woods near streams, cultivated areas with trees; prefers areas with hollow trees; common in suburban and agricultural areas

Human health impacts: carriers of parasites that affect public health and poultry; reservoir for leishmaniasis, toxoplasmosis, tularemia, relapsing fever, leptospirosis, and Rocky Mountain spotted fever

Economic impacts: predation on poultry, eat vegetable and corn crops

Ecological impacts: predation on birds, such as the ground dove, possibly causing local extinctions;

Pathways: cargo, boat, escape, intentional, natural spread

Control measures: exclusion, habitat modification, trapping, shooting

References: Barr 1963; Henry 1969; McManus 1974; Lins and Lopes 1984; Jackson 1994; Carme et al. 2002; Long 2003; Yai et al. 2003; Schallig et al. 2007

A8.3.3 Herpestes javanicus: Established in Hawai'I and Fiji

Common names: Indian mongoose, small Indian mongoose

Synonymous scientific names: *Herpestes auropunctatus*

Adult description: head and body of males 250 to 350 mm (10 to 13.8 in) in length; tail 200 to 310 mm (8 to 12 in) in length; tail shorter than head and body length; weight 312 to 1,300 g (11 to 46 oz); females smaller than males; body slender with short legs; elongated head with a pointed muzzle; tail has a muscular base; coloration ranges from buff to dark gray-brown; coat has a speckled or grizzled appearance

Reproduction: 2 liters per year; gestation 42 to 43 days; 1 to 5 young per litter, with an average of just over 2; altricial; weaned at 4 to 5 weeks; sexually mature in first year

Habitat: open dry bush and savannah; cultivated and disturbed areas; near villages; lives in burrows and crevices but climbs well

Human health impacts: carries diseases transmissible to humans and pets, including rabies, leptospirosis, canine distemper, canine hepatitis, toxoplasma, salmonella, feline panleukopenia, streptococcus, and pulmonary virus

Economic impacts: predation on poultry, eggs, and small livestock

Ecological impacts: predation on native wildlife, causing the near extinction of many ground-dwelling species of frogs, reptiles, mammals and ground-nesting birds

Pathways: biocontrol, intentional, natural spread

Control measures: trapping, poisoning (diphacinone), and bounties

References: Baker and Russell 1979; Nellis and Small 1983; Coblentz and Coblentz 1985; Nellis 1989; Smith et al. 2000; Krebs et al. 2003; Long 2003; Morley 2004; Blanton et al. 2006; Hays and Conant 2007; Watari et al. 2008; Leighton et al. 2009; ISSG 2010

A8.3.4 Macaca fascicularis

Common names: Crab-eating Macaque. Long-tailed Macaque, Cynomolgus Monkey, Kera

Synonymous scientific names: *M. cynomolgus* or *M. irus*

Adult description: Body length in adult 38-55 cm with comparable short arms and legs. Tail is longer than body, 40-60 cm. Females weight 3-6 kg, while males range from 5-9 kg . "In addition to being taller and heavier, males have much larger canine teeth than females. Macaques have cheek pouches in which they can store food as they forage, and transport it away from the foraging site to eat." (Cawthon Lang K.A., 2006). Life span 31 years.

Reproduction: Gestation ranges from 167 to 193 days. Females give birth to one infant.

Habitat: "Long-tailed macaques live in primary, secondary, coastal, mangrove, swamp, and riverine forests from sea level up to elevations of 2000 m (6561 ft). They prefer forested areas near water and are found in higher densities near riverbanks, lakeshores, or along the seacoast. They preferentially utilize secondary forest, especially if it borders human settlement, where they have access to gardens and farms to crop-raid. Long-tailed macaques are widespread throughout the islands of Southeast Asia into mainland Asia." (Cawthon Lang K.A., 2006)

Human health impacts: Carrier of B-virus (Cercopethecine herpesvirus 1), which can be transmitted to humans, and is estimated to be lethal in 70-80% of untreated human cases (Cohen et al. 2002). Most macaques carry B virus without any overt signs of disease (Huff & Barry 2003). Macaques bite and scratch humans, which can result in traumatic injury, and can lead to serious infections. They can also carry a number of other human and zoonotic diseases, and, "in addition to viruses that have been identified, there is the potential for previously unknown diseases to transfer from the monkeys to humans posing a serious health risk to nearby communities and beyond." (Cawthon Lang K.A., 2006)

Economic impacts: In their native range, they are known as crop raiders, having impacts on agriculture, including fruit crops, root crops such as cassava and sweet potato, and many others. These macaques also enter houses when people are not at home and raid food and damage clothing, etc. On the island of Angaur, where they are introduced, these macaques have made crop production virtually impossible, except for small gardens next to people’s homes, and even these are damaged when the residents are away from home.

Ecological impacts: Known predator of bird nests; populations of several native birds on the island of Angaur in Palau have been severely impacted – either severely reduced in population or completely absent. These macaques also prey on insects and small reptiles, as well as small crustaceans, but their impact on these species is unknown. Since they are largely frugivorous, they contribute to the spread of seeds of some tree species, and can perhaps alter forest composition and structure. “Where they forage in mangroves, long-tailed macaques spend time consuming crabs and have also been seen eating frogs, shrimp and octopus.” (Cawthon Lang K.A., 2006)

A8.3.5 Microtus californicus

Common names: California vole, California meadow vole, Amargosa vole

Synonymous scientific names: none

Adult description: 139 to 207 mm (5.5 to 8 in) total length; tawny olive to cinnamon brown with brown to black overhairs; grayish underparts; bicolored tail; pale feet

Reproduction: can breed every 3 weeks in good conditions; breeding season varies depending on region; year-round breeders in coastal populations; nests are located under logs, boards, or a few centimeters under the earth’s surface; nests are made with dried grasses and forbs; produce 1 to 11 offspring; gestation lasts approximately 22 days; young are altricial at birth; young weaned in approximately 2 weeks; young generally independent at 2 weeks; sexual maturity at approximately 3 weeks for females and 5 weeks for males.

Habitat: broad-leafed chaparral, oak woodlands, grasslands, marshy ground, wet meadows, coastal wetlands, agricultural areas, and dry, grassy hillsides.

Human health impacts: vectors of plague, tularemia, hantavirus, and Lyme disease

Economic impacts: girdle seedlings and mature trees; damage or destroy crops such as alfalfa, clover, grain, potatoes, and sugar beets; damage irrigation systems; damage lawns, golf courses, and ground covers

Ecological impacts: girdle seedlings and mature trees; may compete with other rodents

Pathways: nursery trade

Control measures: exclusion, habitat modification, repellents, zinc phosphide, anticoagulants, trapping

References: Greenwald 1956; Jameson Jr. 1958; Stark 1963; Kartman and Hudson 1971; Hudson et al. 1972; Heske et al. 1984; O'Brien 1994; Song et al. 1995; Bennett et al. 1999; Peronne 2002; Long 2003; Vredevoe et al. 2004; Álvarez-Castañeda et al. 2008

A8.3.6 Mus musculus

Common names: common mouse, house mouse

Synonymous scientific names: *Mus domesticus*

Adult description: head and body 70 to 102 mm (2.8 to 4 in) in length; tail 65 to 95 mm (2.6 to 3.7 in) in length; weight 8.5 to 41.5 g (0.3 to 1.5 oz); body brownish grey with a paler venter; coloration ranges from light brown to dark grey; ears and muzzle pointed; large eyes; the semi-naked tail is as long as the head and body

Reproduction: r-selected with high reproductive capacity; often continuous breeding; generally 6 to 8 litters per year, but can be as high as 11; gestation 13 to 31 days; 4 to 12 young per litter; altricial; weaned at 21 days; sexually mature in 3 to 8 weeks

Habitat: habitat generalist; found in every habitat type and on every continent, including Antarctica; found especially in human-inhabited places; can maintain populations in extreme conditions; island populations often thrive even more than those on the mainland

Human health impacts: reservoir for various disease organisms and parasites that can affect humans such as plague, salmonella, leptospirosis, toxoplasmosis, and rickettsial pox

Economic impacts: agricultural damage, especially to grains and legumes; consumption and contamination of stored foods and livestock feed; nuisance noise, odors, and droppings; economic costs due to damage to insulation, wiring, and farm machinery

Ecological impacts: predation on native plants and wildlife, including seabird chicks and eggs, invertebrates, and reptiles; extinction of native island vertebrates

Pathways: aircraft, boat, cargo, escape, natural spread, vehicle

Control measures: anticoagulants, fumigants, traps, repellents, exclusion

References: Timm 1994a: Long 2003: Witmer and Jojola 2006: Meerburg et al. 2009: ISSG 2010

A8.3.7 Myotis lucifugis

Common names: little brown bat, little brown myotis

Synonymous scientific names: *Myotis lucifugus*

Adult description: 60 to 102 mm (2.4 to 4 in) in length; 222 to 269 mm (8.7 to 10.6 in) wingspan; weight 5 to 14 g (0.2 to 0.5 oz); pale tan through reddish brown to dark brown depending on geographic location; ventral side is lighter in color; fur is glossy and sleek

Reproduction: produce 1 to 2 offspring; gestation lasts 50 to 60 days; young are weaned at 3 to 4 weeks; young are independent at 4 weeks; sexual maturity at approximately 7 months

Habitat: habitat generalist; buildings, trees, under rocks, in piles of wood, abandoned mines or caves, forested lands near water

Human health impacts: reservoirs for coronavirus, polyomavirus, rabies; guano is associated with histoplasmosis, associated with bat-aircraft strikes

Economic impacts: may roost in dwellings associated with humans leaving rub marks, guano, and urine; noise may be bothersome to some people; associated with bat-aircraft strikes

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, ships, aircraft, natural dispersal

Control measures: exclusion, repellents, trapping

References: Fenton and Barclay 1980; Burnett 1989; Greenhall and Frantz 1994; Constantine 2003; Havens and Myers 2006; Arroyo-Cabrales and Castaneda 2008; Misra et al. 2009; Peurach et al. 2009

A8.3.8 Pipistrellus javanicus

Common names: Javan pipistrelle

Synonymous scientific names: *Pipistrellus babu Thomas, 1915; Pipistrellus camortae Miller, 1902; Pipistrellus peguensis Sinha, 1969; Scotophilus javanicus Gray, 1838*

Adult description: 75 to 90 mm (3 to 3.5 in) total length; weighs 4 to 7 g (0.1 to 0.2 oz); dark brown fur that is darker at the base; fur is lighter ventrally; flat head with a broad muzzle that appears swollen; short ears

Reproduction: have 3 breeding seasons; produce 2 offspring/breeding season

Habitat: habitat generalist; common in urban and agricultural areas; primary and secondary lowland montane forest, caves

Human health impacts: associated with bat-aircraft strikes

Economic impacts: associated with bat-aircraft strikes

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, ships

Control measures: no information found in the literature

References: Daniel and Yoshiyuki 1982; Constantine 2003; Bates et al. 2005; Francis et al. 2008; Peurach et al. 2009

A8.3.9 Rattus exulans

Common names: kiore, little rat, Maori rat, Pacific rat, Polynesian rat

Synonymous scientific names: *Mus exulans, Mus maorium*

Adult description: head and body 80 to 140 mm (3.2 to 4.1 in) in length; tail 108 to 147 mm (4.3 to 5 in) in length; weight 30 to 180 g (1 to 6 oz); dorsum brown or grey brown, venter whitish; pointed muzzle and large ears; tail dark with fine scales; smaller than the black and Norway rats

Reproduction: breeds year-round, peaks in spring to late summer; 1 to 6 or more litters per year; gestation 19 to 30 days; altricial; weaned at 4 weeks; mature in 8 to 12 months

Habitat: habitat generalist; bush, scrub, grassland, forest; under logs and rocks; houses, clearings, gardens, paddy fields

Human health impacts: carries zoonotic diseases including leptospirosis, plague, lungworm, and others; create breeding sites for mosquitoes by knocking coconuts to the ground

Economic impacts: damages rice, maize, sugarcane, coconut, cacao, pineapple, mangoes, passion fruit, paw paw, cassava, kumarans, and root crops

Ecological impacts: preys on native birds, lizards, and turtle eggs; consumption of native flora

Pathways: boat, cargo, food

Control measures: habitat alteration, snap traps, zinc phosphide, anticoagulants, compound 1080 not effective

References: Kepler 1967; Tobin 1994; Vickery 1994; Spennemann 1997; Robinet et al. 1998; Campbell and Atkinson 1999; SPREP 2000; Atkinson and Towns 2001; Worthy and Holdaway 2002; Long 2003; Meerburg et al. 2009; ISSG 2010

A8.3.10 Rattus norvegicus

Common names: brown rat, common rat, Norway rat

Synonymous scientific names: none

Adult description: head and body 165 to 280 mm (6.5 to 11 in) in length; tail 122 to 230 mm (4.8 to 9 in) in length; weight 120 to 580 g (4.2 to 20.4 oz), up to 909 g (32 oz); robust body; coloration grey to grayish brown on dorsum, with a white venter; ears, feet and tail flesh-colored; blunt muzzle and small ears and eyes

Reproduction: breeds year-round; 6 litters per year; gestation 20 to 26 days; 5 to 10, and up to 22, young per litter; altricial; weaned at 28 days; mature in 3 to 4 months

Habitat: habitat generalist; found everywhere except deserts and polar regions

Human health impacts: consumption and contamination of stored foods; chew through power cables; fleas are vectors of plague; vector of hantavirus

Economic impacts: damage to sugarcane;

Ecological impacts: reduced Canada goose populations in the Aleutian Islands; decimation and extinction of native plant, mammal, reptile, bird and invertebrate populations

Pathways: boat, natural spread, seafreight (container/bulk)

Control measures: exclusion, habitat modification, toxicants, fumigants, traps

References: Timm 1994b; Long 2003; Meerburg et al. 2009; ISSG 2010

A8.3.11 Rattus rattus

Common names: black rat, house rat, roof rat, ship rat

Synonymous scientific names: none

Adult description: head and body of males 165 to 254 mm (6.5 to 10 in) in length; tail 140 to 252 mm (5.5 to 10 in) in length; weight 85 to 350 g (3 to 8.8 oz); sleek body; coloration blue-black, black or brown on dorsum and grey, buff, or whitish on venter; pointed muzzle with black snout; large eyes and ears; black or brown tail, mostly naked with fine scales; feet with five toes; similar to the Asian house rat (*Rattus tanezumi*)

Reproduction: breeds year-round; 5 to 6 litters per year; gestation 21 to 30 days; 1, 5 to 8, or 12 young per litter; weaned at 21 to 28 days; sexually mature in 3 to 4 months; polygamous; makes a spherical nest of loose vegetation and other material

Habitat: habitat generalist; not found in deserts; prefers rivers, streamsides, and human-inhabited areas, such as orchards and gardens

Human health impacts: reservoir of zoonotic diseases, including leptospirosis and trichinosis; rat fleas are vectors for pasteurella, murine typhus, and plague

Economic impacts: agricultural damage to poultry operations and crops such as rice, sugarcane, coconut and macadamia orchards; consumption and contamination of stored foods; economic costs from damage to structures and materials

Ecological impacts: predation on and extinction of native rats, bats, turtles, tortoises, and endemic birds

Pathways: cargo, natural dispersal, seafreight (container/bulk), road vehicles

Control measures: Exclusion, habitat modification, toxicants, fumigants, traps

References: Marsh 1994; Vanderwerf 2001; Long 2003; Meerburg et al. 2009; ISSG 2010

A8.3.12 Rattus tanezumi

Common names: Asian house rat, Oriental house rat, tanezumi rat

Synonymous scientific names: *Rattus rattus mindanensis*

Adult description: males about 191 mm (7.5 in) in length; females about 182 mm (7 in) in length; weight 150 to 280g (5.3 to 10 oz); males larger; reddish to grayish brown or darker dorsum; lighter venter; morphologically similar to the black rat; *R. tanezumi* females have 5 pairs of teats in a different configuration than the 6 pairs found on *R. rattus* females; the two species are separated based on genetic analysis

Reproduction: breeds during growth of rice crops; gestation 21 to 29 days; 4 to 10, with an average of 7 young per litter; polyestrous, possibly up to 6 litters per year; females sexually mature at 2 to 4 months

Habitat: habitat generalist; disturbed lowlands, grasslands, shrublands, various forests; especially found in human-inhabited areas, including agricultural lands, villages, gardens, and urban areas

Human health impacts: reservoir for hanta virus, Bartonella, scrub typhus, leptospirosis, and Cryptosporidium

Economic impacts: damage to rice, sugarcane, and coconut crops; consumption and contamination of stored foods; consumption of livestock feed

Ecological impacts: likely preys on birds and bird eggs

Pathways: unknown

Control measures: removal; zinc phosphide, racumin; clearing vegetation; scrub burning; fencing; research being conducted: timing of application (just prior to the breeding season), cost-benefit analysis (Control measures beneficial when crop losses exceed 5%), trap-barrier systems

References: Coleman et al. 2003; Long 2003; Singleton et al. 2003; Tobin and Fall 2004; Wilson and Reeder 2005; Li et al. 2007; Miller 2007; Stuart et al. 2007; Heaney and Molur 2008; Jittapalapong et al. 2009; Lv et al. 2009; Meerburg et al. 2009; Plyusnina et al. 2009; Johansson et al. 2010

A8.3.13 Suncus murinus: Established on Guam and in the CNMI

Common names: Asian musk shrew, brown musk shrew, house shrew, Indian musk shrew, large musk shrew, money shrew, musk shrew

Synonymous scientific names: *Crocidura murina, Sorex murinus, Suncus caeruleus*

Adult description: head and body 50 to 150 mm (2 to 6 in) in length; tail 46 to 100 mm (1.8 to 4 in) in length; weight of males 30 to 147 g (1 to 5 oz), females 20 to 82 g (0.7 to 2.9 oz); females smaller; coloration pale grey to brown or black with lighter venter; long, pointed nose; prominent, round, human-like ears; mostly naked tail with thick base and thin tip; musky odor from sweat glands on throat and behind ears

Reproduction: breeding varies from seasonal to year-round, depending on location; gestation 29.6 to 30.3 days; 1 to 6 or 8 young per litter; altricial; sexually mature at 36 days

Habitat: habitat generalist; open grassy areas, swamps, pond margins, grassland, deserts, and human-inhabited areas, such as houses, warehouses, drains, croplands, and gardens

Human health impacts: reservoir for plague, hantavirus, Q fever, and probably salmonella; nuisance odors

Economic impacts: consumption of stored foods; possible predation on poultry; damage to seeds, young plants, and grass

Ecological impacts: competition and predation on invertebrates and vertebrates (particularly lizards); damage to seeds, young plants, and grass

Pathways: biocontrol, boat, cargo, seafreight (container/bulk), vehicle

Control measures: exclusion, habitat alteration, traps, anticoagulants

References: Cavanaugh et al. 1969; Yadav et al. 1979; Rodda and Fritts 1992; Fritts and Rodda 1998; SPREP 2000; Varnham et al. 2002; Long 2003 Duplantier et al. 2005; Seymour et al. 2005; Henttonen et al. 2008; Meerburg et al. 2009; ISSG 2010

A8.4 Reptiles: Some species missing from the follow list of possible reptile invaders include Iguana iguana (a known invader in Puerto Rica, Florida, Fiji and other locations with at least one individual having been found on Guam) and Varanus indicus (which is known from some islands of Micronesia but not all suggesting that it might be able to travel and establish on current monitor free islands if permitted). There are probably other species which should also be added to this list.

A8.4.1 Agama agama

Common names: African red-headed Agama, Agama lizard, common agama, rainbow lizard

Synonymous scientific names: *Agama boensis, Agama colonorum, Agama picticauda, Agama smithii, Lacerta agama, Oreodeira gracilipes, Tropidolepis africanus*

Adult description: whitish underside; buff brown back limbs and tail with a slightly lighter stripe down the middle and six to seven dark patches to the side of this stripe. There is some sexual dimorphism. The subordinate males, females, and adolescents possess an olive green head. A blue body and yellow tail and head characterize the dominant male. Has a large head separated from the body, a long tail, well-developed external ear openings and eyelids. The maximum size for male lizards is 25 cm (9.8 in); female lizards are 20 cm (7.9 in) in length.

Reproduction: Females reach sexual maturity at age fourteen to eighteen months, males at two years; reproduce during wet season although are capable of reproducing nearly year round in areas of consistent rainfall; female lays her eggs in a hole she digs with her snout and claws; hole is five centimeters deep and is found in sandy, wet, damp soil that is exposed to sunlight nearly all day and covered by herbage or grasses; eggs are usually laid in clutches ranging from five to seven ellipsoidal eggs; thermoregulated embryo species resulting in all males at 29° C and all females at 26 to 27° C eggs hatch within 8 to 10 weeks. Hatchlings will be between 3.7 and 3.8 cm (1.5 in) snout-vent plus their 7.5 cm (3 in) tail. They will almost immediately start eating rocks, sand, plants, and insects.

Habitat: habitat generalist; any area with enough vegetation for reproduction (including human inhabited areas).

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, pet trade

Control measures: no information found in the literature

References: Hilgris 2000; Lever 2003; Kraus 2009; Uetz 2010

A8.4.2 Anolis carolinensis: already established in parts of the region

Common names: Green anole

Synonymous scientific names: *Anolis bullaris, Anolis porcatus, Anolis principalis, Dactyloa (Ctenocercus) carolinensis, Lacerta principalis*

Adult description: between 127 to 203 mm (5 to 8 in) in length; females are smaller than males; ability to change color; color depends on mood, temperature, humidity and health; resting or content anoles are brown or bright green; they are darker in color when cold, and pasty gray when overly warm. Females have a light vertebral line; displaying males can erect a low vertebral crest on the nape and anterior trunk. They have adhesive lamellae on their foot pads; tails and bodies are long and slender, and their heads have pointed snouts; keeled scales; rounded tail that is longer than snout-vent length (75 mm).

Reproduction: One egg is laid at 14 to 17-day intervals throughout the warm months of the year; eggs need moist soil and foliage; incubation varies between just over a month and 2 months. Breeds from March to October.

Habitat: habitat generalist; arboreal; favors tall native grasses, shrubs, and trees. Requires greenery, some shade and a moist environment; also can be found on walls and fences.

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: decline of native insects such as buprestid, cerambycid, cucurlionid, and melandryid beetles; lycaenid and papilionid butterflies; bees; and odonates.

Pathways: nursery trade, pet trade, biocontrol

Control measures: no information found in the literature

References: Stevenson 1976; Jenssen et al. 1996; Bartlett and Bartlett 1999; Smith 1999; Abe et al. 2008; Kraus 2009; Uetz 2010

A8.4.3 Anolis cristatellus

Common names: crested anole, Puerto Rican crested anole, greater Antillian anole

Synonymous scientific names: *Anolis cozumelae, Anolis lindeni, Ctenonotus cristatellus, Ptychonotus (Istiocercus) cristatellus, Xiphosurus cristatellus*

Adult description: medium-sized anole; trunk-ground ecomorph. Females can reach 50 mm (2 in) in snout to vent length. Males may reach 74 mm (3 in) in length and have dark-bordered dewlaps that range in color from olive-green to yellow or orange. Males typically have a wavy tail crest, and the vertebral and nape crests can be erected by muscular contraction. The dorsal color ranges from olive-tan to almost black, with lighter colored anoles exhibiting dark bars or blotches on the trunk and tail.

Reproduction: reproductive seasonality observed; seasons depend on elevation, photo thermal period and temperature; ample rainfall is not an indicator of successful clutch survival.

Habitat: habitat generalist; native to dry forests but can adapt to any habitat; montane habitats, shrubs, fence posts, building walls, brush piles, and rock piles; open areas in higher elevations; Low density suburban development, areas peripheral to core urban areas; small towns, agricultural habitat, and recently disturbed, early successional community; ability to shift and modify structural habitats in response to competitive interactions thus displacing less adaptable anoles

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: possible displacement of native Anolis species

Pathways: cargo, intentional, pet trade escapees

Control measures: no information found in the literature

References: Gorman and Licht 1974; Light 1974; Genet 2002; Malhotra et al. 2007; Kraus 2009; FLFWCC 2010b; Uetz 2010

A8.4.4 Anolis distichus

Common names: Bahaman Bark Anole, bark anole, Hispaniolan gracile anole

Synonymous scientific names: *Anolis distichoides, Anolis dominicensis*

Adult description: smaller scales than other lizards; granular, double row of unkeeled scales on the back; blunter head; protruding eyes; dark crossbar between the eyes and four dark Vs on the back; yellowish dewlap; snout-vent length about 40 mm (1.6 in); tail somewhat longer.

Reproduction: no information found in the literature

Habitat: shaded, covered areas; forests; trunk ecomorph (middle of tree trunks); uses steep, long perches

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: competition with native anoles

Pathways: cargo, intentional, nursery

Control measures: no information found in the literature

References: Stevenson 1976; Williams and Case 1986; Lever 2003; Mattingly and Jayne 2004; Kraus 2009; Uetz 2010

A8.4.5 Anolis extremus

Common names: Barbados anole

Synonymous scientific names: *Anolis roquet*

Adult description: males can reach 83 mm (3.3 in) snout-vent length and females can reach 60 mm (2.4 in) snout-vent length. females are smaller and less colorful than males. Olive-brown to olive-green in color, and patterned with dark blotches and light spots; greenest on the sides and posterior dorsum. The venter is a sunny yellow, and the head is gray to gray-brown.

Reproduction: no information found in the literature

Habitat: closed areas; edges; inhabits darker, more shaded places in patchy habitats. Trunk-ground species; residential areas with plant cover (such as ornamental palms and citrus trees)

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: may displace native anoles

Pathways: cargo, pet trade, research

Control measures: no information found in the literature

References: Schoener 1970; Bartlett and Bartlett 1999; Kraus 2009; Uetz 2010

A8.4.6 Anolis porcatus

Common names: Cuban green anole

Synonymous scientific names: *Anolis principalis*

Adult description: not found

Reproduction: reproductive seasonality; reproduce during rainy season; oviductal eggs form in April; ovulation occurs April to October; clutch size of one egg;

Habitat: uses the trunk and canopy of trees from 1 to 6 m (3.3 to 19.7 feet) above the ground; Low density suburban development, areas peripheral to core urban areas, and small towns

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: possible competition with other anoles

Pathways: cargo

Control measures: no information found in the literature

References: Ochotorena et al. 2005; Kraus 2009; FLFWCC 2010a; Uetz 2010

A8.4.7 Anolis sagrei: established in Hawai'i

Common names: brown anole, Cuban brown anole

Synonymous scientific names: *Norops sagrei*

Adult description: males can reach up to 64 mm (2.5 in) weighing 6 to 8g (0.2 to 0.3 oz); females only reach up to 48 mm (1.9 in) weighing 3 to 4g (0.1 oz). Brown in color; males have bands of light yellow spots and are dorsally dark. Males erect a nuchal, vertebral, and anterior caudal ridge. Females and juveniles have a dark, scalloped-edged, light vertebral stripe; laterally compressed, keeled tail; orange dewlap; snout-vent length 50 mm (2 in), but tail longer.

Reproduction: breed during the summer; becomes sexually active and establishes territories in March or April, and defends territories through August or September. Females lay eggs singly on an approximately weekly basis for the entire summer by alternating the use of their left and right ovaries.

Habitat: habitat generalist–likes disturbed habitats; forms territory among shrubs, vines, fences and trees; terrestrial inhabiting open vegetation as well as moist forested areas; can also occupy the higher niches in trees. Prefers semi-tropical environment

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: reduction of spider populations, competition with native anoles, predation of native anoles and lizards

Pathways: cargo, intentional, nursery trade, pet trade, ship, vehicle

Control measures: no information found in the literature

References: Stevenson 1976; Spiller and Schoener 1988; Lee et al. 1989; Spiller and Schoener 1990, 1994; Bartlett and Bartlett 1999; Gerber and Echternacht 2000; Campbell 2001; Greene et al. 2002; Wardle 2002; Lever 2003; Varnham 2006; Masterson 2007; Huang et al. 2008; Huang et al. 2009a; Kraus 2009; ISSG 2010

A8.4.8 Boa constrictor

Common names: boa, boa constrictor

Synonymous scientific names: *Boa constrictor constrictor, Boa diviniloqua, Boa diviniloquax, Boa orophias, Boa ortonii, Constrictor auspex, Constrictor diviniloquus, Constrictor formosissimus, Constrictor occidentalis, Constrictor rex serpentum, Epicrates sabogae, Euncetes murinus*

Adult description: no labial pits, a dark brown middorsal stripe running from the snout onto the neck, head surface covered by small smooth scales, the dorsal scales small and smooth, and the subcaudals single. Can reach 4.5 m (14.8 feet) in length with females being larger than males; head distinct from neck; body somewhat compressed, stout; tail short and prehensile; eye small, with vertically elliptical pupil; 2 or 3 nasal scales; no distinct loreal; no enlarged chin shields, distinct mental groove bordered by small scales; pelvic spurs visible. Ground color light brown to gray; head usually with a median elongate dark mark, sometimes bifurcate posteriorly or forming cross between eyes; side of head usually with a distinct downward-slanting dark postorbital stripe that is continuous through eye with a distinct broad dark brown blotch that extends from lip nearly to nostril; usually a narrow vertical dark brown bar below eye; dorsum with 22 to 35 dark brown or black dorsal blotches and similarly colored smaller lateral blotches; dorsal blotches usually with an elongate cream or yellow spot laterally and frequently vertebrally; lateral blotches usually with light centers; dorsal blotches frequently fusing to create a chain of dark figures surrounding a series of oval light areas on middle of back at least anteriorly; tail usually banded with black, yellowish, and red; venter gray with paired lateral dark spots; subcaudal area with a series of median black spots; iris beige, transected by a narrow dark brown horizontal bar.

Reproduction: boas at higher latitudes tend to breed in the cool season and give birth in the warm season, but seasonality in precipitation may be more important in low-latitude areas; reproductive seasonality is incredibly variable; extended gestational durations mean that an entire reproductive cycle may take at least a year for females, considering follicular growth, mating, ovulation, gestation, and parturition. Copulation is rarely observed in the field, and it is difficult to tell whether groups of boas constitute mating aggregations; Reproduction occurs in winter and is synchronized, resulting in mid-spring ovulation. Although based on a small number of neonates, parturition is inferred to be at the end of the wet season (February to March) extends this period through April. Litter sizes vary from 20 to 64.

Habitat: habitat generalist; occurs in agricultural areas, desert, natural forests, planted forests, range/grasslands, ruderal/disturbed, scrub/shrublands, urban areas

Human health impacts: may attack small children

Economic impacts: predation of pets and small animals; carriers of ticks that may impact livestock

Ecological impacts: predation of native fauna; competition with native reptiles; non-native boas may transmit foreign pathogens to U.S. populations of squamate reptiles

Pathways: cargo, escape, intentional, pet trade

Control measures: Capture and euthanasia

References: Martínez-Morales and Cuarón 1999; Burridge et al. 2000; Savage 2002; Burridge and Simmons 2003; Cuarón et al. 2004; Quick et al. 2005; Reed 2005; Romero-Nájera et al. 2007; Kraus 2009; Reed and Rodda 2009; ISSG 2010; Uetz 2010

A8.4.9 Boiga irregularis: established on Guam

Common names: brown catsnake, brown treesnake, catsnake, mangrove snake

Synonymous scientific names: *Boiga flavescens, Coluber irregularis, Dendrophis (Ahetula) fusca, Dipsadomorphus irregularis, Dipsas boydii, Dipsas irregularis, Dipsas ornate, Hurria pseudoboiga, Pappophis flavigastra, Pappophis laticeps, Triglyphodon flavescens, Triglyphodon irregular*

Adult description: nocturnal, opisthoglyphic, euryphagic; slender; vertical elliptical pupils; set in large eyes; short, blunt heads that are noticeably larger than their necks; arboreal; markings range from vague to distinct dark blotches on a background of brown to yellow. Slender tail that average 21% of their total length; slightly venomous

Reproduction: Oviparous; Reproduction occurs during the wetter, warmer months which could be any time of year in Guam. Gravid females are less active or more secretive; courtship includes male mounting female, rubbing her body with his chin, and progressing in a jerky motion toward her head while attempting to lift her tail with his tail. Females have ability to store sperm over extended periods of time. Females lay eggs in holes and crevices or underground; clutch sizes are 4 to 12 eggs

Habitat: habitat generalist; habitat includes: agricultural areas, coastland, natural forests, planted forests, range/grasslands, riparian zones, ruderal/disturbed, scrub/shrublands, urban areas, and wetlands.

Human health impacts: envenomation of humans; increased insect populations carrying diseases

Economic impacts: power outages; loss of tourism; preys on poultry

Ecological impacts: reduction in native biodiversity

Pathways: aircraft stowaway, cargo, military exercises, natural dispersal, pet trade, seafreight (container/bulk), translocation of machinery, vehicles

Control measures: fence barriers, electric barriers, fence line searches, traps, detector dogs, methyl bromide, acetaminophen, reduction of prey base

References: Savidge 1987; Fritts et al. 1990; Fritts and McCoid 1991; Rodda and Fritts 1992; Rodda et al. 1992; Fritts et al. 1994; Wiles et al. 1995; Engeman and Linnell 1998; Engeman et al. 1998a; Engeman et al. 1998b; Engeman et al. 1998c; Fritts and Rodda 1998; Rodda et al. 1998; Perry and Morton 1999; Rodda et al. 1999a; Fritts and Leasman-Tanner 2001; Perry et al. 2001; Savarie et al. 2001; Aguon et al. 2002; Engeman et al. 2002; Fritts 2002; Rodda et al. 2002 Wiles et al. 2003; Avery et al. 2004; Haynes and Marler 2005 Savarie et al. 2005; Vice et al. 2005; Westbrook et al. 2005; Esselstyn et al. 2006; Gragg et al. 2007; Rodda and Savidge 2007; D'Evelyn et al. 2008; DoD 2008c; Mortensen et al. 2008; Kraus 2009; Tyrrell et al. 2009; ISSG 2010; Mauldin and Savarie 2010; Shwiff et al. 2010; Uetz 2010

A8.4.10 Calotes versicolor: a single individual has been removed from the wild on Saipan in the CNMI (Stanford, personal communication) and it is established in multiple locations with SE Asia and on the island of Diego Garcia.

Common names: bloodsucker lizard, changeable lizard, crested tree lizard, Eastern garden lizard, garden lizard, Indian tree lizard, Oriental garden lizard

Synonymous scientific names: *Agama tiedemanni, Agama versicolor, Agama vultuosa, Calotes cristatus, Calotes gigas, Calotes viridis*

Adult description: about 284 to 378 mm (11 to 15 in) in total length, snout-vent length 81 to 140 mm (3.2 to 5.5 in), tail length 203 to 295 mm (8 to 11.6 in); large and shoulder, expandable dewlaps, and a slender tail; body compressed laterally; males have a conspicuous dorsal crest; 35 to 52 scales over the body; lateral scales point backwards and upwards; two spines above the tympanum; lacks an oblique fold; lacks a pit anterior to the shoulder; coloration dull brown, gray, or olive with various brown spots or bars; males have a pale yellow body with black throat patches and crimson areas on the anterior during breeding

Reproduction: oviparous; lays eggs late May to October; 1 to 23 eggs per clutch, may have multiple clutches per year; elliptical, white eggs; eggs average 10-13 x 4-10 mm (0.4-0.5 x 0.2-0.4 in) and increase in size after being laid; hatch in 40 to 47 days; lacks an egg-tooth; precocial; hatchlings 22 to 27 mm (0.9 to 1 in) in length; under unfavorable conditions, females are able to retain eggs over 6 months by arresting embryo development

Habitat: common in human-inhabited areas, including parks, gardens, agricultural areas, waste lands, open forests; near water sources; bask on vegetation and roost in shrubs or trees

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: displaces native lizard and skink species

Pathways: biocontrol, cargo, intentional, nursery trade, pet trade

Control measures: no information found in the literature

References: Pandha and Thapliyal 1967; Erdelen 1984; Lever 2003; Enge and Krysko 2004; Kraus 2009; Uetz 2010

A8.4.11 Carlia ailanpalai: established on Guam, Rota, and several islands in the FSM

Common names: curious skink

Synonymous scientific names: *Carlia fusca, Carlia fuscum*

Adult description: 32 to 66 mm (1.3 to 2.6 in) snout vent length; dorsum and sides mostly brown, but occasionally have a few white, single-scaled spots or narrow brown lines; dorsolateral white stripe, if present, is faded and confined largely to the neck and axilla; lateral brown band similarly uncommon, faded, and darkest on neck to axilla; midlateral stripe absent; venter cream to ivory

Reproduction: no information found on wild populations

Habitat: open, grassy ruderal habitats

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: serves as a prey source for BTS; competes with native lizards

Pathways: ecosystem disturbance

Control measures:

References: Case and Bolger 1991; Rodda et al. 1991; Rodda and Fritts 1992; Fritts and Rodda 1998; Rodda et al. 1999a; Rodda et al. 1999b; Lever 2003; Zug 2004; Bomford et al. 2005; Pitt et al. 2005; Buden 2009; Kraus 2009

A8.4.12 Chondrodactylus bibronii

Common names: Bibron's gecko, Bibron's thick-toed gecko, cape button-scaled gecko

Synonymous scientific names: *Pachydactylus bibronii, Tarentola bibronii*

Adult description: 140 to 200 mm (5.5 to 7.9 in) in total length, snout-vent length 75 to 100 mm (3 to 4 in), tail roughly the same length as the body; large head and stout body; covered with tough tubercles; segmented body with even, keeled scales; enlarged toe pads with 10 to 12 transverse lamellae under the middle toes; ventral scales do not overlap; lacks loose skin flaps; coloration tan to brown to gray with irregular dark bars and white spots; 8 to 10 white bands on the tail of juveniles; white venter

Reproduction: breeds in spring; lays pairs of eggs; two clutches per female per year; hatch in late summer; hatchlings 63 mm in length

Habitat: arid climates, agricultural areas; terrestrial, among rocks, vertical surfaces

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: urine and feces in structures

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, intentional, pet trade

Control measures: no information found in the literature

References: Griffin 2002; Cape Nature 2007; Kraus 2009; GeckoWeb 2010; Uetz 2010

A8.4.13 Cnemidophorus lemniscatus

Common names: rainbow lizard, rainbow whiptail, tropical racerunner

Synonymous scientific names: *Cnemidophorus cryptus, Cnemidophorus gramivagus, Cnemidophorus picturatus, Cnemidophorus pseudolemniscatus, Cnemidophorus sctitata, Lacerta lemniscata*

Adult description: snout-vent length 35 to 90 mm (1.4 to 3.5 in), tail length 136 to 175 mm (5.4 to 6.9 in), weight 4 to 10 g (0.1 to 0.4 oz); males larger; females with 9 dorsal stripes which may diffuse into spots; males with 3 dorsal stripes, rows of dorsolateral white and yellow spots, sides with areas of green, yellow, and gray, sides and bottom of head blue with white spots, and venter a combination of ivory, blue, and green with spots

Reproduction: bisexual and parthenogenetic populations; breeds during the wet season, August-September in Amazonia; possibly multiple clutches per female; lays 1 to 4 eggs per clutch; snout-vent length 26 to 45 mm (1 to 1.7 in), and weight 0.9 g (0.03 oz) at hatching; white to pale yellowish dorsal stripes on a dark background; light brown venter; stripe down the dorsal midline; dark hind legs with spots

Habitat: coastal scrub, beach strand, savannah, grasslands, forest edges, and human-inhabited areas, including suburban/urban areas; near water; on the ground or in perches

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: competition with native lizards

Pathways: cargo, pet trade, intentional

Control measures: no information found in the literature

References: Serena 1984; Vitt et al. 1997; Lever 2003 Mesquita and Colli 2003; van Buurt 2006; Montgomery et al. 2007; Kraus 2009; Uetz 2010

A8.4.14 Cryptoblepharus carnabyi

Common names: Carnaby's wallskink, spiny-palmed snake-eyed skink

Synonymous scientific names: *Cryptoblepharus plagiocephalus*

Adult description: information not found

Reproduction: information not found

Habitat: open forests with or without a dense understory, rocky outcrops; utilizes tree hollows; avoids grazed areas; will utilize restored habitats

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo

Control measures: no information found in the literature

References: Asher and Bell 1998; Gibbons and Lindenmayer 2002; Cunningham et al. 2007; Kraus 2009; Michael et al. 2010; UniProt 2010b

A8.4.15 Cryptoblepharus peocilopleurus

Common names: mottled snake-eyed skink, snake-eyed skink

Synonymous scientific names: *Ablepharus boutonii poecilopleurus, Ablepharus heterurus, Ablepharus poecilopleurus, Cryptoblepharus boutoni*

Adult description: 46 to 48 mm (1.8 in) in length, weight 1.2 to 1.5 g (0.05 oz); stationary, transparent scale over the eye and lower eyelid unable to close; small eye surrounded by small scales; front- and interparietal shields usually fused into diamond shape; large, shiny scales; coloration olive; indistinct white stripe along each side of the back bordered with brown splotches; all dorsal surfaces with small brown and white spots; whitish venter

Reproduction: information not found

Habitat: open, disturbed, grassy woodlands, rocky areas; near coasts

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: significant prey source for BTS

Pathways: boat, cargo, possibly natural colonization

Control measures: no information found in the literature

References: Garman 1901; Crombie and Steadman 1986; Gill 1993; Fritts and Rodda 1998; Lever 2003; USGS 2005c; McCoy 2006; Kraus 2009; Uetz 2010

A8.4.16 Cryptoblepharus plagiocephalus

Common names: Callose-palmed shinning-skink, Peron's snake-eyed skink

Synonymous scientific names: *Ablepharus boutoni punctatus, Ablepharus boutonii plagiocephalus, Ablepharus peronii, Cryptoblepharus burtonii, Cryptoblepharus carnabyi, Scincus plagiocephalus*

Adult description: snout-vent length 30 to 55 mm (1.1 to 2.2 in); shallow head and short legs; stationary, transparent scale over the eye; ear opening present; pale, acute plantar scales; coloration grayish to dark brown with irregular stripes

Reproduction: reproduces year-round with a peak September-January; eggs 13 x 5 mm (0.5 x 0.2 in); 2 eggs per clutch

Habitat: open woodlands; arboreal, utilizes tree hollows; inhabit diverse environments

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo

Control measures: no information found in the literature

References: Davidge 1980; James and Shine 1985; Gibbons and Lindenmayer 2002; Sullivan 2005; Kraus 2009 JCU 2010a Uetz 2010)

A8.4.17 Cryptoblepharus virgatus

Common names: cream-striped shinning-skink, fence skink, wall skink

Synonymous scientific names: *Ablepharus boutoni pulcher, Ablepharus boutoni virgatus, Ablepharus boutonii clarus, Ablepharus virgatus*

Adult description: snout-vent length less than 40 mm (1.6 in), tail equally long; blunt snout; granules partially surround the eye; small ear opening; rounded, pale plantar scales; smooth lamellae beneath the digits; 22 rows of smooth or slightly keeled scales on the body; coloration gray to yellowish brown; sides of head brown; brown marking down the dorsal midline; smooth, narrow brown longitudinal stripes; small brown and white spots on flanks and toes; white venter

Reproduction: breeds August-January or year-round, depending on latitude

Habitat: woodland, saltmarshes, shrublands, habitat edges, and human inhabited areas, including agricultural and urban areas; arboreal, utilizes tree hollows

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, railways

Control measures: no information found in the literature

References: Garman 1901; Clerke and Alford 1993; Gill et al. 2001; Anderson and Burgin 2002; Gibbons and Lindenmayer 2002; Garden et al. 2007 JCU 2007; Kraus 2009; Spencer et al. 2009; Macdonald 2010; Uetz 2010

A8.4.18 Cyrtopodion scabrum

Common names: roughtail gecko, rough-tailed gecko

Synonymous scientific names: *Cyrtodactylus basoglui, Cyrtodactylus scaber, Cyrtopodion scaber, Gymnodactylus scaber, Stenodactylus scaber, Tenuidactylus scaber*

Adult description: rather prickly looking lizard. Rows of prominent pointed keeled scales covering the tail, along with enlarged warty tubercles on the body. A medium-sized gecko, 7.5 to 11.7 cm (3 to 4.6 in) with enlarged toe pads and immoveable eyelids, it is sand colored above with small dark brown spots. The tail has dark rings. Nocturnal.

Reproduction: no information found in the literature

Habitat: in and around buildings, where it feeds on insects and other arthropods

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: displaces Mediterranean gecko (another invasive)

Pathways: cargo

Control measures: no information found in the literature

References: Kraus 2009; GeckoWeb 2010; Uetz 2010

A8.4.19 Diadophis punctatus

Common names: ring-necked snake, southern ring-necked snake

Synonymous scientific names: *Ablabes punctatus, Calamaria punctata, Coluber punctatus, Homalosoma punctata, Natrix punctatus*

Adult description: small; greenish-gray or blackish dorsal coloration, yellow to reddish ventrally, yellow color extending dorsally to form a ring around the neck, sometimes interrupted middorsally; maximum length about 38 cm (15 in). Some may have spots on venter; 13 to 17 anterior rows of body scales, 14 to 17 rows at mid-body and 13 to 15 rows anterior to anal vent; scales are smooth but with an apical pit; anal plate is divided. Each maxillary has 12 to 21 teeth; those anterior are slender and erect, the 2 most posterior teeth are longer, thicker and directed backward, and separated from the anterior teeth by a diastema. Males have ridges on the body scales near anal vent.

Reproduction: females mature by 2nd spring; ovulation occurs in June; reproduce annually; oviparous; embryos are somewhat more advanced than other oviparous snakes; aggregations occur in the spring and fall and mating may occur during these times also; egg laying occurs in June or July; nesting sites are under rocks, leafpiles, or fallen bark, in rotting logs and stumps, sawdust piles, or in the walls of animal burrows. 2 to 10 eggs are laid in one clutch (average 3 to 4); larger females lay more eggs; eggs are white, rough, leathery and elongate; hatching occurs in late August or September after an incubation period of 46 to 60 days; hatching process takes several hours.

Habitat: woodlands; shrublands; meadows; prairies; hides in rocks, logs, stumps, fallen bark or human debris; moist habitats

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, nursery trade

Control measures: no information found in the literature

References: Stevenson 1976; Ernst and Barbour 1989; Kraus 2009; FMNH 2010b

A8.4.20 Dinodon rufozonatum

Common names: red banded snake

Synonymous scientific names: *Coronella striata, Dinodon cancellatum, Dinodon rufozonatus, Eumesodon striatus, Lycodon rufo, Lycodon rufozonatus*

Adult description: 800 mm (31 in) in length; nocturnal

Reproduction: no information found in the literature

Habitat: widely distributed from the periphery of croplands to forest

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: unknown

Control measures: no information found in the literature

References: Atsuo 2004; Uetz 2010

A8.4.21 Elaphe carinata

Common names: Chinese king ratsnake, keeled ratsnake, king ratsnake, Taiwan stink snake, stinking goddess

Synonymous scientific names: *Coluber camillo, Coluber phyllophis, Elaphe osborni, Phyllophis carinata, Spaniopholis kreyenbergi, Spaniopholis Souliei*

Adult description: large, impressive, heavy-bodied constrictor; habit of eating other snakes; heavily keeled scales that give the skin a rough texture; distinctive habit of releasing a strong, offensive odor from post-anal glands when handled or otherwise threatened; undergoes a rather radical color transformation from relatively non-descript tan-colored juveniles into dark brown or black adults with a striking pattern of bright yellow highlights; tear-drop shaped pupil; can reach 240 cm (94 in) in length.

Reproduction: Mating usually occurs in spring, with 6 to 12 eggs being laid in early to mid-summer; 40 to 60 days incubation before hatching

Habitat: terrestrial; known to inhabit open forests, fields, meadows and bamboo thickets, although it has also been collected near houses

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: pet trade

Control measures: no information found in the literature

References: Arkive 2010; Uetz 2010

A8.4.22 Elaphe guttata

Common names: chicken snake, corn snake, red corn snake, red rat snake

Synonymous scientific names: *Collopeltis guttatus, Coluber carolinianus, Coluber compressus, Coluber floridanus, Coluber guttatus, Coluber guttatus guttatus, Coluber guttatus sellatus, Coluber laetus, Coluber maculates, Coluber molossus, Coluber pantherinus, Coluber rosaceus, Coryphodon pantherinus, Elaphe emoryi intermontana, Elaphe guttata guttata, Elaphe guttata rosacea, Elaphe laeta, Elaphe rosacea, Elaphe rosaliae, Elaphis alleghanensis, Elaphis guttatus, Natrix guttatus, Natrix maculatus, Natrix pantherinus, Pantherophis guttata, Pantherophis guttatus, Pituophis guttatus, Scotophis guttatus, Scotophis laetus*

Adult description: gray with black-bordered orange or red dorsal blotches and spots, black spots on the lips, and large black squared-blotches on a white venter. A prominent black-bordered, spear-shaped blotch extends forward from neck between eyes, and another black-bordered stripe extends back-ward from the eye past the corner of the mouth and onto the neck. Underside of tail is dark striped; pitted body scales are keeled and occur in 25 rows anteriorly, 27 at mid-body, and 19 at the anal vent; divided anal plate; no sexual dimorphism; 9 to 12 smooth, equal-sized teeth on each maxilla; nocturnal.

Reproduction: females reach sexual maturity at 16 to 18 months, males at 18 months; mating occurs from March to May; ovulation occurs in late May; gestation period between copulation and oviposition is 35 to 68 days; eggs are laid in late May or June; nest sites are in mammal burrows, sawdust piles, and rotting stumps and logs; eggs are white and elongated and tough; clutch size ranges from 3 to 30 eggs (average of 10 to 15 eggs). Incubation is 51 to 58 days; hatching occurs July to early September. Females can lay one or two clutches per year.

Habitat: brush fields, pine barrens, open deciduous woodlands, canyons, rocky ledges, caves, around trash dumps and old buildings; often in trees or bushes; occasionally swimming across small streams;

swamps; agricultural fields; residential areas; pinelands; hardwood hammocks; man-made structures such as erosion control rocks

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, nursery trade (such as in the root ball of plants), pet trade

Control measures: no information found in the literature

References: Ernst and Barbour 1989; Lever 2003; Henderson 2004; Sperry and Taylor 2008; Kraus 2009; FMNH 2010a

A8.4.23 Elaphe taeniura friesi

Common names: beauty snake, Taiwan beauty snake

Synonymous scientific names: *Coluber taeniurus, Coluber taeniurus var. friesei, Coluber schmackeri, Elaphe schmackeri, Elaphe taeniura, Elaphe taeniura friesi, Elaphe taeniura grabowskyi, Elaphe taeniura mocquardi, Elaphe taeniura ridleyi, Elaphe taeniura schmackeri, Elaphe taeniura yunnanensis, Elaphe taeniura vaillanti, Elaphe taeniurus, Elaphis grabowskyi, Elaphis taeniurus, Elaphis yunnanensis, Orthriophis taeniurus, Orthriophis taeniurus friesi, Orthriophis taeniurus ridleyi, Orthriophis taeniurus yunnanensis*

Adult description: variable in color, but usually has light and dark shades of brown and yellow; the anterior part of the snake has a pattern of splotches and banding; the tail is just striped.

Reproduction: oviparous; Eggs: 4 to 5

Habitat: forests

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, pet trade

Control measures: no information found in the literature

References: Kraus 2009; Oakland Zoo 2010; Uetz 2010

A8.4.24 Elgaria multicarinata

Common names: southern alligator lizard

Synonymous scientific names: *Gerrhonotus multicarinatus*

Adult description: Adult length up to 53 cm (21 in); half of total length is its long, slim tail; small legs when compared to body size; light or medium brown to yellow ochre in color with variable cross-bars on the back and some black and white spots along the sides; have a fold of skin along the lower sides where the scales of the belly meet the scales of the back; faint, thin black stripes on belly that run through the middle of each scale row; scales on the back are large with very distinct keeling; skin texture appears rough; have large, triangular-shaped heads (more pronounced in males).

Reproduction: oviparous; mate in May; up to 20 eggs laid in June or July.

Habitat: habitat generalist, dry, open woodlands of ponderosa pine and oak; often found among rocks, and the leaf litter of oaks, wild grapes, other vines, and poison oak; frequently found in coastal plains as well as in mountainous regions up to 2,286 m (7,500 feet) in elevation; adapted to living in urban habitat; often seen in yards, gardens, in garages, and under piles of wood, rocks, and debris

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, possibly in aircraft

Control measures: no information found in the literature

References: Mahoney et al. 2003; BMNHC 2006; Kraus 2009

A8.4.25 Emoia cyanura

Common names: azure-tailed skink, bluetail emo skink, copper-tailed skink, white-bellied skink

Synonymous scientific names: *Emoia pheonura, Eumeces lessonii, Eusoma lessonii, Lygosoma arundelii, Lygosoma cyanurum, Lygosoma cyanurum schauinslandi, Lygosoma impar, Scincus cyanurus, Tiliqua kienerii, Tiliqua lessonii*

Adult description: small, striped skink; has 65 to 70 scales on the underside of the fourth toe. When compared to *Emoia caeruleocauda*, the bluetail emo skink has a vertebral stripe that is wider on the head and the stripes are whiter. Also, there is a pineal eye spot that is visible in the middle of the head behind the eyes. The scales of the vertebral stripe are unfused which means that median scales are not present. The belly and underside of the thighs are white. The tail will never be a bright blue color; instead it is a pale blue-green. The belly will also never be bright green.

Reproduction: no information found

Habitat: forest, grassy and rocky areas near seashore, and gardens. In areas where it exists with Emoia caeruleocauda, the bluetail emo skink can usually be found living at the forest edge and not in the interior. On the islands in American Samoa it occurs in most habitats, but is less abundant in dense forest at higher elevations

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: may be contributing to the naturalization of species that prey on it

Pathways: cargo, personal effects

Control measures: no information found in the literature

References: Gill 1993; Schwaner and Ineich 1998; Lever 2003; USGS 2005c Kraus 2009; Uetz 2010; UniProt 2010a

A8.4.26 Eulamprus tenuis

Common names: bar-sided forest skink, bar-sided skink, barred-sided skink

Synonymous scientific names: *Lygosoma erucata, Lygosoma (Sphenomorphus) tenue, Lygosoma tenue, Sphenomorphus tenuis, Tiliqua tenuis*

Adult description: no information found

Reproduction: no information found

Habitat: open habitat, disturbed areas, areas with open canopies, and wet habitats like rainforests and wet sclerophyll forests. They are arboreal.

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo

Control measures: no information found in the literature

References: Kraus 2009; Uetz 2010

A8.4.27 Gehyra mutilata: established on numerous islands within Micronesia and the broader Pacific region

Common names: common four-clawed gecko, mutilating gecko, stump-toed gecko

Synonymous scientific names: *Dactyloperus insulensis, Gecko pardus, Gehyra beebei, Gehyra harrieti, Gehyra insulanus, Gehyra insulensis, Gehyra mugtilata (sic), Gehyra mutilate, Gehyra packardii, Hemidactylus mutilates, Hemidactylus navarii, Hemidactylus navarri, Hemidactylus Peronii, Hemidactylus*

(Peropus) mutilates, Hemidactylus platurus, Hemidactylus pristiurus, Peripia mutilate, Peripia Peronii, Peropus (Dactyloperus) Peronii, Peropus mutilates, Peropus multilatus (sic), Peropus packardii

Adult description: Total adult length is between 8.5 to 11.5 cm (3.4 to 4.5 in); absence or near-absence of a claw on the inner digit of its fore and hind feet; stout body; row of enlarged scales running along the underside of tail; during day they are gray to grayish brown in color, but fade to whitish when active at night; head and body speckled with light and dark spots; very thin light lines ring the tail; dark-edged light line runs through eyes; has a flattened tail that is constricted at the base so that it has a carrot-like shape; skin is somewhat translucent.

Reproduction: females lay two round eggs that are adherent to each other and to the substrate.

Habitat: habitat generalist; may occur in natural forests, disturbed garden areas, and urban areas. They are arboreal.

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, pet trade, zoo trade

Control measures: no information found in the literature

References: Fisher 1997; Kraus 2009; Rocha et al. 2009; GeckoWeb 2010; Uetz 2010

A8.4.28 Gekko gecko: established in Hawai'i

Common names: Tokay gecko

Synonymous scientific names: *Gecko reevesii, Gecko verticillatus, Gekko aculeatus, Gekko annulatus, Gekko guttatus, Gekko indicus, Gekko perlatus, Gekko tenuis, Gekko teres, Gekko verticillatus, Gekko verus, Gymnodactylus tenuis, Lacerta gecko, Platydactylus guttatus*

Adult description: one of the largest gecko species in the world reaching nearly 305 mm (12 in) in length. Orange and white markings against a gray or blue-gray ground color; upperparts ultramarine with numerous spots of rusty red or orange; the protuberant eyes may vary from yellow-green to orange. The pupils are complex and vertically elliptical; no eyelids; toe pads are large and easily visible. Nocturnal; head relatively large and triangular; tail banded with dark pigment; total length up to 350 mm (13.8 in).

Reproduction: may lay several clutches annually; the young exceed 76 mm (3 in) at hatching; communal nesting occurs; the hard-shelled, paired, adhesive-shelled eggs are deposited in secluded areas of buildings, tree hollows, or other like spots; females lay pairs of eggs communally; as many as 140 eggs have been found in one nest

Habitat: urban

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: preys upon native lizard and frog species

Pathways: biocontrol, cargo, intentional, pet trade

Control measures: no information found in the literature

References: Stevenson 1976; Meshaka Jr. et al. 1997; Bartlett and Bartlett 1999 Kraus 2009; GeckoWeb 2010; Uetz 2010

A8.4.29 Gekko hokouensis

Common names: Kwangsi gecko

Synonymous scientific names: *Gekko japonicas, Gekko liboensis, Luperosaurus amissus*

Adult description: small; arboreal; insectivorous; nocturnal; possessing a single process in each side of the base of tail, and limbs covered only with granular scales; has a single spur on each side of the base of the tail; tubercles are absent on the four limbs, and relatively few around the middle of the body.

Reproduction: females have oviductal eggs in April and may have multiple clutches until the end of July, when egg production ceases. This pattern of Reproduction differs from the continuous Reproduction seen in tropical geckos, and is common to other subtropical and temperate geckos. Cessation of ovulation during the late summer when temperature is still high may result from selection caused by the low tolerance of developing embryos against lower temperature in autumn, as in a few other East Asian geckos.

Habitat: montane environments

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: nursery trade, cargo

Control measures: no information found in the literature

References: Zhou et al. 1982; Okada et al. 2002; Bauer and Baker 2008; Kraus 2009; Uetz 2010

A8.4.30 Gonatodes albogularis

Common names: yellow-headed gecko

Synonymous scientific names: *Gonatodes fuscus*

Adult description: Has round pupils and lacks toe pads; very dimorphic, it is only the dark bodied males (with a bluish sheen, especially at night) that have the yellow head and a dark shoulder spot sometimes outlined with blue. The male's tail is yellow and if not regenerated, will have white tip. Coloration is brightened during breeding season. Females are gray with a lighter collar; markings on body may have a light crossbanded effect. Belly is usually light. Diurnal; snout-vent length is 38 mm (1.5 in) with tail about the same length; head and body slightly depressed and limbs well developed; hind legs noticeably stouter than the forelegs; very large eyes that lack lids.

Reproduction: lays a single egg at a time; each female can produce several eggs annually; incubation lasts a little more than 2 months; eggs are large compared to the size of the animal; are white and brittle; hatchlings are about 15 mm (0.6 in) long from snout to vent; may reproduce year-round, but Reproduction decreases during the dry season

Habitat: inhabiting large-diameter, rough-barked, horizontal limbs; rock and rubble piles and behind exfoliating tree bark; found inside and outside dwellings or other buildings; prefers dry microhabitats

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, pet trade

Control measures: no information found in the literature

References: Smith 1946; Stevenson 1976; Bartlett and Bartlett 1999; Krysko 2005 Kraus 2009

A8.4.31 Hemidactylus frenatus: established on numerous islands in Micronesia as well as the broader Pacific region

Common names: Common house gecko

Synonymous scientific names: *Hemidactylus mabouia*

Adult description: average length is 76 to 102 mm (3 to 4 in) and can reach 114 mm (4.5 in). Ashy gray dorsal color with an irregular pattern of obscure darker pigment; lighter color at night; ventral surface is nearly white; a gray lateral line may be present; scales are mostly smooth, and six rows of pronounced spinous scales on tail.

Reproduction: eggs are only weakly adhesive and are usually placed in crevices or beneath loose ground debris. Females produce several clutches are produced annually; communal nesting; 48-day incubation period; 51 mm (2 in) long hatchlings.

Habitat: habitat generalist

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: competition with native geckos; has displaced to some extent the gecko species *Nactus coindemirensis*; predation on native geckos; host of the pentasome parasites *Raillietiella frenatus* and *Waddycephalus* species; carries the red gecko mite *Geckobia bataviensis*

Pathways: boat, cargo, intentional, natural dispersal, nursery trade, pet trade, seafreight (container/bulk)

Control Methods: exclusion, euthanasia

References: Case and Bolger 1991; Case et al. 1994; Hanley et al. 1995 Petren and Case 1996 Canyon and Hii 1997; Hanley et al. 1998; Bartlett and Bartlett 1999; Brown et al. 2002; Jones and Cole 2004; Barquero and Hilje 2005; Cole et al. 2005; Cogger et al. 2006; Dame and Petren 2006; Varnham 2006; Barton 2007; Couper et al. 2007; Newbery and Jones 2007; Conroy et al. 2009; Csurhes and Markula 2009; Kraus 2009; Hoskin 2010; ISSG 2010

A8.4.32 Hemidactylus garnotii

Common names: fox gecko, Garnot's house gecko, Indo-Pacific gecko

Synonymous scientific names: *Doryura garnotii, Doryura gaudama, Doryura vulpecula, Hemidactylus blanfordii, Hemidactylus (Doryura) mandellianus, Hemidactylus garnetii, Hemidactylus guadama, Hemidactylus ludekingii, Hemidactylus mortoni, Hemidactylus peruvianus, Hoplopodion (Microdactylus) peruvianum, Hoplopodion (Onychopus) garnotii, Lepidodactylus garnotii, Nycteridium gaudama*

Adult description: small with a sharply denticulate lateral fringe on the strongly depressed tail and claws on the inner fingers and toes; large divided digital pads and no retractile claws. All are females. 65 mm (2.6 in); dorsum with small flat granular scales except along sides, where small tubercles present; two or three pairs of large chin shields. Dorsum uniform grayish tan or marbled with darker brown, usually with small whitish spots of various sizes and shapes; venter yellow, underside of tail pale red.

Reproduction: Parthenogenetic; motions of courtship are still indulged and may be necessary to stimulate egg development. Several sets of two eggs are produced annually; breeds year-round in warm areas; eggs are placed in crevices; incubation lasts for 7 weeks; hatchlings are 51 mm (2 in) long.

Habitat: buildings, trees, fences and similar structures

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, intentional, nursery trade, zoo trade

Control methods: no information found in the literature

References: Stevenson 1976; Lazell Jr. 1989; Bartlett and Bartlett 1999; Savage 2002; Kraus 2009 Uetz 2010

A8.4.33 Hemidactylus platyurus

Common names: flat-tailed house gecko

Synonymous scientific names: *Cosymbotus platyurus, Gecko marginatus, Hemidactylus marginatus, Hemidactylus platyurus, Lomatodactylus platyurus, Platyurus marginatus, Stellio platyurus*

Adult description: nocturnal; snout longer than the distance between the eye and the ear-opening, one time and a half the diameter of the orbit; forehead concave; ear-opening small, oval, oblique. Rostral four-sided, not twice as broad as high, with median cleft above; nostril bordered by the rostral, the first labial and three nasals. Tail depressed, flat inferiorly, with sharp denticulated lateral edge, covered above with uniform small granules, below with a median series of transversely dilated plates. Body depressed; limbs moderate, depressed; digits strongly dilated, about half-webbed, inner well developed; 3 to 6 lamellae under the inner, 7 to 9 under the median digits. Grey above, marbled with darker grey; generally a dark streak from eye to shoulder; lower parts white; length of head and body 61 mm (2.4 in); tail 66 mm (2.6 in); lateral skin flaps on the body.

Reproduction: mating does not take place seasonally, and copulation occurs when the ovarian eggs are small, indicating that viable spermatozoa may be retained by the females for considerable periods of time. Reproduce at any time of the year without undergoing a definite seasonal cycle; lay pairs of eggs in crevices above ground.

Habitat: bright commercial areas such as walls of warehouses

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, pet trade

Control methods: no information found in the literature

References: de Rooij 1915; Church 1962; Kraus 2009; Biolib 2010 GeckoWeb 2010

A8.4.34 Hemidactylus turcicus

Common names: Mediterranean gecko, Mediterranean house gecko

Synonymous scientific names: *Gecko meridionalis, Gecko verrucosus, Gecko verruculatus, Gecus cyanodactylus, Hemidactylus exsul, Hemidactylus granosus, Hemidactylus karachiensis, Hemidactylus robustus, Hemidactylus verruculatus, Lacerta turcica*

Adult description: large eyes, toe pads, and size (maximum snout-vent length is 60 mm, tail about the same); transverse lamellae divided medially. This is the most warty species of the four species of house geckos, its head, body, legs and tail covered with prominent tubercles. Adults may reach 13 cm (5 in). Like all house geckos they are rather flattened, with large heads, bulging eyes with vertical pupils and covered with an immoveable clear spectacle. It is usually darker brown or gray with darker spots by day than at night, when it may appear a ghostly white. Irregular dark markings across the head and back may disappear at night. The tail has dark bands, which are especially prominent in juveniles. The belly is white and somewhat translucent.

Reproduction: Females lay pairs of oval white hard shelled eggs above ground, under loose bark, palm fronds or other protected location. They are a communal nesting species. A female's clutch of two eggs may amount to 25% or more of her body weight.

Habitat: often found lurking on walls or ceilings near lights, waiting to ambush moths and other insects

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: outcompetes native nocturnal climbing geckos

Pathways: biocontrol, cargo, intentional, pet trade, vehicle

Control methods: no information found in the literature

References: Stevenson 1976; Kraus 2009; GeckoWeb 2010; Uetz 2010

A8.4.35 Hemiphyllodactylus typus

Common names: common dwarf gecko, Indo-pacific tree gecko

Synonymous scientific names: *Hemiphyllodactylus albostictus, Hemiphyllodactylus ceylonensis, Hemiphyllodactylus crepuscularis, Hemiphyllodactylus insularis, Hemiphyllodactylus leucostictus, Hemiphyllodactylus margarethae, Lepidodactylus auranticus, Lepidodactylus ceylonensis, Lepidodactylus crepuscularis, Platydactylus crepuscularis, Ptyodactylus gracilis, Spathodactylus mutilates, Spathoscalabotes mutilates*

Adult description: tiny; secretive; nocturnal; slender, translucent body covered in tiny granular scales; lacks the warty tubercles and spines found on many other geckos; relatively long thin body and proportionately short legs, but only reaches 6 to 9 cm (2.4 to 3.5 in); rudimentary, clawless inner toe on the forefoot; color varies from almost white at night to light or dark gray or brown; tiny white flecks and irregular black smudges are scattered along the back; there is a thin black line running from the snout through the eye and across the neck and shoulder; underside of the tail is orange.

Reproduction: all are females; lay fertile eggs without copulating with a male. Each gecko lays pairs of adherent eggs under bark or other protected location.

Habitat: forested areas and valleys, not around urban areas

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, nursery trade, zoo trade

Control methods: no information found in the literature

References: Kraus 2009; GeckoWeb 2010 Uetz 2010

A8.4.36 Lampropholis delicata

Common names: dark-flecked garden sun skink, delicate skink, garden skink, penny skink, rainbow skink

Synonymous scientific names: *Leiolopisma delicata*

Adult description: snout-vent is 4 to 5 cm (1.6 to 2 in); tail is 6 cm (2.4 in); active during the day as well as the night; upper portion of the body is darker than the underside, and there is often a white line present on the flank; lower eyelid is movable; plain-looking with short limbs, a small head and a small ear. Usually rich brown above, sometimes bordered on the edges of the back by a narrow, often broken, narrow line of paler color; no vertebral stripe; narrow black stripe runs back from the tip of the snout, through the eye, often breaking up above the ear before reforming into a dark band on the upper sides; sides dark dorsally, becoming paler toward the belly. Uniform coloration on side of neck; head is generally not distinct from the neck; cream colored below, without any trace of orange or pink.

Reproduction: share an egg-laying site; clutch sizes range from 3 to 6 eggs.

Habitat: generalist; widespread; often seen foraging in gardens for small insects in gardens where there is moisture; occur most commonly in dry areas amongst open grassy woodland at low altitudes

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: possible competition with native reptiles

Pathways: cargo, nursery trade

Control methods: no information found in the literature

References: Baker 1979; Howard et al. 2003; Lever 2003; Peace 2004 NZHS 2008; TPWS 2008; Kraus 2009 JCU 2010b

A8.4.37 Lepidodactylus aureolineatus

Common names: golden scaly-toed gecko

Synonymous scientific names: no information found in the literature

Adult description: no information found in the literature

Reproduction: no information found in the literature

Habitat: coconut palms and aerial ferns

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo; nursery trade

Control methods: no information found in the literature

References: Zug 2006; Kraus 2009

A8.4.38 Lepidodactylus lugubris: Established on numerous islands of Micronesia as well as the broader Pacific

Common names: common smooth-scaled gecko, mourning gecko

Synonymous scientific names: *Amydosaurus lugubris, Dactyloperus Pomareae, Gecko harrieti, Gecko lugubris, Gehyra neglecta, Gehyra ogasawarasimae, Gehyra variegata ogasawarasimae, Gymnodactylus candeloti (sic), Gymnodactylus caudeloti, Hemidactylus meijeri, Lepidodactylus candeloti, Lepidodactylus ceylonensis, Lepidodactylus crepuscularis, Lepidodactylus divergens, Lepidodactylus lugubris, Lepidodactylus mysorensis, Lepidodactylus roseus, Lepidodactylus woodfordi, Peripia cantoris, Peripia lugubris, Peripia meyeri, Peripia mysorensis, Peripia ornate, Peropus neglectus, Peropus roseus, Peropus variegatus ogasawarasimae, Platydactylus (Lepidodactylus) crepuscularis, Platydactylus lugubris*

Adult description: nocturnal; large digital pads, non retractile claws on the outer digits, the first digit clawless, and basally webbed digits. Males are 35 to 39 mm (1.5 in) in standard length and females are 31 to 45 mm (1.2 to 1.8 in) in length. Digits webbed basally; dorsal scales homogeneous, granular; chin shields small, several in contact with infralabials; ventral scales flat, rounded, imbricate; tail flattened beneath with some-what serrate margin, covered with small flat scales; subcaudal scales somewhat enlarged. Skin on back is satiny and lacks tubercles. Dorsum pale light pinkish gray to light brown, sometimes uniform but usually with prominent pair of brown spots just anterior to forelimbs; often with scattered small dark spots and/or irregular lines or chevrons; a wide dark band from snout through eye to forelimb; tail usually with dark markings; venter creamy white.

Reproduction: an all-female species, the uni-sexual mourning geckos are communal nesters, laying pairs of eggs in favored locations such as tree cavities, in leaf axils or under loose bark. Some females seem to take on a dominant role, even showing courtship-like behavior. Eggs are saltwater tolerant.

Habitat: arboreal and found in and around residences

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, pet trade, zoo trade

Control methods: no information found in the literature

References: Savage 2002; Kraus 2009; GeckoWeb 2010; Uetz 2010

A8.4.39 Lipinia noctua: Native to parts of Micronesia

Common names: moth skink

Synonymous scientific names: *Euprepes novarae, Leilopisma noctua, Lygosoma (Leiolopisma) miotis, Lygosoma (Leiolopisma) noctua, Lygosoma (Leiolopisma) subnitens, Lygosoma (Lipinia) aurea, Lygosoma miotis, Lygosoma noctua, Lygosoma vertebrale, Scincus noctua*

Adult description: small, 55 mm (2.2 in); has paired scales; yellow spot on the top of the head, which may be contiguous with a narrower yellow mid-dorsal stripe continuing onto the body but fading before reaching the base of the tail. It also has an interparietal scale and lacks supranasal scales, small scales between the scale containing the nostril and the internasals on the top of the snout. Overall, the coloration is brown or tan flecked with lighter and darker marks. A thick black line runs from the snout to the eye and onto the lateral body, fragmenting before reaching the base of the hindlimb. The lips are marked with alternating black and white bars. The belly is yellow to orange under the body and legs, fading to a pale bluish green under the tail and chin. This lizard will break its toes as well as its tail to escape the grasp of a potential predator.

Reproduction: gives birth to live young; ovoviparous; both oviducts are functional

Habitat: habitat generalist; found on the ground or low in trees; walls of buildings; has terrestrial and arboreal habits

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo

Control methods: no information found in the literature

References: Zweifel 1979; USGS 2005c; Kraus 2009; Uetz 2010

A8.4.40 Lycodon aulicus: This species has been captured several times including a probable record from Yap (Stanford, personal communication)

Common names: common wolf snake, Indian wolf snake, wolf snake

Synonymous scientific names: *Lycodon aulicus capucinus*

Adult description: nocturnal; large front teeth; enlarged, non-grooved rear maxillary teeth. The common wolf snake is a relatively slender-bodied snake with a ventrolateral keel along the body commonly associated with arboreal snakes. It also has a head that is distinctly wider than the neck, a vertically elliptical pupil, 17 longitudinal rows of smooth dorsal scales at midbody, dorsal scales with apical scale pits, 181 to 211 ventral scales, 56 to 70 subcaudals, a divided anal scale, a weak ventrolateral keel on lateral margins of ventrals, a preocular scale, a loreal scale in broad contact with divided internasal scales, and a snout somewhat flattened and protruding beyond lower jaw. The dorsal coloration is variable, usually brown with a reticulation of fine white lines, and occasionally with white crossbars. The reported maximum size is variable and may be related to the abundance and diversity of prey. Females may attain larger sizes than males with a maximum length of 50 to 84 cm (19.7 to 30 in) (depending on the location).

Reproduction: oviparous with up to a dozen eggs laid at one time up to twice per year. Clutch size is correlated to female body size. Females have been discovered curled around eggs and males are known to stay in close association with females after mating.

Habitat: habitat generalist; in and around rock walls, stone piles, and trash piles; in drier areas where lizards are abundant. Usually found around urban areas and human-made structures. They occupy terrestrial and arboreal habitats as well as almost any kind of disturbed habitat

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: possible detrimental effect on gecko, mouse, skink, and frog populations

Pathways: cargo, natural dispersal

Control methods: no information found in the literature

References: Mehrtens 1987; Fritts 1993; Kraus 2009

A8.4.41 Mabuya multifasciata

Common names: common sun skink, East Indian brown mabuya, many-lined sun skink, rough mabuya

Synonymous scientific names: *Euprepes sebae, Eutropis multifasciata, Eutropis multifasciatus, Mabuia monticola, Mabuia multifasciata, Plestiodon sikkimensis, Scincus multifasciatus, Tropidolepisma macrurus*

Adult description: 30 to 34 mid-body scale rows; 43 to 45 paravertebral scale count; 3 dorsal keels; reduced size of the first supraocular, not in contact with the frontal; upper secondary temporal overlaps the parietal. Relatively large; slight sexual dimorphism occurs where males are generally larger than females; males can reach 117 mm (4.6 in) and females can reach 116 mm (4.6) in length.

Reproduction: viviparous; parturition begins in early May and females can produce up to 2 litters each breeding season; litter size ranges from 2 to 7;

Habitat: terrestrial; open sunny space; prefers disturbed habitats such as forest edges and riverbeds; gardens; rice fields

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, pet trade

Control methods: no information found in the literature

References: Pauwels et al. 2003; Ji et al. 2006; Howard et al. 2007; Kraus 2009 Uetz 2010

A8.4.42 Naja kaouthia

Common names: Bengal Cobra, Monocellate Cobra, Monocled cobra, Thailand Cobra

Synonymous scientific names: *Naja naja sputatrix, Naja tripudians var. fasciata*

Adult description: have a single circular mark on dorsal hood; relatively placid; has spitter fangs but rarely spits. Throat pale, with scarcely any dark mottling, often followed by a single dark band. Ventro-lateral throat spots distinct and remainder of venter is pale or increasingly cloudy with darker pigmentation towards rear. Hood markings are usually distinct and is usually a pale, oval, or circular marking with a dark center and occasionally a narrow dark outer border. Medium to large in length, heavy bodied snake with long cervical ribs capable of expansion to form a hood when threatened. Body is compressed dorsoventrally and sub-cylindrical posteriorly. Can grow to a maximum of about 2 m (6.6 feet) but rarely exceeds 1.6 m (5.2 feet). Head is elliptical, depressed, slightly distinct from neck with a short, rounded snout and large nostrils. Eyes are medium in size with round pupils. Dorsal scales are smooth and strongly oblique. Underside of tail is usually light, but often suffused with dark pigment. Nocturnal.

Reproduction: the female will lay about 25 to 45 eggs and she usually stays with them until they hatch. The offspring are independent as soon as they are born.

Habitat: adaptable to a wide range of terrain including grassland plains, jungle, open fields and even heavy populated regions. Usually found at elevations below about 700 m (2,296 feet). Often found in tree holes and areas where rodents are plentiful.

Human health impacts: venomous; bites are potentially fatal

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo

Control methods: no information found in the literature

References: Looareesuwan et al. 1988; Greene 1997; Wüster 1998 Khandelwal et al. 2007; Amin et al. 2008; Kraus 2009; Kulkeaw et al. 2009; UAA 2010; Uetz 2010

A8.4.43 Pelodiscus sinensis

Common names: Chinese soft-shell turtle, Chinese softshell

Synonymous scientific names: *Trionyx spiniferus*

Adult description: carapace length averages 112 to 250 mm (4.4 to 10 in); carapace is oval with a marginal ridge; carapace smooth except for a few enlarged blunt knobs on the anterior rim above the neck; head and limbs olive to yellowish-white; head and neck may have fine black lines; throat is either light with vermiculations or dark with yellow spots; often fine black lines radiating from the eye; tubular snout with a lateral ridge projecting from each side of the nasal septum; fleshy lips; ventral surface pale or white; cluster of wattles between neck and carapace lacking or underdeveloped

Reproduction: males produce mature sperm in October to November; female may retain viable sperm for up to one year; females ovulate 2 to 5 times a year; mating May to August depending on region; nest squarish hole with corners rounded out; clutch size 7 to 30 eggs; eggs are white and spherical to oval; eggs weighing 3.3-6.2 g (0.1 to 0.2 oz) and 17.6-22.2 mm (0.7 to 0.9 in) in diameter; incubation lasts 23 to 89 days depending on soil temperature; sexually mature in 4 to 6 years

Habitat: habitat generalist; lowland aquatic habitats; rivers; lakes, ponds, canals, and creeks with slow currents; marshes; drainage ditches

Human health impacts: potential reservoir for cholera

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: may negatively impact native freshwater fish; carriers of iridovirus

Pathways: pet trade, food, religious, ecosystem disturbance

Control methods: no information found in the literature

References: ATWG 2000; Tokita and Kuratani 2001; Wong et al. 2002; Ji et al. 2003; Lever 2003; Zhang et al. 2008; Huang et al. 2009b; Kraus 2009; Chen and Lue 2010; Somma 2010a

A8.4.44 Python molurus bivittatus

Common names: Asian rock python, Burmese python, Indian python, Indian rock python, rock python

Synonymous scientific names: *Boa albicans, Boa castanea, Boa cinerea, Boa orbiculata, Boa ordinata, Coluber boaeformis, Coluber molurus, Python bivittatus, Python bivittatus bivittatus, Python bora, Python jamesonii, Python molurus, Python tigris, Python trivittatus*

Adult description: have light-colored skin with a characteristic pattern of many dark brown patches bordered in black. A non-venomous constrictor having short prehensile tail; heavy body; large, angular but supple skull with high counts of small, severely recurved teeth; vertical pupils; temperature-sensing thermal pits in their lips; narrow belly scales; bodies circular in cross section; flanks with many rows of tiny scales; males are 2.0 to 4.5 m (6.6 to 14.8 feet) in length and between 5 and 50 kg (11 to 110 pounds); females are 2.6 to 8.2 m (8.5 to 27 feet) in length and between 10 and 182 kg (22 to 401 pounds); Females usually larger than males.

Reproduction: hatchlings are independent, grow rapidly, mature in a few years and reproduce. Females brood their eggs, enclosing the eggs in their coils for incubation, raising their body temperature if necessary by shivering thermogenesis. Courtship occurs as temperatures warm (March/April). Females shed their skin, males rub on female, if receptive, female opens cloaca and intromission occurs. Females have ability to fertilize own eggs. Female fasts prior to oviposition and brooding. Clutch size varies between 8 and 107, however, average clutch size is towards the low end of that range; females produce one clutch per year; 60 to 90 day gestation period.

Habitat: habitat generalist

Human health impacts: could attack humans

Economic impacts: predation on livestock; attacks on livestock; carrier of ticks that could harm livestock

Ecological impacts: predation and competition with native fauna; reduction in native biodiversity; transmission of Inclusion Body Disease to native reptiles

Pathways: cargo, escape, natural dispersal, pet trade, intentional release by pet owners

Control Methods: radio telemetry, pheromones, traps, detector dogs, hand capture, acetaminophen

References: Burridge and Simmons 2003; Lovgren 2005; Reed 2005 Schumacher 2006; Pitt and Witmer 2007; Beck et al. 2008; Kraus 2009; Reed and Rodda 2009; ISSG 2010; Mauldin and Savarie 2010; Uetz 2010

A8.4.45 Ramphotyphlops braminus: widespread throughout the Pacific region including Micronesia

Common names: blind snake, Brahminy blindsnake, flower pot snake

Synonymous scientific names: *Argyrophis bramicus, Argyrophis truncatus, Eryx braminus, Glauconia braueri, Onychocephalus capensis, Ophthalmidium tenue, Tortrix russelii, Typhlina braminus, Typhlops braminus, Typhlops limbrickii, Typhlops russeli, Typhlops (Typhlops) euproctus, Typhlops (Typhlops) inconspicuus, Typhlops pseudosaurus*

Adult description: 6.35 to 16.5 cm (2.5 to 6.5 in); small, thin, and shiny silver gray, charcoal gray, or purple; head and tail-tip indistinct; neck not narrow; eyes are small dot-like remnants under the scales; tail is tipped with a tiny pointed spur; head scales are small and similar to body scales; grayish to brown belly; scales smooth and shiny; 14 dorsal scale rows along entire body.

Reproduction: lays eggs or may be live-bearing; individuals are all female and reproduce unisexually; parthenogenic and up to eight genetically identical female offspring are produced; species is a complex of unisexual and bisexual species

Habitat: habitat generalist; urban and agricultural areas. Lives in soil and leaf litter, and found under rotting logs, leaves, and trash. Also found in gardens.

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, nursery trade

Control measures: no information found in the literature

References: Nussbaum 1980; Kamosawa and Ota 1996; Kraus 2009; FLMNH 2010

A8.4.46 Saproscincus mustelina

Common names: southern weasel skink, weasel shadeskink, weasel skink

Synonymous scientific names: *Lampropholis mustelina, Lygosoma (Leiolopisma) mustelinum, Lygosoma (Liolepisma) pseudotropis, Lygosoma (Mocoa) lacrymansm, Lygosoma (Mocoa) orichalceum, Lygosoma (Mocoa) sonderi, Lygosoma paraeneum, Mocoa mustelina, Saproscincus mustelinus*

Adult description: snout to vent length from 45 to 160 mm (1.8 to 2.3 in); body is coppery brown with darker flecks on the back; ventral surface is cream colored; has a prominent white spot below and immediately behind the eye; has a dark streak through the eye; the color of the tail is similar to the back, but with a short, paler, dark edged streak starting immediately in front of the hind limb and continuing onto the upper section of the tail.

Reproduction: females lay eggs in a communal nest that contains the eggs of many females; up to four eggs per clutch.

Habitat: Prefers habitat with fallen timber or rotting vegetation; found among leaf litter in wet sclerophyll forests

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, nursery trade

Control measures: no information found in the literature

References: MNP 1999; Gill et al. 2001; Kraus 2009; Uetz 2010

A8.4.47 Sceloporous occidentalis

Common names: coast range fence lizard, Great Basin fence lizard, Island fence lizard, northwestern fence lizard, Pacific blue-bellied lizard, San Joaquin fence lizard, Sierra fence lizard, western fence lizard

Synonymous scientific names: *Sceloporus becki, Sceloporus biseriatus nigro-ventris, Sceloporus biseriatus var. A, azureus, Sceloporus frontalis, Sceloporus longipes, Sceloporus occidentalis, Sceloporus occidentalis becki, Sceloporus occidentalis biseriatus, Sceloporus occidentalis bocourtii, Sceloporus occidentalis longipes, Sceloporus occidentalis occidentalis, Sceloporus occidentalis taylori, Sceloporus occidentalis var. b, variegates, Sceloporus smaragdinus, Sceloporus undulatus biseriatus, Sceloporus undulatus occidentalis*

Adult description: snout-vent length is 89 cm (3.5 in); 15 to 25 cm (6 to 10 in) in total length; scales are keeled and somewhat spiny; color ranges from light gray to black with dark blotches on the back that continue down the tail; males have bright blue, sometimes greenish, bellies and the underside of their legs are yellow; females lack this decorative coloring.

Reproduction: breed in May or June; up to 10 eggs per clutch that can be laid as early as July, producing hatchlings as early as mid-August.

Habitat: habitat generalist; found from the coast to the highest mountain areas at over 1,829 m (6,000 feet); ranging from coastal sage scrub and chaparral on the coast and foothills, to the forests of higher elevations; found near ground in rock and wood piles, tree trunks, and lower branches of shrubs; urban areas; desert landscapes

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, research

Control measures: no information found in the literature

References: Kraus 2009; NVDoW 2010; Uetz 2010

A8.4.48 Sphaerodactylus argus

Common names: common ocellated gecko, ocellated gecko

Synonymous scientific names: *Sphaerodactylus argus argus, Sphaerodactylus henriquesi*

Adult description: 5 to 6 cm (2 to 2.5 in) in length; have small toe pads and eyelash-like scales projecting above each eye; Adults and juveniles have similar coloration. They are brownish in color with light dorsal and lateral spots from head to tail. The ocelli on head and neck tend to form a lineate pattern. Have a coral red tail and has small, keeled and slightly overlapping dorsal scales. Occasionally individuals are almost patternless.

Reproduction: females lay single eggs at intervals (in the Caribbean).

Habitat: is found around buildings, in vacant lots, and stands of Australian pine

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo

Control measures: no information found in the literature

References: Krysko and King 2002; Kraus 2009; GeckoWeb 2010; Uetz 2010

A8.4.49 Sphaerodactylus elegans

Common names: ashy gecko, Cuban ashy gecko

Synonymous scientific names: *Sphaerodactylus alopex, Sphaerodactylus cinereus, Sphaerodactylus elegans elegans, Sphaerodactylus elegans punctatissimus, Sphaerodactylus punctatissimus, Sphariodactylus [sic] elegans, Sphaeriodactylus [sic] punctatissimus*

Adult description: total length is 7 cm (2.75 in); are dark gray-brown in color with head, body, tail, and legs covered with a network of tiny salt and pepper spots; can be paler at night; smooth granular scales along the back, with a small spine-like scale over each eye. Are distinguished by having a vertical pupil, digits without widened subdigital lamellae, and dorsal scales relatively small, smooth, granular, and juxtaposed. They also have numerous light dorsal and lateral ocelli each comprised of only one scale.

Reproduction: females lay single eggs under loose bark or other cover objects; eggs are sometimes laid communally; have been found together with those of common and Amerafrican house geckos.

Habitat: trees, buildings, vacant lots, and stands of Australian pine

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo

Control measures: no information found in the literature

References: Krysko and Daniels 2005; Kraus 2009; GeckoWeb 2010; Uetz 2010

A8.4.50 Tarentola mauritanica

Common names: common wall gecko, Moorish gecko

Synonymous scientific names: *Gecko fascicularis, Gecko muricatus, Gecko stellio, Lacerta mauritanica, Platydactylus facetanus, Platydactylus mauritanicus, Platydactylus muralis, Tarentola mauritanica mauritanica, Tarentola mauritanica subvar. Atlantica, Tarentola mauritanica subvar. Lissoide, Tarentola saharae, Tarentola (Tarentola) mauritanica, Tarentola tuberculata*

Adult description: up to 15 cm (6 in) in total length; has golden, vertically slit eyes with red veins; distinct rows of large tubercles shingle the back, pointed tubercles cover the neck and legs, and whorls of tubercles on the tail give it a spiny, armored appearance; is sandy gray in color; paler at night; belly is white with overlapping ventral scales; males are larger and have broader heads; have enlarged, undivided toe pads; large, bulging eyes with a fixed transparent covering.

Reproduction: Females lay pairs of eggs.

Habitat: habitat generalist; In the United States it is confined to the walls of buildings; It is found in warm, dry coastal regions around the Mediterranean, in stone walls, boulders, and wood piles

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, intentional, nursery trade, pet trade

Control measures: no information found in the literature

References: Mahrdt 1998; Vogrin et al. 2008; Kraus 2009; GeckoWeb 2010; Uetz 2010

A8.4.51 Tiliqua scincoides

Common names: common bluetongue, eastern bluetongue, eastern blue-tongued lizard, northern bluetongue

Synonymous scientific names: *Cyclodus boddaertii, Lacerta scincoides, Scincus crotaphomelas, Scincus tuberculatus, Tiliqua scincoides chimaerea, Tiliqua scincoides intermedia, Tiliqua whitii*

Adult description: Is a large, flattened, terrestrial lizard with small limbs; snout to vent length is approximately 400 mm (15.7 in); weight up to 700 g (25 oz); blue colored tongue; color patterns can vary between individuals where some have banded markings while others have blotchy markings; typical color pattern is a white ventrolateral region, stopping at the dorsoventral scales, and a brown dorsolateral surface; head pale brown to gray and this color decreases in intensity posteriorly; also has dorsal transverse pale markings and oblique dorsolateral black markings that interrupt this coloration; body has wide yellow-orange large bands or blotches as well; limbs are tertiary gray.

Reproduction: viviparous; 10 to 20 individuals per litter; a female will produce a litter every 1 to 2 years; individuals are born precocious; breeding occurs in the spring; males exhibit mate guarding.

Habitat: suburban gardens, urban areas, seasonally wet and dry savannah woodlands, coastal heathlands, montane wet sclerophyll woodlands, and fringes of rainforests. Common in highly disturbed areas

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, intentional

Control measures: no information found in the literature

References: Carpenter and Murphy 1978; Lissone 1999; Koenig et al. 2001; Kraus 2009; Uetz 2010

A8.4.52 Trachemys scripta

Common names: red-eared slider, common slider, Cumberland slider turtle, slider, yellow-bellied slider

Synonymous scientific names: *Chrysemys scripta, Chrysemys scripta elegans, Chrysemys picta, Emys cumberlandensis, Emys elegans, Emys troostii, Pseudemys ornate, Pseudemys scripta, Testudo scripta, Trachemys scripta elegans*

Adult description: carapace length is 125 to 289 mm (5 to 11 in); prominent yellow to red patches on each side of the head; carapace and skin are olive to brown with yellow stripes or spots; males smaller than females with a longer, thicker tail

Reproduction: mating may occur in both spring and fall; nesting April to July in temperate zones, December to May in the tropics; females may store sperm up to 79 days; nests are flask-shaped with a chamber 11 to 21 cm (4 to 8 in) deep; may have up to 6 clutches; 2 to 30 eggs per clutch depending on size of female; incubation 59 to 112 days; timing of sexual maturity highly variable

Habitat: habitat generalist; lakes, riparian zones, water courses, wetlands; prefers large, quiet bodies of water with soft bottoms; can tolerate brackish water

Human health impacts: carrier of *Salmonella enterica*; host to *Gnathostoma binucleatum*, the causative agent of gnathostomosis

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: competes with and may displace native turtles

Pathways: pet trade, intentional release, religious, zoo trade, natural dispersal

Control measures: trapping; use of detector dogs to locate turtles and nests; egg removal

References: TFTSP 1996; Cadi and Joly 2003; Lever 2003; Cadi and Joly 2004; Nagano et al. 2006; Scalera 2006; Guerrero and Alba-Hurtado 2007; Gaertner et al. 2008; Polo-Cavia et al. 2008; Kraus 2009; ISSG 2010; Polo-Cavia et al. 2010

A8.4.53 Trimeresurus elegans

Common names: elegant pit viper, Sakishima habu

Synonymous scientific names: *Craspedocephalus elegans, Lachesis lutea, Lachesis luteus, Lachesis mucrosquamatus, Protobothrops elegans, Trimeresurus luteus*

Adult description: resembles the Okinawan Habu (*Trimeresurus flavoviridis*) in color and pattern, but is smaller in size (usually 91 cm [3 feet] long).

Habitat: found on Irimote, Ishigaki, and Miyako Islands; found in several types of terrain and active mainly at night

Human health impacts: venomous (have a hemorrhagic toxin)

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: exhibit, as food, in medicinal drinks

Control measures: no information found in the literature

References: Keegan and Yoshino 1959; Mehrtens 1987; Nikai et al. 1991; Rodda et al. 1999b; Chijiwa et al. 2006; Kraus 2009; Uetz 2010

A8.4.54 Trimeresurus flavoviridis

Common names: Habu, Okinawan habu

Synonymous scientific names: *Lachesis flavoviridis, Protobothrops flavoviridis, Trimeresurus flavoviridis flavoviridis, Trimeresurus riukiuanus*

Adult description: average length is 122 to 152 cm (4 to 5 feet), but they have been known to exceed 213 cm (7 feet) in length. They are the largest of the Asian terrestrial pit vipers; usually pale or dark brown, greenish-brown, or olive in color; has a pattern of irregular blotches that vary in shades of green or brown and bordered with yellow or grayish-yellow (this pattern can represent a marbled effect); large, triangular head attached to a slim neck.

Reproduction: mate in early spring and a female may lay up to 18 eggs in mid-summer. The eggs hatch after 5 to 6 weeks of incubation. The hatchlings are ten inches in length and are identical to the adults.

Habitat: sparsely wooded plains and fields adjacent to forests; brushy, rocky hillsides

Human health impacts: venomous; bites cause permanent physical damage or impairment; bites may sometimes be fatal

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo

Control measures: electric fencing, traps

References: Hayashi et al. 1980; Hayashi et al. 1983; Mehrtens 1987; Ford and Seigel 1989; Shiroma and Akamine 1992; Yokoyama and Yoshida 1994; Sawai et al. 1996; Rodda et al. 1999b; Yamamoto et al. 2001; Yamamoto et al. 2002; Kitano et al. 2003; Kraus 2009; Uetz 2010

A8.4.55 Trimeresurus mucrosquamatu

Common names: brown-spotted pit viper, pointed-scaled pit viper, Taiwan habu

Synonymous scientific names: *Lachesis mucrosquamatus, Protobothrops mucrosqamatus, Trigonocephalus mucrosquamatus, Trimeresurus mucrosquamatus*

Adult description: adult length: males 1122 mm (44 in) and females 1160 mm (46 in); tail length: males 195 mm (7.7 in) and females 205 mm (8 in); sharp, triangular head with a thick black-brown lateral band behind eyes; mottled top of head, below is whitish; body is yellow-brown with large black patches on back; patches on dorsal side of body usually form a wave-like pattern that serve as camouflage; belly is white in color, but heavily powdered with light brown; tail is brownish in color with dark dorsal spots (but the tail can possibly be pink during their life). The scales are in 25 longitudinal rows at midbody; the scales on the upper surface of head are small and each scale is keeled posteriorly; internasals are 5 to 10 times the size of adjacent scales and are separated by 3 to 4 scales; supraoculars are long, narrow, and undivided and there are 14 to 16 small interocular scales in line between them; are two scales in line between upper preocular and nasal; has 9 to 11 upper labials and the first upper labial is separated from the nasal by a suture; are 2 to 3 small scales between upper labials and subocular; 2 to 3 smooth rows of temporal scales above the upper labials, but above those the scales are keeled.

Reproduction: eggs: 3 to 15 per nest; laid in summer; females show egg protecting behavior.

Habitat: mountainous habitat, cultivated land, houses, farms, bushes, barns

Human health impacts: venomous; bites may cause death without the proper antivenom

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: unknown

Control measures: no information found in the literature

References: Smith 1943; Leviton et al. 2003; Hung 2004; Kraus 2009; Uetz 2010

A8.4.56 Uta stansburiana

Common names: northern ground uta, northern side-blotched lizard, side-blotched lizard, western ground uta

Synonymous scientific names: *Uta antique, Uta mannophorus, Uta stellata*

Adult description: mostly brown, with five, light-colored, dorsal stripes running from the head at least to the beginning of the tail (these stripes are sometimes indistinct); during the breeding season, males often take on a distinctly bluish hue on the head, tail, top of the back, and sides.

Reproduction: breeding begins early in spring. Females typically lay 1 to 2 clutches from spring to midsummer; 3 to 4 eggs per clutch; females in warmer climates may lay up to 7 clutches in one year; most eggs hatch from June to August and the offspring mature quickly.

Habitat: lives in flat desert habitat, rocky outcrops, hills, and mountainous regions. Prefer sites with some vegetation

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: cargo, possibly in aircraft, possibly in construction materials

Control measures: no information found in the literature

References: Nussbaum 1981; Ferguson et al. 1990; Hutchins et al. 2003b; Mahoney et al. 2003; Kraus 2009; Uetz 2010

A8.4.57 Xenochrophis piscator

Common names: Asiatic water snake, checkered keelback

Synonymous scientific names: *Amphiesma flavipunctatum, Col. Quincunciatus, Hydrus piscator, Natrix piscator, Nerodia (Tropidonotus) piscator, Tropidonotus piscator, Tropidonotus quincunciatus*

Adult description: Total length: males up to 947 mm (37 in) and females up to 1,020 mm (40 in); chess-like pattern on the body, sometimes with broad blotches and very conspicuous and sometimes with smaller blotches; large, cloudy cream or pale gray dorsolateral blotches; nuchal marking often absent (if not absent then present as an inverted V); subocular streaks are faint, reduced to a blotch or absent; a venter uniform, with the ventrals darker only on the outermost edges; a high number of ventral and subcaudal scales in males.

Reproduction: clutch size ranges from 9 to 74; clutch size increases with increasing body size

Habitat: lowland habitat; mangroves; occurs close to water quite often, although they are not strongly aquatic

Human health impacts: none found in the literature, but undocumented impacts may exist

Economic impacts: none found in the literature, but undocumented impacts may exist

Ecological impacts: none found in the literature, but undocumented impacts may exist

Pathways: unknown

Control measures: no information found in the literature

References: IUCN 2009, Vogel and David 2006; Brooks et al. 2009; Uetz 2010

A9 CRITERIA QUESTIONS USED TO EVALUATE RISK OF TRANSPORTING VERTEBRATE INVASIVE SPECIES

A risk level was assigned to each pathway based on 16 criteria questions pertaining to probability of species transport, invasive potential of species, the pathway's conduciveness to transport species, and control-interdiction-eradication methods. These 16 evaluated criteria questions are as follows:

3. Introducing invasive species on a frequent basis?

Extremely high frequency ranking is defined, in relative terms, as introducing numerous invasives (i.e., 10 or more) that have had either human health pandemic implications resulting in deaths; moderate is 5 or more that have caused serious **Economic impacts** on (i.e., failure of) major industries; low is 2 or more introduced invasives that negatively impacted 2 or more ecological niches).

4. Transmitting a large number of different viable species?

Extremely High (i.e., ranking of 10) infers a pathway capable of transferring 100 or more viable invasives species in a single event.

5. Transmitting a large number of viable individuals per invasive species?

Extremely High infers the pathway transmits numerous (i.e., 100 plus) viable populations that can readily be established. Extremely low infers that only 1 to 2 specimens capable of establishment/**Reproduction** are transmitted. Zero is 'no risk'; infers no specimen survival.

6. Introducing invasive species into hospitable ecosystems or Habitats?

Level 10 infers exact ecosystem match with invasive species' natural **Habitat**; plentiful food sources, no predators or ecosystem controls. Zero (0) risk is when environmental factors preclude invasive species establishment.

7. Introducing invasive species at multiple entry points?

Level 10 equals 100% likelihood of invasive species survival due to hospitable pathway ecosystem. Level 1 equates to pathway that by nature (i.e., travel through arctic climes) will result in invasive mitigation.

8. For transmitting invasive species, based on standard treatment measures?

Level 10 infers multiple entry points (4 or more) that expand across the continental United States; Level 1 infers single, localized entry point.

9. To assist spread of invasive species to uncontaminated shipments during transport or storage?

Zero (0) level indicates all IS are dead upon arrival; 3 indicates most (60%) of the invasive species are still reproductively viable; 5 indicates 100% of invasive species are alive, and have expanded populations, colonies or enhanced invasiveness capabilities).

10. For transmitting invasive species based on current screening techniques?

High reflects a pathway that commingles multi-source vectoring agents with multiple dissemination points i.e., multi-source, commingled WPM in a cargo hold with multiple dissemination points. Low equates to no cross-contamination or spread.

11. Transporting an invasive species that is difficult to detect once in the destination ecosystem?

A rating of zero (0) indicates that virtually all invasives are detected prior to or during transit. A rating of 5 indicates that there are no detection methods for the invasives prior to or during transit.

12. Transmitting invasive species that are capable of surviving in multiple Habitats?

Zero (0) indicates that all invasives are detected immediately at the pathway endpoint. A rating of 5 indicates the species is/are so difficult to detect, there is a 100% likelihood they will be disseminated without detection.

13. Transmitting invasive species into ecosystems conducive to natural spread?

An assessment of zero (0) indicates the pathway does not transmit any generalists. An assessment of 5 indicates the majority of invasives transmitted by this pathway are generalists with at least 3 or more populations capable of surviving in any of the pathway endpoints.

14. Transmitting invasive species that are further spread by human activities?

A rating of zero (0) indicates the pathway transmits invasives with low reproductive rates or ones that are fragile in any ecosystem other than that of origination. A ranking of 5 indicates the pathway transmits multiple (i.e., 10 or more) invasives that are highly mobile; spread by wind, water; have/high reproductive rates in multiple ecosystems.

15. Introducing invasive species that are known to be invasive in similar ecosystems but are not yet in the endpoint ecosystem?

A rating of zero (0) indicates that humans or human activities do not spread the invasive species. A rating of 5 indicates humans or human activities are the primary agent for the rapid spread of pandemic invasive species.

16. Transmitting invasive species that are novel and have limited scientific data upon which to develop control methods?

Zero (0) indicates the pathway transmits no compatible IS; 3 rating indicates the pathway transmits invasives that are in some, not all, U.S. ecoregions, but are not yet present in the pathway endpoint ecosystem. Level 5 infers the pathway transmits viable invasive species into pristine ecosystems.

17. Transmitting an invasive species for which existing control options are too expensive to implement?

Zero (0) indicates there are comprehensive control options to mitigate all invasives transmitted. Level 5 indicates there are no existing control options.

18. To what degree does the pathway's own ecosystem enhance the viability of opportunity for transmission of invasive species?

Level 0 equates to a pathway that by nature results in mitigation (i.e., no movement of invasive species). Level 5 equals 50% likelihood in invasive species survival. In other words, some species may be able to survive in the pathway ecosystem whereas others cannot. Level 10 equals 100% likelihood of invasive species survival due to a hospitable pathway ecosystem.

A10 UMBRELLA CATEGORY PATHWAY OUTLINE

Major **Pathways** were organized under three umbrella categories: Transportation, Living Industry, and Miscellaneous, and further divided into sub- and nested **Pathways** identified as being pertinent to the military mission.

(T) TRANSPORTATION Pathways and Sub-pathways

T. 1. Modes of Transportation

- T.1.1 Air Transportation
  - T.1.1.1 Commercial Air Traffic
  - T.1.1.2 Military Air Traffic
- T.1.2 Water Transportation
  - T.1.2.1 Commercial Maritime Traffic
  - T.1.2.2 Military Maritime Traffic

T.2 Military Travel and Transportation of Military Vehicles

- T.2.1 Military Cargo and Vehicles Used in Training Exercises

T.3. Items Used in the Shipping Process

- T.3.1 Cargo Containers
- T.3.2 Wood Packaging Materials

T.4. Travel/Tourism/Relocation

- T.4.1 Household Goods and Personal Vehicles

T.5. Transportation of Construction Materials, Equipment, and Vehicles

(L) LIVING INDUSTRY Pathways and Sub-pathways

L.1 Plant **Pathways**

- L.1.1 Plant Materials and Plant and Nursery Trade

L.2 Food **Pathways**

- L.2.1 Aquaculture
- L.2.2 Plants and Plant Parts as Food

(M) MISCELLANEOUS Pathways and Sub-pathways

M.1 Ecosystem Disturbance

- M.1.1 Natural Spread of Established Populations
- M.1.2 Man-made and Natural Disturbances

M.2 Garbage

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A12 PRELUDE TO THE DRAFT PATHWAY ANALYSIS FOR HAWAI'I

A12.1 WHAT IS THE PATHWAY ANALYSIS OF INVASIVE SPECIES INTRODUCTION INTO THE STATE OF HAWAII?

The Pathway Analysis of Invasive Species Introduction into the State of Hawai'i is a working document that was created by the United States Department of Agriculture (USDA), Animal Plant Health Inspection Service (APHIS), Plant Protection Quarantine (PPQ) to assist in identifying terrestrial biological risks to Hawai'i. It is important to note that this document is a "Pathway Analysis" and not a "Pest Risk Assessment" (PRA or "risk analysis" in Intergovernmental Panel on Climate Change terms). A Pathway Analysis uses available science, information, and technology to determine appropriate measures to mitigate risks of sometimes multiple pests and commodities moving via a specific pathway. A pathway is any means that allows the entry or spread of a pest. This includes travelers, conveyances, commodities, cargo, military movements, and others. A PRA uses available science, information, and technology to determine appropriate measures to address specific risks associated with specific pests or commodities.

Hawai'i is unique in that it has different ecosystems and vulnerabilities than the rest of the United States. For example, although Hawai'i is one of the smallest states in the United States, comprising just 0.2% of its total land mass, more than 25% of the endangered species in the United States occur there (OTA 1993). Hawai'i is infamous not only as "the extinction capital of the United States," with 72% of the country's recorded extinctions (Gagné 1988; OTA 1993) but also as the location with the greatest species extinction rate per square mile of anywhere in the world (http://hbs.bishopmuseum.org/endangered/).

Hawai'i imports the majority of agriculture products consumed. Commodities have been imported into Hawai'i before PRAs were completed on individual commodities. Because of Hawai'i's location, commercial and private conveyances arrive there from a variety of locations. Many of the originating locations are without sound quarantine and export practices. Other originating locations are without a complete understanding of the pests present in their countries or of the pest pressures on their countries.

APHIS developed this Pathway Analysis to assist PPQ in developing approaches and strategies to minimize all risks within its authority, and to further develop effective actions to prevent the introduction and spread of pests and to promote appropriate measures for their control.

A12.2 WHY RELEASE IN DRAFT FORM?

With the exception of Chapter B5, the quantitative data sufficient for statistical analysis were not available, especially for domestic arrivals (and the suspected foreign origin commodities arriving through domestic trade). Despite these shortcomings (that kept the analysis in draft form), APHIS has enhanced and implemented actions and fortified partnerships to address key elements in the pathway analysis. Entities outside of APHIS believe their activities may benefit, as APHIS has benefited, from the draft information. Thus, APHIS is releasing the draft. APHIS believes the release of this information is timely to the completion of the Micronesian Biosecurity Plan and fits well with the information in that document.

In understanding the information and risks, it is beneficial for the reader to understand that preventing pest and invasive species from entering Hawai'i falls mainly on two agencies. There are many agencies within Hawai'I that work on protecting resources from invasive species; USDA-APHIS and HDOA are the two agencies that specifically handle prevention through import inspections. USDA-APHIS-PPQ holds authority and by a Memorandum of Agreement, holds joint responsibility with Customs and Border Protection for quarantine activities and actions as they relate to foreign arrivals of people, commodities, and conveyances. Because the State of Hawai'i is under official quarantine for a variety of pests, APHIS also holds authority and responsibility for reducing the risks of pests moving from Hawai'i to the U.S. mainland. The State of Hawai'i holds the authority and responsibility for reducing the risks of pests entering Hawai'i from other U.S. states. While USDA and the Hawai'i Department of Agriculture (HDOA) have different authorities and responsibilities, both agencies have entered in to a Memorandum of Understanding (MOU) that generally describes shared roles, responsibilities, resources, and enabling authorities, and facilitates cooperation in phytosanitary issues and risk mitigation activities.

A12.3 ACTIONS BASED ON THE PATHWAY ANALYSIS

While additional, yet unavailable, information could be used to gain a more complete understanding of the pest pressures on Hawai'i, PPQ has used the available information presented in this document to strengthen and create programs that reduce the risks and close pathways for pests entering Hawai'i regardless of what the pests are or their origin. PPQ is present on the islands of Hawai'i, Kauai, Lanai, Maui, Molokai, and Oahu with an outlaying work unit in Guam where it works closely with state, private and federal partners to achieve the reduction of risks. PPQ–Hawai'i also supports operations in the Commonwealth of Northern Mariana Islands (CNMI) and America Samoa. Together many agency programs serve as a safety net to reduce risks from entering Hawai'i. Some of the activities PPQ has undertaken to address the risks identified in this document are outlined below.

A12.3.1 Cooperative Agriculture Pest Survey Program

PPQ funds the Cooperative Agriculture Pest Survey (CAPS) program and works with the HDOA, the University of Hawai'i, the Guam Department of Agriculture, the University of Guam, the CNMI Department of Land and Natural Resources, the Northern Mariana College, the American Samoa Department of Agriculture, and the Samoa Community College to determine if pests of concern have entered the island ecosystems. In fiscal year (FY) 2011, PPQ entered into 24 agreements (including Farm Bill and CAPS agreements), totaling $1.2 million. This included working with six agencies from Hawai'i, Guam, the CNMI, and American Samoa. These agreements covered surveys for various pests including citrus greening and imported fire ants. These cooperative surveys allow for early detection of invasive species and quick response to reduce pest risk to the State of Hawai'i. For FY 12, there are 29 agreements, totaling $1.6 million. Actions of PPQ and other agencies may be based on the information that is produced by the CAPS program.

A12.3.2 Smuggling Interdiction and Trade Compliance

PPQ's Smuggling Interdiction and Trade Compliance (SITC) program is very active in Hawai'i and the American Pacific with the purpose of detecting and closing pathways in which restricted or prohibited agricultural commodities make illegal entry into the United States and its territories. More funding and capacity is needed for similar programs in the non-US jurisdictions covered by this plan if the FSM, Palau and the RMI are to establish similar standards. SITC partners with various agencies including other USDA agencies, the Department of Homeland Security's (DHS) Customs and Border Protection (CBP), the U.S. Fish and Wildlife Service (USFWS), the U.S. Department of Health and Human Services, Food and Drug Administration (FDA), various Hawai'i state agencies, and the University of Hawai'i at Manoa to achieve its goal of closing pathways. PPQ strengthened the Hawai'i SITC team by shifting employees to the program and allowing employees from other operations to assist when needed. Hawai'i SITC also conducted PPQ officer and safeguarding training in American Samoa, Guam, and the CNMI Departments of Agriculture for local quarantine officers. SITC established a network of informants, importers, retailers, and joint federal/state/county agency contacts that allows for the quick acquisition of intelligence, making APHIS' mission objectives more easily achieved. SITC and the cooperating agencies provide outreach to industry and market owners about pest risk concerns. SITC works to identify and close pathways. This work assists to mitigate pests that are not detected during the entry process. SITC Hawai'i created a searchable and user-friendly database (PPQ287), used specifically for mail interceptions that has become a module in the national Agricultural Quarantine Activity System (AQAS) system. The PPQ287 Mail Interception Database provides a means to do the following in the event of a mail interception:

- Electronically generate a notification (Form 287) to be provided to the intended recipient and the sender. Theses notifications indicate that an unauthorized material—animal products, animal byproducts, plants, plant products, plant pests, or soil—was removed from the mail package, and why.
- Record the regulatory action that CBP took when intercepting the mail.
- Provide a means to prepare monthly and quarterly reports.
- Centralize the management of all mail interceptions into a single database. This greatly improved the accessibility and quality of data gathered for intercepted mail.

While the database is now used nationally, the Honolulu Post Office became the postal location where most pests and pest risks are intercepted. Hawai'i SITC also conducts joint activities with the HDOA to mitigate pest risk concerns and to support HDOA-led operations such as the Maritime Agriculture Risk Survey in which red imported fire ants (RIFA) (*Solenopsis invicta* Buren) were targeted in cargo containers that are not traditionally inspected. Again, while this appears to be a very worthwhile program, the non-US jurisdictions of Micronesia are not covered by it and would be greatly assisted in helping to protect the entire region if they could develop similar initatives.

A12.3.3 Funding and Grants

USDA provides funding through the Farm Bill to develop Pest Management Practices for non-native pests on nursery plants. In addition, Hawai'i is applying for new funds to develop similar strategies for cut flower and foliage production. Hawai'i will be applying for future USDA funding for these management programs.

A12.3.4 Emergency Response

PPQ-Hawai'i takes a lead role in emergency response exercises in cooperation with HDOA, the University of Hawai'i at Manoa, and Hawai'i industry representatives. These exercises, which practice the use of the Incident Command System, are designed to enable quick and effective responses from all regulatory agencies to effectively and swiftly address ecological, agrosecurity emergencies.

A12.3.5 Containment Facilities

As the lead regulatory agency, APHIS has many programs to ensure the safe trade and movement of commodities, people, and conveyances to Hawai'i. Regulated containment facilities are used so commodities with restricted market access may enter prior to being cleared for movement to consumers. Some commodities are stored in containment facilities until they are transferred from Hawai'i under safeguarded conditions. In addition to increasing the number of inspections of existing containment facilities to verify compliance with permit conditions, PPQ-Hawai'i has trained additional containment facility inspectors to oversee new and existing facilities that house imported plant pests and diseases not known to occur in Hawai'i. Increased interaction with HDOA has been achieved to assist stakeholders by streamlining the containment facility inspection process.

A12.3.6 Post-entry Quarantine and Inspections

At HDOA's request PPQ maintains a strong post-entry program. APHIS also regulates all post-entry activities where plants and plant cuttings that have the potential to harbor unseen diseases, viruses, plasmas, etc. are brought into Hawai'i under quarantine conditions to be grown out until the plants are at a stage where symptoms occur and contaminated plants can be identified. PPQ-Hawai'i conducts joint inspections with HDOA that allow for more thorough inspections and also strengthen state and federal roles in the program. The quarantined products are only released from quarantine after both APHIS and HDOA are confident that the product is pest-free. PPQ-Hawai'i regularly conducts Field Plant Pathology Training to improve inspecting capabilities of inspecting officers.

A12.3.7 Biotechnology

PPQ strictly regulates biotechnology activities in Hawai'i. APHIS' Biotechnology Regulatory Service (BRS) reviews all potential risk of biotech materials being spread and/or released in Hawai'i. Strict guidelines, regulations, and protocols are considered and developed jointly by BRS and HDOA. Only materials approved by both Hawai'i and BRS are considered for approved for growing in Hawai'i. PPQ-Hawai'i developed a tracking system that allows monitoring biotech activities at a local level. HDOA is invited to jointly conduct inspections with PPQ. Biotech training is held in Hawai'i every 3 years to certify that inspecting officers are current in all laws, regulations, and protocols.

A12.3.8 Convention on International Trade in Endangered Species of Wild Fauna and Flora Materials

PPQ facilitates legal and safe trade of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) materials by maintaining CITES protocols and abilities at the USDA Honolulu Plant Inspection Station. All CITES shipments entering Hawai'i are inspected for proper documentation and all materials are inspected for quarantine pests to ensure protection of Hawai'i's agricultural and nursery industries. Over the last year 393,242 plants have been inspected with 47 plants refused entry. All CITES plants seized due to lack of CITES documentation are sent to authorized Plant Resource Rescue Centers.

A12.3.9 Import Permits

To further close pathways, PPQ and HDOA require permits to be obtained for the importation, transit, domestic movement, and environmental release of foreign organisms that could impact the ecosystem and agriculture if permitting requirements are not established. Permits are issued in consultation with HDOA and in accordance with federal regulation and under the authority of the Plant Protection and Honeybee Acts. Other actions taken in responses to the information gained from the analysis include adding additional information in import permits for palm seeds entering Hawai'i, training CBP Agriculture Inspectors on the requirements and inspection of seeds entering Hawai'i under special Import Permits, and working closely with CBP Agriculture Inspectors at the U.S. Postal Service (USPS) facility identifying plants and plant products that are admissible or prohibited into Hawai'i. All of these achievements further contribute to the reduction of the movement of pests into Hawai'i.

A12.3.10 Fruit Fly Detection Program

PPQ maintains a Fruit Fly Detection Program (FFDP) in Hawai'i that is designed to detect exotic fruit fly species in high-risk areas and to provide a "first alert" trigger for swift emergency actions in cooperation with HDOA. This program collaborates with groups like the HDOA, USDA's Agricultural Research Service, and PPQ's Center for Plant Health Science and Technology (CPHST) to develop and implement new control technologies for invasive fruit fly pests. Examples include developing traps and lures for surveillance and detection, as well as methods for the mass rearing of sterile insects to be released in combat against invasive fruit fly species. PPQ maintains the USDA Fruit Fly Facility in Waimanalo, Hawai'i and collaborates with the California Department of Food and Agriculture Fruit Fly Facility, the University of Hawai'i, and CPHST to sterilize fruit fly pupae for programs that use the Sterile Insect Technique to rear larvae for USDA sterilized fruit fly release programs. Furthermore, since the analysis was conducted, PPQ's FFDP has participated in the evaluation of Oahu to determine which areas are at the highest risk for possible introduction of new fruit fly species. The FFDP focuses on these areas with year-round fruit fly trap monitoring. With its expertise, the Hawai'i FFDP also assists with other pest detection/trapping programs as needed including the Nettle Caterpillar (*Darna pallivitta* Moore) Survey, European Pepper Moth (*Duponchelia fovealis*) Survey, Coconut Pest Survey (Coconut Rhinoceros beetle *Oryctes rhinoceros*), and Red Palm Weevil (*Rhynchophorus ferrugineus*) Survey.

A12.3.11 Key Partnerships

PPQ works to identify high-risk commodities and associated pathways, adapt targeting and compliance methodologies, utilize risk analysis in determining inspectional processes, and provide cross-training at the port level. This work is carried out in partnership with a number of organizations in APHIS and federal and state agencies discussed below. PPQ takes a lead role in the Hawai'i Risk Assessment Committee meetings, where federal and state regulatory agencies meet to discuss new and emerging risks and collaborate to develop mitigations. In this venue, PPQ partners with Veterinary Services, Wildlife Services (WS), DHS CBP, FDA, USFWS, and HDOA to identify high-risk commodities and associated pathways, adapt targeting and compliance methodologies, utilize risk analysis in determining inspectional processes, and in providing cross-training at the port level. For example; PPQ developed and delivered pest detection and pest identification training to CBP Agricultural Specialists working in foreign passenger baggage, air cargo, maritime, and the mail branch. Included in the training were modules addressing pests of concern that are seen at ports of entry, most common pests of concern intercepted at the Port of Honolulu, insect and federal noxious weed identification, and disease symptom recognition. By offering continual training opportunities, PPQ is strengthening working relationships with CBP and improving the ability to effectively exclude exotic pests.

PPQ is a steering committee member in the Coordinating Group on Alien Pest Species (CGAPS), where management-level staff from every major agency and organization in Hawai'i, including federal, state, county, and private entities influence policy and funding decisions, improve communications, increase collaboration, and promote public awareness as it relates to quarantine and in invasive species work. CGAPS provides policymakers with information for decision making, and works closely with legislators to write and introduce new legislation to address safeguarding, quarantine, eradication, and preventative actions and abilities. CGAPS successfully secured a new funding mechanism from the legislature in 2007 and 2008 to pay for cargo inspection and associated infrastructure. It plays a key role in facilitating communication and cooperation among federal and state agencies, and developed the Silent Invasion public education campaign, which includes television, print media, and direct community outreach by staff. CGAPS has reduced the risk of the brown treesnake (BTS) (*Boiga irregularis* [Merrem]) becoming established in Hawai'i by training state-wide rapid-response search teams and supporting interdiction measures. As a proactive measure, CGAPS has developed a rapid-response plan to eradicate incursions by the RIFA. CGAPS also worked to create the Hawai'i Invasive Species Council (HISC) for the special purpose of engaging cabinet-level leadership to provide policy direction, coordination, and planning among state departments, federal agencies, and international and local initiatives. The HISC approves an annual budget to support invasive species prevention, control, research and technology, and public outreach projects across the state. Funded projects include the county-based Invasive Species Committees, Aquatic Invasive Species team and hull fouling/ballast water coordinator, the Weed Risk Assessment program, and the Hawai'i Ant Lab. For FY 13, HISC funded a project in conjunction with the Hawai'i Biodiversity Information Network to create an interagency pest notification system and link online reporting to the pest hotline.

PPQ is working with HDOA to address its concern for improved notification procedures of the possible importation of federal non-actionable pests that may not have significant impacts to the nation's agriculture industry, but may have significant impacts to Hawai'i's agriculture and natural resources. These non-actionable pests are imported into Hawai'i, either accidentally or intentionally through the air and maritime pathways.

Key partners in Hawai'i should be more connected with regional entities involved with IAS such as RISC, SPREP, SPC, PIP and others.

A12.3.12 Pacific Safeguarding Initiative

Recognizing the uniqueness of Hawai'i and the pest pressures from the Pacific and Asia Regions, PPQ established the Pacific Safeguarding Initiative (PSI), which is designed to reduce or eliminate risks before they approach the shores of the United States. The PSI accomplishes this by building a coordinated framework and partnership network with national plant protection organizations, regional plant protection organizations, universities, non-government organizations (domestic and foreign), U.S. Embassy staffs, and other organizations. Its goal is to strengthen regional and national pest exclusion activities within the Asia and Pacific Region, enhance pest detection activities within the region, strengthen pest mitigation and suppression activities, and enhance communication and reporting of pest detection and mitigation activities within the region. Further, PSI works to build the capacity of national and regional plant protection organizations as well as key stakeholders to effectively manage current and future pest risks, and to negotiate with other U.S. agencies to elevate invasive species issues within their departments.

In the past year the PSI has:

- Co-drafted a resolution for the Micronesian Chief Executives in which the Chief Executives of Guam, the CNMI, Palau, the Federated States of Micronesia and the Republic of the Marshall Islands resolve that they shall, among other things, integrate invasive species concerns into national and regional efforts and provide dedicated staff to work on Micronesia Regional Invasive Species Council initiatives to reduce the movement of pests into and out of their respective countries and the region. This resolution was signed by all Presidents and Governors in the region.
- Led discussions and actions with HDOA, the National Invasive Species Council (NISC), The Nature Conservancy, and the Coordinated Group on Invasive Species to develop a more efficient method of evaluating plant pests that are not known to occur in Hawai'i for potential federal action and to harmonize actionable pest lists.
- Worked with airlines to reduce risk in international passenger flights in the region.
- Met with members of the Pacific Plant Protection Organization (PPPO) to help draft the PPPO 2012-2018 Strategic Framework (adopted), and to develop a 3-year implementation plan (adopted).
- Assumed the USDA lead role in the Micronesia Biosecurity Plan.

All these activities and programs are accomplished to reduce risk to Hawai'i while maintaining transparency. Not only do these activities result in increased safe trade, they also result in the protection of American agriculture and natural resources in Hawai'i, the Pacific, and the U.S. mainland from threats posed by foreign invasive and agricultural pests.

A13 PATHWAY ANALYSIS OF INVASIVE SPECIES INTRODUCTION INTO THE STATE OF HAWAI'I

A13.1 INTRODUCTION

A13.1.1 Rationale for Pathway Analysis of Invasive Species Introduction into Hawai'i

Three characteristics contribute to the uniqueness of the Hawai'ian Archipelago: 1) the islands are arranged linearly in chronological order; 2) there is a large number of endemic species, many of which are numerically dominant and display traits distinct from related taxa; and 3) evolutionary phenomena characteristic of island environments in general, such as adaptive shifts, loss of dispersal ability, and arborescence, are developed to an extraordinary degree (Simon 1987). The features of island life—isolation, specialization, limited mobility, and lack of defenses (e.g., toxins, thorns)—have rendered it vulnerable to various kinds of disturbance. For example, unlike the organisms that have originated on continents, most species endemic to Hawai'i and other oceanic islands have evolved in isolation from certain evolutionary pressures, such as grazing and trampling by ungulate mammals; predation by rodents, ants, amphibians, reptiles, and carnivorous mammals; virulent diseases; and frequent and intense fires (Westbrooks 1998). Because of this, the biota of oceanic islands is thought to be comparatively fragile—lacking defenses against introduced predators, parasites, pathogens, and grazers, and adaptations to allow coexistence with introduced competitors (Simberloff 1995). Thus, like other oceanic islands, Hawai'i is particularly vulnerable to biological invasions. For example, although Hawai'i is one of the smallest states in the United States, comprising just 0.2% of its total land mass, more than 25% of the endangered species in the United States occur there (OTA 1993). Hawai'i is infamous as "the extinction capital of the United States," with 72% of the country's recorded extinctions (Gagné 1988; OTA 1993).

A growing recognition of Hawai'i's unique status and the vulnerability of its agriculture and other economic sectors, as well as its natural environment, to biological invasion has prompted legislative action. On July 27, 2005, former Congressman Ed Case (2nd District, Hawai'i) introduced the Hawai'i Invasive Species Prevention Act (H.R. 3468) to the U.S. House of Representatives. The purpose of this bill was "to recognize the unique ecosystems of the Hawai'ian Islands and the threat to these ecosystems posed by non-native plants, animals, and plant and animal diseases, to require the Secretary of Agriculture and the Secretary of the Interior to expand federal efforts to prevent the introduction in Hawai'i of non-native plants, animals, and plant and animal disease, and for other purposes." The bill concluded that "the current Federal statutory and regulatory regime is not sufficient to minimize the introduction of invasive species into Hawai'i and the environmental, economic, and social harm that would result from the introduction of additional invasive species." Among other things, the bill proposed "rules regarding the establishment of a system of post-arrival quarantine protocols for all persons, baggage, cargo, containers, packing materials, and other items traveling or being shipped to Hawai'i from domestic and foreign locations" and the establishment of "an expedited process for the State of Hawai'i and its political subdivisions to seek the approval of the Secretaries to impose general or specific prohibitions or restrictions upon the introduction or movement of invasive species or diseases from domestic or foreign locations to Hawai'i…."

In order to address the invasive species problem in Hawai'i, the origins of alien species, and the means or "pathways" by which they are introduced into the state, must be examined. To date, no pathway analysis has been conducted by the USDA to assess and quantify the risks posed by invasive species to Hawai'i's agriculture and natural environment, and to provide a sound basis for science-based decision making. The objectives of this study, requested by the Deputy Administrator of the USDA-APHIS-PPQ branch, were several. The study sought to answer the following questions:

- What are the major pathways by which invasive species are introduced into Hawai'i?
- What is the present risk to Hawai'i of introduction and establishment of invasive species from foreign countries and from the U.S. mainland and its overseas territories?
- What are the current sanitary and phytosanitary regulations, practices, and resources in Hawai'i?

The present report is divided into two broad sections. In the first section, providing background information, invasive species already established in Hawai'i and their consequences are discussed (Chapter B3). Next, an outline of state and federal programs for alien species interdiction in Hawai'i is presented (Chapter B4). Chapters B5 through B9 in the second section present results of analyses of the risks of quarantine material and invasive pests entering the State of Hawai'i via the airline passenger, cargo, "hitchhikers," wood packaging material, and military pathways, respectively. Lastly, a discussion of some species with potential to invade Hawai'i, including potential consequences, is presented (Chapter B10).

A14 INVASIVE SPECIES IN HAWAI'I AND THEIR CONSEQUENCES

As a tourist destination and center for commerce at the "crossroads of the Pacific," Hawai'i has always been vulnerable to the introduction and establishment of exotic organisms. Based on current estimates, the total number of plant species present in the Hawai'ian Islands exceeds 11,000, of which approximately 8,000 to 10,000 (72 to 90%) have been introduced (Staples et al. 2000; Staples and Cowie 2001; Eldredge 2006). This amounts to an average of more than 40 new plant introductions per year over the past two centuries (Loope 1998). Of the more than 2,100 introduced species that constitute the more commonly cultivated plants in Hawai'i, at least 470, or 22%, are considered invasive or potentially invasive (Staples et al. 2000). At least 79 of the exotics have been officially designated as noxious weeds by the HDOA (Hawai'i Administrative Rules § 4-68).

An estimated 9,277 terrestrial arthropod species are known from Hawai'i, of which 3,432 (37%) are nonindigenous (Eldredge 2006). The first alien insects undoubtedly were brought with the early Hawai'ians, who introduced fleas and the head louse (*Pediculus humanus capitis* De Geer) to the islands; later, European explorers and whalers introduced other noxious arthropod pests, such as mosquitoes (probably *Culex quinquefasciatus* Say), first recorded in 1826 from Lahaina on the island of Maui (Pemberton 1964). Immigrants comprise 6% (133 species) of the estimated total of 2,171 mollusc species. In all, some 500 species of arthropods and molluscs in Hawai'i can be classified as pests (Beardsley 1991). Of these, 98% have been introduced. In recent years, the rate of new pest arthropods and molluscs establishing in Hawai'i has averaged 3.5 species annually (Beardsley 1991). Over 1,100 plant parasitic and pathogenic species (nematodes, bacteria, fungi, and other microorganisms) are known to occur in Hawai'i (Raabe et al. 1981). Most of these are non-indigenous.

A14.1 IMPACT ON THE ENVIRONMENT

At least one half of the wild species in Hawai'i today are non-indigenous (OTA 1993). No other area in the United States has as great a proportion of established non-indigenous species (OTA 1993). They have had a profoundly negative effect on natural environments in Hawai'i; natural areas that still support indigenous species in relatively intact habitats make up only about 25% of Hawai'i (OTA 1993). For all natural areas, the control and management of invasive species consumes the vast bulk of resource management budgets (OTA 1993).

Introduced arthropods have been implicated in the decline or extinction of rare native plant and animal species through direct feeding, predation, or parasitization; disruption of pollination; transmission of pathogens; and competition (e.g., Warner 1968; Howarth 1985; van Riper et al. 1986; Gambino et al. 1987; Gambino 1992; Howarth et al. 2001; Oboyski et al. 2004; Johnson and Denslow 2005). Some of the greatest harm visited upon native species and ecosystems, directly or indirectly, has resulted from invasion by ants (Krushelnycky et al. 2005), no species of which occurred in Hawai'i before the arrival of humans (Wilson 1996). Similarly, the introduction of alien snails has led to drastic declines or extinctions in endemic snail species (Hadfield and Mountain 1980; Cowie 1998).

Invasive plants, many of which were intentionally introduced, are systematically altering the basic properties of some of Hawai'i's ecosystems, such as light availability, soil water-holding capacity, nutrient uptake, and other microclimatic variables (Vitousek 1992; Cordell et al. 2002). Non-native grasses have played a major role in altering the natural fire regime in Hawai'i (Staples 2001; Benton 2006). Smith (1985) discussed the characteristics of 86 alien plant species that have become significant pests of native ecosystems in Hawai'i, many displacing populations of less competitive native plants. Additional plant species with the potential to become invasive continue to be introduced into the state (e.g., Staples et al. 2006), a major route being the trade in horticultural plants (Staples and Cowie 2001).

Plant invasions in Hawai'i often have been facilitated by the grazing and other disturbances to native habitat caused by introduced ungulate mammals (Stone 1985). Although single-species invasions in Hawai'i, such as those involving plants, in themselves may be devastating to native biota or ecosystems (e.g., Vitousek et al. 1987; Hughes and Denslow 2005), invasive species (e.g., alien grasses and vines, mammals, predatory and parasitic Hymenoptera) also may act in concert to threaten native species, such as birds, drastically restricting their foraging ranges (e.g., Banko et al. 2002).

The precarious state of the endemic Hawai'ian biota has been summarized thusly (OTA 1993): "By many measures, the Hawai'ian Islands represent the worst-case example of the Nation's [nonindigenous species] problem. No other area in the United States receives as many new species annually, nor has as great a proportion of [nonindigenous species] established in the wild. At the same time, Hawai'i, the Nation's so-called extinction capital, has the greatest concentration of threatened and endangered species in the United States and the greatest number of extinct species as well. While habitat destruction has been and continues to be a main factor in the demise of the indigenous biota, [nonindigenous species] have been identified as an important, if not the most important, current threat."

A14.1.1 Impact on Agriculture

All of the crops cultivated and livestock raised in Hawai'i are introduced species, and virtually all of the agricultural pests in Hawai'i have been introduced as well (OTA 1993). Invasive pests impact agriculture directly by destroying crops and increasing costs of production, and by limiting markets in mainland and foreign areas that have imposed quarantines on produce from Hawai'i because of the threat of new pests (OTA 1993). For example, because of a federal quarantine, fruit fly host products can only be sold in the rest of the United States if they have undergone some type of quarantine treatment (e.g., fumigation, irradiation). Quarantine treatments are generally required even for commodities, to which the damage caused by pests of concern is insignificant or rare. Quarantine treatments add significant costs to these commodities, which reduce their competitiveness in the global marketplace (McGregor 2004).

Although the full economic impact of invasive species on Hawai'i's agriculture is unknown, the presence of non-indigenous quarantine pests in Hawai'i was estimated to result in a $300-million annual loss of agricultural export revenue from the closure of U.S. mainland and foreign markets alone (USDA 2006b).

Additionally, invasive pests have had a profound impact on shaping Hawai'i's agriculture as a whole. For example, McGregor (2004) noted that, although the agronomic conditions are favorable in Hawai'i for a variety of fruit crops, these crops are never seriously considered for commercial development in Hawai'i because of the imposing nature of fruit fly damage, quarantine restrictions, and costly post-harvest treatments. In particular, the loss of export markets, resulting from quarantine restrictions in the U.S. mainland and some foreign countries, is often cited as the main barrier to the expansion of Hawai'i's diversified agriculture (OTA 1993).

A14.1.2 Case Studies

A14.1.2.1 Plants

A14.1.2.1.1 Miconia calvescens DC (Melastomataceae) (miconia, velvet tree)

Origin: Tropical America: Mexico, Central and South America

Mode of introduction: Introduced intentionally as an ornamental plant in the 1950s or 1960s.

Environmental impacts. Miconia has been spreading aggressively in both native and disturbed forests since its introduction, threatening many of Hawai'i's remaining native plants (Staples and Cowie 2001; Kaiser 2006). This invasive weed has the potential of completely dominating all of Hawai'i's native wet forests, as it has in Tahiti, where dense, monotypic stands of the tree now cover 65% or more of the main island after the introduction of just a single specimen in 1937 (Kaiser 2006). Miconia's ability to out-compete native plants is well documented: it forms dense thickets that block sunlight and crowds out other plants, and it produces an enormous number of seeds that are spread by birds and rats, and remain viable in soil for many years (Staples 2001). Additionally, it promotes erosion because its shallow root system does not hold soil on steep slopes, particularly in heavy rains (Reaser et al. 2007).

Economic impacts. Miconia is not an agricultural pest per se, and it is difficult to measure its economic impact because damages are indirect, impacting ecosystem services and non-market goods, such as biodiversity (Kaiser et al. 2006; Kaiser 2006). Kaiser (2006) attempted to quantify such damages, and estimated that if miconia were to become established throughout its potential range in Hawai'i, total damages could reach an average of $377.4 million per year.

Miconia was targeted for eradication in the Hawai'ian Islands in 1991, and there is an active campaign to remove it from all islands where it occurs and to prevent its spread. While the budget for the program on all islands is unknown, Kaiser et al. (2006) reported that the Oahu Invasive Species Committee allocated $321,000 to miconia control in 2005 and that Maui expends approximately $1 million per year on miconia-related activities. Tavares (1998) reported that, between 1995 and 1997, approximately $500,000 was spent on miconia control and research programs on the Big Island of Hawai'i. Currently Miconia is not considered eradicable from Hawai'i Island and not likely eradicable from Maui. If a successful biocontrol could be developed then eradication might become a more feasible option.

A14.1.2.1.2 Psidium cattleianum Sabine (Myrtaceae) (strawberry guava)

Origin: Brazil

Mode of introduction: Originally introduced for cultivation in the 1800s.

Environmental impacts. Strawberry guava was introduced intentionally as a fruit tree, but since has become one of the islands' worst pests (Smith 1998; Staples 2001), especially in native rain forests where it infests thousands of hectares (Johnson and Denslow 2005). Its dense thickets suppress native species, and the plant is adapted to disturbance (Jacobi and Warshauer 1992). Strawberry guava may build up an enormous seed bank in the soil, and seeds tend to germinate at higher rates in areas subject to disturbance, such as that caused by feral pigs. In areas where strawberry guava is established, the ground may be carpeted with highly shade-tolerant seedlings, which release compounds into the soil that prevent other species from germinating (Staples 2001; Johnson and Denslow 2005), an adaptation termed allelopathy. Additionally, strawberry guava plants produce an enormous number of fruit, which are eaten by birds and other animals, and which, in turn, spread the seeds (Staples 2001).

The displacement of native trees is also facilitated by the interaction of strawberry guava with two invasive species of ginger: *Hedychium gardnerianum* Shepard ex Ker-Gawl. (kahili ginger) and *Hedychium coronarium* Koenig (white ginger). These species tend to cover and strangle the seedlings of both native trees and strawberry guava, but guavas are more tolerant of the cover, and are better able to survive than are native trees (Cox 1999).

Economic impacts. As with miconia, it is difficult to measure the economic impacts of strawberry guava. In addition to the damages caused to ecosystem services and biodiversity, the numerous fruit produced by a single plant provide a major food resource to fruit fly pests of Hawai'ian agriculture, which increases the difficulty and cost of controlling these species (Johnson and Denslow 2005). Unfortunately, strawberry guava, and its congener, *Psidium guajava*, the common guava, are still planted as ornamentals and fruit trees (Staples and Cowie 2001).

A14.1.2.1.3 Pennisetum setaceum (Forssk.) Chiov (Poaceae) (fountain grass)

Origin: Northern Africa

Mode of introduction: Introduced as an ornamental grass around 1914.

Environmental impacts. Fountain grass is one of several non-native grasses that have played a major role in altering the natural fire regime in Hawai'i. Lightening is uncommon on oceanic islands; therefore, in contrast to many other terrestrial environments, fire has not played much of an evolutionary role in the native ecosystems of Hawai'i (Westbrooks 1998). Thus, few Hawai'ian endemic plant species possess adaptations to fire. Humans are the cause of most fires in Hawai'i, and these fires are fueled primarily by non-native grasses (Brooks et al. 2004).

Like other invasive grasses in Hawai'i, fountain grass is a highly aggressive, fire-adapted colonizer of pastures and grasslands that readily out-competes and replaces native plants and rapidly re-establishes after burning. In the summer, when the grass dries out, it becomes a fire hazard. The grass burns quickly with intense heat, resulting in severe damage to native forest species, which are not adapted to such extreme fire regimes (Staples 2001; Benton 2006). Fountain grass out-competes other grasses by regenerating quickly after burning; native grasses and many forage grasses do not have this capacity (Staples 2001).

In addition to increasing the frequency and intensity of fires, there is some evidence that fountain grass also alters basic ecosystem properties, such as light availability, soil water holding capacity, nutrient uptake, and other microclimatic variables (Cordell et al. 2002). Fountain grass is also an aggressive invader of bare lava flows, where it reportedly interferes with normal plant succession (Tunison 1992; Staples and Cowie 2001). Its seeds are dispersed by wind, water, humans, vehicles, and birds (Tunison 1992), but because of an active control program to prevent it from spreading to other islands, so far, extensive damage has been limited to the Big Island (HDLNR 2007).

Economic impacts. Control of fountain grass is difficult and expensive, often costing more than $12,000 per hectare (Cordell et al, 2002).

A14.1.2.2 Arthropods

It has been estimated that since European contact with the Hawai'ian Islands in the 18th century, approximately 15 to 20 new species of insect immigrate to Hawai'i each year (Beardsley 1962; 1979).

A14.1.2.2.1 Bactrocera dorsalis (Hendel) (Diptera: Tephritidae) (oriental fruit fly)

Origin: Southern Asia

Mode of introduction: Military air transport from Saipan (Jang and Harris 2005).

Environmental impacts. The oriental fruit fly is widespread in native forests, and feeds on both native and introduced fruits. Efforts to control fruit fly populations, particularly with organophosphate pesticides, may severely impact native species.

Economic impacts. The oriental fruit fly was introduced into Hawai'i around 1945, and quickly displaced the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) (introduced around 1910 [Clausen et al. 1965]), throughout most of its range (Vargas et al. 2001; Jang and Harris 2005). Along with the melon fly, *B. cucurbitae* (Coquillett), the oriental fruit fly is the most damaging of Hawai'i's exotic fruit flies. It has a wide host range, and is a major pest of almost every variety of fruit grown commercially in Hawai'i (Harris 1989). Guava, mango, papaya, carambola, passion fruit, citrus, tomato and breadfruit are particularly susceptible, and, left uncontrolled, oriental fruit flies can damage up to 100% of fruit in a production area (CABI 2006).

In Hawai'i, producers suffer significant direct and indirect economic losses from fruit fly damage (Hendrichs 1996). Even with control, annual losses in fruit crops resulting from infestations by the oriental fruit fly may exceed 13% (Culliney 2002), undoubtedly an underestimate. Globally, *B. dorsalis* causes millions of dollars worth of damage each year (SPC 2002b). Additionally, fruit flies can have a significant impact on crop values, even when they do not actually infest the fruit. Fruit quality can be reduced due to fruit fly oviposition punctures ("stings"), which affect the appearance of fruit, even in fruits unfavorable for larval survival (Harri 1989). Moreover, many fruits, including papayas and tomatoes, are harvested before they are ripe, in part to avoid fruit fly stings and infestations. Harvesting these fruits early affects their taste. Papayas, for example, increase in sugars and sweetness as they mature on the tree. McGregor (2004) estimated that growers could expect about $.11 more per kilogram (kg) for tree-ripened papaya than papaya picked green, which would translate into approximately $750,000 per year for the industry.

Strict quarantine regulations are necessary to prevent the movement of fruit flies from the Hawai'ian Islands to fruit fly-free areas, and fruit producers have had to invest in expensive post-harvest treatments and facilities to disinfest fruit cargoes before or during shipment (Hendrichs 1996; Howarth et al. 2001). Costs of post-harvest treatments can be significant. Additionally, millions of dollars continue to be spent on fruit fly-related research, including research on various control techniques (e.g., area-wide pest management, sterile insect technology) and alternative post-harvest treatments.

In addition to these direct costs, there are immeasurable indirect costs associated with lost markets and industries. McGregor (2004) speculated that these costs are likely to be much greater than the direct costs mentioned above. A study conducted by the Nature Conservancy of Hawai'i (Miller and Holt 1992) postulated, based on industry estimates, that oriental and melon flies cost Hawai'i $300 million per year in lost markets. While there are few data available to confirm this estimate, it is clear that the presence of exotic fruit flies is a significant deterrent to the research and development of crop industries that are significant hosts of fruit flies. For example, in Hawai'i, practically all guavas are processed—none is sold for fresh consumption—due to high oriental fruit fly infestations (McGregor 2004).

A14.1.2.2.2 Aleurodicus dispersus Russell (Hemiptera: Aleyrodidae) (spiraling whitefly)

Origin: Central America and the Caribbean

Mode of introduction: Accidentally introduced about 1978, probably on flowers or produce (Howarth et al. 2001).

Environmental impacts. The spiraling whitefly has a broad host range. It is generally found in coastal areas (Howarth et al. 2001), but environmental impacts due to the introduction of this pest seem to have been minimal.

Economic impacts. The spiraling whitefly has been recorded on more than 100 species of plant, belonging to 38 genera and 27 families, and commonly attacks many vegetable, ornamental, fruit, and shade tree crops in Hawai'i (Kessing and Mau 1993; CABI 2006), including annona, avocado, banana, bird-of-paradise, breadfruit, citrus, coconut, eggplant, guava, kamani, Indian banyan, macadamia, mango, palm, paperbark, papaya, pepper, poinsettia, rose, sea grape, and tropical almond (Kessing and Mau 1993).

Following its introduction into Hawai'i, *A. dispersus* became a major economic pest, and the HDOA and its cooperators conducted extensive searches for biological control agents that could be introduced to reduce its populations. Several natural enemies were introduced into Hawai'i from the Caribbean in the early 1980s. The biological control program seems to have been successful, and at least one agent was documented to reduce populations by as much as 79% at lower elevations and 99% at higher elevations. At present, the spiraling whitefly is generally considered only a minor pest (Kessing and Mau 1993). Infestations can have serious economic impacts in at least three ways:

- Direct damage to the plant caused by feeding: *A. dispersus* larvae (and to a lesser degree, adults) cause damage by sucking sap from leaves. Direct feeding can cause premature leaf drop, which may reduce plant vigor and yields, but rarely kills plants outright (CABI 2006).
- Indirect damage to the plant caused by excreted honeydew: Damage is caused when sooty molds develop on honeydew excreted by the insects. Sooty molds covering leaves can hinder photosynthesis and reduce yields (CABI 2006).
- Cosmetic damage to the fruit: Damage is caused by both sooty molds and the white flocculent wax secreted by immature stages. Although cosmetic damage does not affect the plant itself, it can significantly reduce the market-value of crops (CABI 2006).

Aleurodicus dispersus is a quarantine pest for other countries, and is listed as a reportable/actionable pest for the contiguous United States (despite its presence in Florida) (USDA 2007a). Crop exports are sometimes rejected at a mainland port due to the presence of this pest (Staples and Cowie 2001), meaning lost income for Hawai'i growers.

A14.1.2.2.3 Coptotermes formosanus Shiraki (Isoptera: Rhinotermitidae) (Formosan subterranean termite)

Origin: Taiwan or South China

Mode of introduction: Accidentally introduced via shipping (Staples and Cowie 2001).

Environmental impacts. There are seven species of termite in Hawai'i, all of them introduced (Woodrow et al. 1999). Although, in general, *C. formosanus* is an urban pest, it has also been found attacking living plants (especially trees), resulting in damage to all parts of the plant, but in particular the heartwood, roots and branches (Lai et al. 1983). In New Orleans, an estimated 30 to 50% of the historic live oak trees are infested with *C. formosanus* (Anonymous 2007). Similar estimates for Hawai'i were not available, but Lai et al. (1983) reported several instances in Hawai'i in which apparently healthy trees were hollowed out by termites, causing them to fall.

Additionally, increased use of pesticides to control termite populations has led to negative effects on the environment, including contamination of water supplies caused by runoff (Anonymous 2007).

Economic impacts. *Coptotermes formosanus* commonly attacks structural timbers, books, and other finished wood or paper products. The termite is considered the single most costly economic pest in Hawai'i, causing over $150 million worth of damage each year to buildings, furnishings, and trees (Woodrow et al. 1999; Staples and Cowie 2001). Moreover, this species is not believed to have reached its full distribution in Hawai'i, and it is believed that costs will probably increase in the future as 1) the termite moves into areas in Hawai'i where it does not yet occur; 2) the colony density increases in areas where the termite does occur; 3) the values of existing buildings increase; and 4) additional buildings are constructed, putting more buildings at risk (Yates 1992).

One of the reasons for the high costs associated with this insect stems from the fact that *C. formosanus* is an aggressive pest that leaves little evidence of attack until considerable damage has been done. According to Yates (1992), “often the first indication of an infestation is a sagging floor or door, leaking roof, warping of walls, hollow sounding beams, short circuits, telecommunication blackouts, etc.” Colonies of *C. formosanus* are large: in Hawai’i, an average colony contains over 2 million individuals, and some may have as many as 10 million individuals. Because of their numbers, a great deal of damage can occur in a short amount of time. In some cases, unprotected homes built over strong existing colonies have been almost completely destroyed in 2 years (Yates 1992).

A14.1.2.2.4 Ants (Hymenoptera: Formicidae)

There are 43 species of ant in Hawai’i, all of them introduced. In terms of environmental impact, they are arguably the most harmful invasive insect species in Hawai’i. After being introduced into a new area, many species of ant are able to establish colonies quickly in a variety of habitats. They prey on other invertebrates or feed on the seeds of plants, and often out-compete native species for food and space. In Hawai’i, they have been directly associated with the destruction of many native insect species (Staples and Cowie 2001).

A14.1.2.2.5 Pheidole megacephala (Fabricius) (bigheaded ant)

Origin: Tropical Africa

Mode of introduction: Accidentally

Environmental impacts. This ant is widely considered a serious threat to biodiversity and one of the “world’s worst invaders” (Hoffman 2006). In the environment, it is a major predator implicated in the extermination of many lowland insects (Staples and Cowie 2001). Evidence also exists of reductions in vertebrate populations in areas where this ant is extremely abundant. Additionally, it is known to facilitate the invasion of introduced plant species (Hoffman 2006).

Economic impacts. The bigheaded ant is often a household pest, with large, inter-connected colonies that are difficult and expensive to control (Staples and Cowie 2001). It is also known to chew on irrigation lines, telephone cabling, and electrical wires (Hoffman 2006).

In agriculture and horticulture, bigheaded ants can be serious pests, either directly, by collecting and harvesting seeds, or indirectly, by protecting and tending phytophagous Homoptera, such as the pink pineapple mealybug, resulting in population increases of these pests and consequent reductions in plant productivity (Staples and Cowie 2001; Hoffman 2006).

A14.1.2.2.6 Linepithema humile (Mayr) (Argentine ant)

Origin: Brazil and Argentina

Mode of introduction: Accidentally

Environmental impacts. The Argentine ant was introduced into Hawai'i about 1940 (Staples and Cowie 2001). Although it is generally associated with disturbed habitats throughout its introduced range, it has also invaded native habitats that have experienced little human disturbance (Krushelnycky 2006).

Native arthropods are greatly threatened by Argentine ants. They compete aggressively with native arthropods for limited food resources and nesting sites. For example, in South Africa, the Argentine ant can collect up to 42% of available nectar before bees can forage (Krushelnycky 2006). In Hawai'i, the Argentine ant is believed to be responsible for declines in populations of many native arthropods, including moths and bees, which are essential pollinators of native plants (Cole et al. 1992; Staples and Cowie 2001; Krushelnycky 2006). In addition to out-competing native arthropods, Argentine ants actively prey on a number of native arthropod species, and have even been reported attacking the eggs of the native Hawai'ian goose, or nene, *Branta sandvicensis* (Vigors) (Cole et al. 1992; Krushelnycky 2006). The pest has not yet reached its full potential distribution in the islands (Staples and Cowie 2001).

Economic impacts. Argentine ants do not appear to be important agricultural pests. However, they may have an indirect, negative impact on agriculture and horticulture because they attack the predators and parasitoids of scale insects, causing the scales to multiply and become more serious pests of crops and horticultural plants (Staples and Cowie 2001).

A14.1.2.2.7 Varroa destructor Anderson & Trueman (Parasitiformes: Varroidae) (varroa mite)

Origin: Far East

Mode of introduction: Unknown; smuggling, honey bee swarms aboard ships, and shipments of bees transiting Hawai'i are possible sources

Environmental impacts. The varroa mite is recognized as the most serious pest of the western honey bee, *Apis mellifera* L., worldwide (Anderson and Trueman 2000; Sammataro et al. 2000). Australia and Hawai'i were among the last few areas known to be free of infestation (Culliney 2003). However, in April 2007, varroa mites were detected in three abandoned hives on Oahu (Hao 2007).

In parasitizing the immature stages of the honey bee, *V. destructor* often kills its host outright (De Jong et al. 1982). If the host survives, the resulting adult bee usually is deformed in some way and incapable of contributing to colony welfare. Colony population size dwindles over time, and, left untreated, a heavy infestation can kill a colony within 3 to 4 years. The mite is known to be a vector for at least four honey bee viruses: sacbrood, acute paralysis, black queen cell, and deformed wing (the latter three not known to occur in Hawai'i), some of which may cause severe mortality in colonies (Bailey and Ball 1991). To combat the parasite, beekeepers must resort to the use of expensive pesticides, although there now are clear indications that the mite is developing resistance to these (Sanford 1998). Wild bee colonies have no defense; they have been reported to be dying out in the continental United States, where *V. destructor* is well-established (Kraus and Page 1995).

Varroa disperses locally through phoresy, attaching itself to worker and drone honey bees, as well as to a variety of other flower-frequenting insects, including other species of bee, flies, and beetles; flowers may thusly be used by the mite as way stations to transfer to new insect vehicles (Kevan et al. 1990). Spread of the mite over wide areas within countries results from migratory beekeeping (De Jong 1990). The post-World War II increase in international travel and commerce has facilitated the spread of *V. destructor* globally (Sammataro et al. 2000). First recorded on *A. mellifera* in Asia around 1960 (De Jong 1990), at present, the species is almost cosmopolitan in distribution (Anderson and Trueman 2000). That this pernicious parasite has dispersed so widely and quickly attests to the ease with which it surmounts geographic barriers and thwarts international quarantines.

Economic impacts. As agriculture in Hawai'i depends heavily on the pollination services provided by the large feral honey bee population, it could be severely impacted should *V. destructor* become established. For example, since its first detection in 2000, the total economic impact of *V. destructor* on agriculture in New Zealand has been estimated at $251 to $566 million (Canyon et al. 2002).

The Hawai'i legislature recently passed legislation appropriating $650,000 to be spent on training and pesticides, and to reimburse beekeepers for mite control costs among other measures (Hao 2007).

A14.1.2.3 Molluscs

A14. 1.2.3.1 Achatina fulica Bowdich (Achatinidae) (giant African snail)

Origin: East Africa, but introduced from Japan

Mode of introduction: Intentionally introduced on more than one occasion as a human food item and as a pet species (Staples and Cowie 2001).

Environmental impacts. The giant African snail was first introduced into Hawai'i in the 1930s. Since that time, it has become widespread (CABI 2006). Although *A. fulica* is primarily found in disturbed low- to mid-elevation sites in Hawai'i, it has also been observed as an invader of primary or secondary forests (Raut and Barker 2002). Large numbers in native ecosystems pose a threat to native plants, and it may compete with native snails for food and space (Staples and Cowie 2001).

Economic impacts. The giant African snail is a generalist feeder and is a major crop and garden pest, requiring frequent use of snail bait for control. As Raut and Barker (2002) noted, there are three main costs associated with this pest in tropical agriculture. First, there is a loss of productivity caused by direct feeding on crop plants or on other plants that provide shade or soil enrichment. The snails may also transmit plant pathogens. Secondly, there are costs associated with management of this pest both in terms of labor and in materials. Finally, there are opportunity costs associated with changes in agricultural practices, such as planting only crop species resistant to *A. fulica* (Raut and Barker 2002). The extent to which Hawai'i has incurred such costs is unknown.

Additionally, the snail is an intermediate host of the parasitic nematode, *Angiostrongylus cantonensis* (Chen), or rat lungworm, which causes the disease eosinophilic meningoencephalitis in humans (Staples and Cowie 2001).

A14.1.2.3.2 Euglandina rosea Ferussac (Spiraxidae) (rosy wolf snail)

Origin: Latin America, southeastern United States

Mode of introduction: Intentionally introduced to control African snails.

Environmental impacts. This snail was introduced into Hawai'i in 1955 as a potential biological control agent against the giant African snail (Cox 1999; Staples and Cowie 2001). It is found in damp places in both disturbed areas and native forests. Instead of controlling African snails, the rosy wolf snail has devastated native snails, eliminating up to half of the 800 snail species endemic to Hawai'i, and is the most serious predator of *Achatinella* spp. (Cox 1999), listed as endangered in Title 50, Part 17, Section 11 of the United States Code of Federal Regulations (50 CFR § 17.11).

A141.2.3.3 Pomacea canaliculata (Lamarck) (Ampullariidae) (channeled or golden apple snail)

Origin: South America, but probably introduced to Hawai'i from Southeast Asia (Staples and Cowie 2001)

Mode of introduction: Intentionally as a potential human food item for home consumption and as an exotic escargot for the restaurant trade (Staples and Cowie 2001).

Environmental impacts. The channeled apple snail was introduced into Hawai'i about 1989. Since that time, it has become increasingly widespread in taro growing areas, ponds, streams, and wetlands (Staples and Cowie 2001). It has reached most wet areas on the islands of Kauai, Oahu, Maui, Lanai, and Hawai'i (Levin 2006). According to Levin, almost 4,400 hectares of wetlands, ponds, streams, taro-growing systems, and other habitats are at risk or have already been invaded by this pest. There is little information available on the impact of this snail on freshwater wetland ecosystems and watersheds. However, one recent study suggested that, in Thailand, high densities of *P. canaliculata* were associated with the almost complete absence of aquatic plants, high nutrient concentrations, and subsequent phytoplankton blooms (Carlsson et al. 2004; Levin 2006).

Economic impacts. *Pomacea canaliculata* is a general feeder that has been recorded on various aquatic weeds, ong choi, and watercress (Levin 2006). It is a major pest of rice throughout much of Japan and Southeast Asia (Staples and Cowie 2001; Cowie 2002). In Hawai'i, it is a serious pest of taro, feeding on the stem, corms, and other plant parts (Staples and Cowie 2001), and accounts for yield losses ranging from 18 to 25% annually (Levin 2006). Mitigation of the impact of this pest has increased labor, time, and cash inputs by as much as 50% above traditional production costs (Levin 2006). Additionally, taro is a crop of considerable cultural importance to Hawai'i (Ooka and Brennan 2000).

A14.1.2.4 Vertebrates

A14.1.2.4.1 Eleutherodactylus coqui Thomas (coqui frog)

Origin: Caribbean

Mode of introduction: Believed to have entered Hawai'i on uninspected potted plant material from Puerto Rico about 1988 (HDOA 2007a).

Environmental impacts. *Eleutherodactylus coqui* is a small frog (less than 2.5 cm [about 1 inch] in length) with a loud call (Staples and Cowie 2001). Aside from being a major nuisance pest, coqui frogs pose a major threat to Hawai'i's native biota. For example, the population established in Hawai'i is estimated to consume as many as 125,000 insects per hectare per night (CTAHR 2006; HDOA 2007a). Additionally, the frogs compete with Hawai'i's native birds and other fauna that rely on insects for food (Staples and Cowie 2001; CTAHR 2006). Thus, large frog populations could have adverse effects on these species—many of them already threatened or endangered. The frogs also are known to increase soil fertility by converting arthropod biomass into nutrients more readily available to plants, thus potentially altering plant species composition and providing conditions favorable to weed invasion (Beard and Pitt 2005).

Coqui frogs are quite adaptable to the varied ecological zones and topography in Hawai'i. Whereas, in Puerto Rico, frog populations are kept in check by predators, such as owls, snakes, tarantulas, and scorpions, in Hawai'i, the coqui frog has no natural enemies (CTAHR 2006; HDOA 2007a). Populations have exploded in the last 15 years; there are now over 200 infestations on the Big Island alone, and Maui has over 40 infestations. The Coqui has been found on Oahu in at least five locations (CTAHR 2006), but currently there are no established populations. Coqui have been declared eradicated from Kauai as of mid-2012.   was recently discovered on Kauai In some areas where Coqui have been able to establish, populations exceed 25,000 frogs per hectare (HDOA 2007a).

Economic impacts. There is little information on the actual economic consequences of the introduction of this species. However, there is some speculation that, as populations of the frog increase, tourism may be negatively impacted due to the extremely loud noise levels produced by this frog: calls can be as loud as 80 to 90 decibels, about the same as a lawn mower (Staples and Cowie 2001; HDOA 2007a). Since this frog is active at night, many residents and visitors in coqui-infested areas have complained that they are unable to sleep due to the noise produced by the frogs (HDOA 2007a). Beyond potential impacts on tourism, there is a possibility that Hawai'i's nursery industry could be negatively impacted by the presence of this frog if exports are banned because of quarantine restrictions (Staples and Cowie 2001). An impact which has not been fully examined is the requirement of property owners to disclose the existence of this species on their property.

A14.1.2.4.2 Sus scrofa Linnaeus (feral pig)

Origin: East Indies

Mode of introduction: Intentionally by the Polynesians for food.

Environmental impacts. Feral pigs represent one of the major threats to forests and other natural areas (OTA 1993). In the process of rooting for food, they damage ground-level plant cover and greatly assist in germination and spread of invasive plants, including strawberry guava. They also topple and eat native tree ferns (Kishinami 2001).

Economic impacts. Pigs are considered the number one economic and environmental threat to watersheds in Hawai'i, reducing the extent of plant cover, which impacts freshwater resources (Kishinami 2001). Estimated damages from feral pigs range from $1 million to almost $24 million per year (Kaiser et al. 1999). A further $450,000 per year is spent to control pigs in national parks in Hawai'i (Pimentel et al. 2000).

A14.1.2.5 Conclusions

Invasive species have caused hundreds of millions of dollars worth of damage in Hawai'i in terms of crop losses, increased production costs, and lost markets. The sheer number of invasive species makes it nearly impossible to evaluate the full impact of past biological invasions on the Hawai'ian economy. From the few studies that have been conducted, it is clear that the impact must be considerable. For example, fruit flies alone have been estimated to result in a $300-million annual loss of agricultural export revenue from the closure of U.S. mainland and foreign markets (Miller and Holt 1992). Potential damages to the Hawai'i economy associated with the invasive weed, *Miconia calvescens* DC., have been projected to exceed $377 million per year (Kaiser 2006). Exotic termites cause more than $150 million in damage annually to structures throughout the state (Howarth et al. 2001). Estimated damages from feral pigs range from $1 million to almost $24 million per year (Kaiser et al. 1999).

Perhaps more serious, invasive species have been responsible for endangering and causing the extinction of native species—many of which are not found anywhere else in the world—and for the destruction of native forests and other natural areas.

A summary of the impacts associated with the selected non-indigenous species reviewed in this chapter is presented in Table B3-1. The introduction and establishment of other invasive pests, such as RIFA, West Nile virus, and BTS , likely would have a similar or greater impact on Hawai'i's economy, and further endanger the archipelago's endemic biota as well (Choo 2004) (see also Chapter 10).

Table B3-1: Summary of Some of the Impacts Associated with Selected Non-indigenous Species in Hawai'i

Name	Origin	Mode of Introduction	Economic impact	Environmental impact
Miconia calvescens (miconia, velvet tree)	Tropical America	Intentionally, as an ornamental	Almost $2 million was allocated for control programs in 2005	Forms dense thickets that block sunlight and crowd out other plants; promotes erosion
Psidium cattleianum (strawberry guava)	Brazil	Intentionally, for cultivation	Costly to control	Dense thickets suppress native species; adapted to disturbance
Pennisetum setaceum (fountain grass)	Northern Africa	Intentionally, as an ornamental	Costly to control	Changes the fire regime; out-competes native plants
Bactrocera dorsalis (oriental fruit fly)	Southern Asia	Accidentally on military transports	An estimated $300 million per year in lost market access; significant crop losses; significant costs of control	Attacks native fruits; large quantities of insecticide are used to control this pest
Aleurodicus dispersus (spiraling whitefly)	Central America and the Caribbean	Accidentally, probably on cut flowers or fresh produce	Considered a major economic pest until biological control agents were introduced	Probably unimportant
Coptotermes formosanus (Formosan subterranean termite)	Taiwan or South China	Accidentally, probably via shipping material	An estimated $150 million worth of damage every year to wooden structures and other products	May attack living trees; large quantities of insecticide are used to control this pest
Ants (*Pheidole megacephala* and *Linepithema humile*)	Africa (*P. megacephala*); Brazil and Argentina (*L. humile*)	Accidentally	Household pests that are costly and difficult to control; have indirect impacts on agriculture	Responsible for the extinction or endangerment of several species of endemic insects
Varroa destructor (varroa mite)	Far East	Unknown; smuggling, swarms aboard ships, and shipments of bees transiting Hawai'i are possible sources	New introduction; total economic impact in New Zealand was estimated at $251 to $566 million; potential threat to Hawai'i agriculture	Could devastate wild bee populations; plants that depend on pollination for reproduction may be negatively impacted

Name	Origin	Mode of Introduction	Economic impact	Environmental impact
Achatina fulica (giant African snail)	Africa; probably introduced into Hawai'i from Japan	Intentionally, for food and as a pet species	Can be a major crop and horticultural pest	Competes with native snails for food and space
Euglandina rosea (rosy wolf snail)	Latin America	Intentionally, as a biological control agent for the giant African snail	Probably unimportant	Has devastated Hawai'i's native snails, eliminating up to half of the 800 species endemic to Hawai'i
Pomacea canaliculata (channeled or golden apple snail)	South America, but probably introduced into Hawai'i from Southeast Asia	Intentionally, for food	Has a major effect on taro production in Hawai'i; increases costs of production as much as 50%	May be devastating to communities of aquatic plants
Eleutherodactylus coqui (coqui frog)	Caribbean	Accidentally, probably on plants imported from Puerto Rico	Potential impact on nursery trade if quarantines are put in place; potential impact on tourism	Poses a threat to native Hawai'ian insect populations, including plant pollinators; may compete with native birds for food
Sus scrofa (feral pig)	East Indies	Intentionally, for food by Polynesians	Costly to control	Damaging to indigenous plants; in altering plant cover, indirectly may affect watersheds

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A15 PROGRAMS FOR ALIEN SPECIES INTERDICTION IN HAWAI'I

A15.1 HAWAI'I DEPARTMENT OF AGRICULTURE, PLANT INDUSTRY DIVISION, PLANT QUARANTINE BRANCH

Among its many responsibilities, the HDOA is charged with preventing the introduction and establishment of alien species in the state. Because of Hawai'i's geography and diverse climatic zones (tropical to temperate), the state is vulnerable to the entry and establishment of more foreign pests than are mainland states. HDOA collaborates with federal agencies to prevent introduction of regulated invasive pests. Similarly, HDOA inspectors involve federal agencies if a detected organism is an endangered species and subject to provisions of the CITES or other federal restrictions.

The Plant Quarantine Branch (PQ) of HDOA regulates the importation and movement within the state of all plants and exotic animals (vertebrate and invertebrate). Its primary goal is to prevent the introduction of harmful insects, plant pathogens, illegal animals, and other pests into Hawai'i. HDOA PQ also provides clearance for exporting horticultural products from the state (e.g., rooted plants), and may inspect cut flowers and foliage under cooperative agreement with the USDA.

A15.1.1 Overview of Regulatory Authority

Hawai'i Revised Statutes (HRS) §§ 141 and 150A define the regulatory authority of HDOA. HRS § 141 authorizes HDOA to quarantine, inspect, fumigate, disinfect, destroy, or exclude commodities infested with pests or any article which is, in itself, a pest, which may be injurious to the agricultural industries and forest resources of the state. Further, HRS § 141 authorizes HDOA to enforce applicable regulations governing the importation into Hawai'i of any agricultural commodities from anywhere outside of the state, at any time or place within the state.

HRS § 150A authorizes HDOA to regulate plant, animal, and micro-organism importation into the state, including conditions of importation; the listing of prohibited, restricted, and conditionally approved plants, non-domestic animals, and microorganisms; as well as issuance of permits, collection of user fees, application of interim rules, and imposition of penalties.

A15.1.2 Plant Quarantine Duties and Operations

For imported commodities moving domestically via incoming cargo from the U.S. mainland, HDOA has oversight of all rules and regulations pertaining to airport and sea operations. With regard to export or movement of agricultural commodities from Hawai'i to the U.S. mainland, HDOA complies with federal regulations as stipulated in 7 CFR § 318.13.

Shippers of domestic cargo bound for Hawai'i by air or sea must notify HDOA of incoming goods requiring inspection (Miller and Holt 1992). If such freight arrives during nonworking hours, the shipping company must hold the cargo until the next business day to provide PQ inspectors adequate opportunity to examine it. Low staffing levels relative to the large volume of goods entering the state do not allow for inspection of all cargo. Instead, inspectors separate incoming goods into one of three risk categories: high, medium, and low risk, and systematically inspect the items in decreasing order of risk.

The record of past interceptions also influences the selection of items for inspection. For high-risk goods, such as all animals (including fish) and all propagated plants, PQ will inspect 100% of the declared items. For items considered to be of medium or low risk, the inspectors will randomly inspect two or three boxes from a particular cargo lot. Medium-risk goods include cut flowers and foliage, whereas produce is considered to be low risk. Commodities, such as livestock feed, coffee beans, organic fertilizer, and planting media, fall along a continuum between medium and low risk. Lacking any prescribed method or basis for a statistical sampling process, the level of inspection devoted to these spot checks depends on the availability of inspectors.

In recent years, PQ also has initiated an Agricultural Quarantine Inspection Monitoring (AQIM) program, in which statistically valid, random sampling techniques are employed to estimate pest incidence in maritime containerized cargo from the mainland. Sampling and data collection follow protocols specified in the USDA-APHIS-PPQ AQIM manual (USDA 2006a).

A15.1.2.1 Airport Inspection

Currently, PQ inspectors are assigned to inspect domestic incoming articles at various facilities in or around the airport, including airline cargo stations, baggage claim areas, the USDA mail cargo inspection station at the USPS facility, Federal Express (FedEx) and United Parcel Service (UPS) facilities, and the HDOA airport animal quarantine holding facility. All articles regulated by the state must be inspected by a PQ inspector before they can be released to the importer. Requests for inspection are called in to the PQ airport office, and inspectors are dispatched to each inspection site in the order in which the calls are received.

PQ inspectors screen packing lists and cargo manifests for commodities that might be hosts of specific pests, based on previous interceptions or interception records. Labels specifying the identity of commodities and their origins are also factors in determining if the commodities in cargo require increased scrutiny. All restricted items are inspected for pests, and the required documents, such as permits, phytosanitary certificates, and certificates of treatment, are verified before the shipment is released.

A15.1.2.2 Maritime Inspection

Maritime inspections usually involve plant-related commodities only (e.g., produce with longer shelf lives, such as bananas, and materials, such as planting media and organic fertilizer), whereas airport inspections include items of both plant and animal origin, as most fish and other seafood, animals and perishable produce, and plants are air-shipped. PQ inspects containerized freight (other than dry goods) and vehicles upon arrival; dry goods inspection was discontinued years ago because of staff shortages.

Through an agreement between HDOA and certain ocean carriers, fully loaded, refrigerated maritime containers that may contain perishable items are allowed to be taken out of the container yard for inspection at a separate, authorized facility, which may be a warehouse, packing and distribution facility, or a repacking facility. Similarly, containers only partially loaded with agricultural commodities may be delivered to a freight forwarding company where the individual shipments are broken down and set aside for inspection.

A15.1.2.3 Inter-island Inspection

As required by statute (Hawai'i Administrative Rules § 4-72), all plants and propagative plant parts, and non-domestic animals, including mammals, birds, fish, reptiles, amphibians, and insects, require inspection and certification prior to shipping from Oahu to the outer islands. No inspection is required for seeds, cut greens (including Christmas trees), flowers, and leis, or for pigeons, domestic rabbits, poultry, horses, cattle, cats, and dogs.

Private, non-commercial shipments are transported to either the airport or maritime offices for inspection and certification. Large commercial shipments may be inspected at their point of origin before being loaded into containers for inter-island barge transport.

A15.1.2.4. Military Inspection

Military maritime and airport facilities are subject to PQ inspection, but such inspections are limited due to staff shortages. The branch has established cooperative agreements with military bases clarifying each agency's inspection and interception responsibilities. In addition, PQ has assigned one supervisor full-time responsibility for coordination with military bases.

Since 1992, PQ has conducted inspections for detection of BTS in commercial aircraft and ships arriving from Guam. For the purpose of snake detection, PQ attempts to meet and inspect all flights from Guam, with the result that 97 to 98% of arriving flights are inspected. PQ also inspects all military aircraft and ships arriving from Guam. Snake inspection is conducted through visual inspection and sometimes with the help of the BTS canine unit. Aircraft wheel wells are inspected with dogs. For military flights, PQ inspectors do a walk-through of the cargo hold without dogs, and use dogs to check cargo when it is off-loaded. Commercial flights are handled similarly, with cargo checked by dogs when it is off-loaded. During the 6-month period prior to April 25, 2004, PQ inspected 267 commercial flights, 323 military flights, and seven private flights for BTS (Loope and VanGelder 2005).

The funding for BTS inspection and interdiction had been subsidized by the Department of the Interior and USDA-APHIS-WS until the current fiscal year. Due to the loss of WS funding, the State of Hawai'i will provide or obtain the necessary funds to continue the operations.

A15.1.2.5 Passenger Inspection

All passengers, officers, and crew members arriving in Hawai'i via commercial aircraft or vessels, and carrying plants, animals, microbial cultures, or soil must complete an HDOA declaration form and submit the imported items for inspection. This and an in-flight informational film are the only means the state currently has to make travelers from the U.S. mainland aware of restrictions on what can be brought into the state, enabling PQ to inspect and, if necessary, seize prohibited items. Passengers arriving from the mainland by private aircraft or boat also must complete the declaration forms. Private boat owners arriving at any of the harbors must report to the harbormaster, who, in turn, directs them to PQ for inspection.

Airline passenger declaration forms were the sole basis for inspection of incoming passenger baggage until late 1989, when HDOA initiated a citation program and retained a small cadre of trained beagle dogs to inspect checked baggage and express parcels (Miller and Holt 1992). The citation of airlines that were derelict in passing out and collecting declaration forms, in combination with the use of the beagles, resulted in a substantial increase in the number of passengers declaring agricultural items when entering the state.

Persons importing illegal species into Hawai'i have been subject to penalties, such as fines or imprisonment, since 1927. Currently, fines range from $100 to $25,000 and prison sentences from 30 days to 1 year. An amnesty provision exempts from penalties persons who voluntarily surrender, prior to the beginning of any seizure action, a prohibited animal or a restricted animal, for which they have no permit.

A15.1.2.6 Species Importation Permitting

The Hawai'i Board of Agriculture (BOA) is responsible for establishing the broad operating policies of HDOA, including the species permit application process (Miller and Holt 1992). By law (Hawai'i Administrative Rules § 4-71), the ten-member, governor-appointed board maintains three lists pertaining to the importation of animals and micro-organisms. Listed species are: 1) those conditionally approved (permit required for importation); 2) those restricted (permit required for both importation and possession); and 3) those prohibited. The law makes clear that any animal or micro-organism not on the first two lists also is prohibited. Any violation of permits issued for restricted or conditionally approved organisms is a violation of law. BOA also is responsible for determining additional micro-organism and animal species that are prohibited or approved entry into the state. Under existing rule-making procedures prescribed by the Hawai'i Administrative Practices Act, whenever the lists are revised, they must go through public notice, hearings, and comment.

In addition to the animal and micro-organism lists, state law provides for two lists for exotic plants: one for species that may be imported with a permit and one for those that are prohibited. However, unlike the regulation of imported animals and micro-organisms, there is no statutory language that states that plants not appearing on the approved list cannot be imported.

A15.1.2.6.1 Species Permit Application Process

To prevent introductions of pest species, HDOA has developed a permitting process involving technical review and BOA approval. All individuals requesting to import a plant, animal, or microbial species must file an application with PQ. If an applicant is requesting to import an animal or micro-organism that is not on the conditionally approved or restricted list, a revision must be made to the appropriate list before the species may be imported. All revisions to the animal and micro-organism list must go through the administrative rule-making process. Plants not on the permitted or prohibited lists are not required to go through this process, and may be imported.

If the request is for a species that is on an animal or micro-organism list and has received prior approval by BOA, or is a plant that has received such approval, PQ can issue the permit. If, however, an applicant is requesting a permit for a species that has not received prior BOA approval, PQ will conduct a three-tiered review process to bring the request before the Board.

First, the application is submitted to BOA's Technical Advisory Subcommittees. The five subcommittees (Land Vertebrates, Invertebrates and Aquatic Biota, Entomology, Microorganisms, and Plants) are composed of biologists, industry representatives, and government officials. The subcommittees evaluate the application along technical or scientific lines, particularly with regard to the organism's potential impacts. The subcommittees then pass their analyses to the Plant and Animals Advisory Committees, which consider the application and the subcommittee findings, weighing the potential harmful impacts against potential benefits. BOA then reviews the Advisory Committees' recommendation and issues the final decision on the application.

BOA may impose permit conditions, such as cage requirements or limitations on breeding or sale of the organism. If an animal is listed in Hawai'i Administrative Rules § 4-71-7 as requiring a bond, it will either be in the amount of $250, if the importer has a USDA license for the animal under the federal Animal Welfare Act, or $1,000. PQ also inspects and approves facilities (e.g., laboratories) of applicants before issuing permits for restricted organisms.

A15.1.2.6.2 Permitted Species Inspection Activities

Once a permit is issued, PQ will inspect and clear a new organism prior to its introduction into the state. This inspection verifies that the species arriving in Hawai'i is in fact the permitted species, and that it does not carry any pests or diseases. PQ conducts port-of-entry inspections at BOA-designated ports. Presently, five harbors (Hilo, Honolulu, Kahului, Kawaihae, and Lihue) and four airports (Honolulu International, Kona, Kahului, and Lihue) are primary port-of-entry inspection sites. Time and manpower permitting, PQ inspectors also may conduct follow-up, post-entry inspections to enforce any permit conditions.

A15.1.2.6.3 On-Site Inspection Process

In addition to inspecting permitted organisms for compliance with state regulations, PQ conducts on-site inspections of cargo and passengers entering Hawai'i to detect species entering the state without a permit. Inspections are conducted at the nine BOA-designated ports listed above.

A15.1.2.7 Other Regulatory Programs

Biotechnology Program: HDOA participates in the permit review process, subject to federal oversight, while promoting public confidence in the regulatory system. A PQ inspector accompanies the APHIS-PPQ Hawai'i Safeguarding Specialist to perform inspections of genetically modified organism (e.g., GMO corn) field trials.

Pest Surveys and Control and Eradication Programs: PQ surveys for new pest introductions, as well as newly detected pests. Information obtained is used to develop aggressive control or eradication strategies.

Rapid Response Programs: PQ has developed a statewide program aimed at mobilizing a rapid response to snake sightings. PQ and other agency's staffs have attended 3-week early detection and rapid response training on Guam for alien snakes. Rapid response teams are mobilized following credible reported sightings of snakes or other invasive species.

Diagnostics: PQ provides positive identification of intercepted pests; identification is required before enforcement of any applicable regulatory action.

Compliance and Enforcement: HDOA compels compliance and enforcement of quarantine laws and regulations through penalties and fines.

A15.1.2.8 Inspection Procedures During Regularly Scheduled Quality/Efficiency Assessments

HDOA has conducted regularly scheduled, quality/efficiency assessments (so-called risk assessments) throughout the state to evaluate the quality of inspection at ports, determine invasive species pathways, and target commodities that are of the highest pest risk. These operations are performed using a standardized inspection protocol for incoming passengers and cargo. Based on staff availability, multiple teams are dispatched to various inspection targets (e.g., passengers and baggage, cargo, and aircraft), with concentration on higher-risk commodities and other articles.

There are several inspection sites. Inspection of air and maritime cargo is performed at the port-of-entry, including, but not limited to, individual airline cargo facilities, express mail stations, or produce distribution sites that meet food safety standards (also known as transitional facilities). The inspection of air cargo, typically arriving in air containers, such as LD3s and LD8s, and ocean cargo, arriving in 20-, 24- and 40-foot-long shipping containers, follows the following general procedures.

Inspection teams acquire a packing manifest detailing the exact content and quantity of the commodities in each lot to be inspected. Restricted and prohibited items are refused entry or destroyed. All (100%) commodities deemed high-risk are inspected. Higher-risk commodities include propagative plant materials, various types of cut flowers, leafy vegetables, certain fruits, and organic produce. Upon completing inspection of higher-risk products, 10 to 50% of the volume of lower-risk commodities are inspected.

Inspection of aircraft and passengers is conducted as follows: inspectors board the aircraft, obtain and examine the mandated Agricultural Declaration Forms for declared items, walk through the cabin, and check cargo holds and wheel wells. Inspectors monitor passengers and baggage in the baggage claim area. Recorded data include airline and flight number, date of inspection, arrival time, number of passengers and crew, number of collected and completed Agricultural Declaration Forms, number of declared agricultural commodities, and number of intercepted agricultural commodities. Pest interception data are also recorded.

Additional inspection is performed by an inspector and a detector dog. The focus is on monitoring passenger baggage in the baggage claim areas and the small packages arriving via FedEx, UPS, and other package and mail carriers.

A15.1.2.9 Standard Operating Procedures

PQ utilizes a standard operating procedures (SOP) manual that was last revised in November 1989. Several sections in the manual are outdated or no longer apply to PQ's current facilities, operations, or staff. The branch would benefit greatly from a professional manual writer; however, in lieu of that option, a team made up of program specialists, operations supervisors, and inspectors is collaborating on revising the SOP manual. Based on the current implementation of the HDOA Biosecurity Program, developed in 2005, the existing SOPs are being revised and amended.

A15.1.3 Inspection Facilities

The major ports-of-entry for the State of Hawai'i are located in the major cities on four of the main islands: Hawai'i, Maui, Oahu, and Kauai (Table A15-1). The ports are the major commercial entry points and the foci of inspections in the state for imported and exported goods.

Table A15-1: Major Ports-of-entry in Hawai'i

Island	Airport	Seaport
Hawai'i	Hilo International Airport (ITO)	Hilo Harbor
	Kona International Airport at Keahole (KOA)	Kawaihae Harbor
Maui	Kahului Airport (OGG)	Kahului Harbor
Oahu	Honolulu International Airport (HNL)	Honolulu Harbor
	Hickam Air Force Base (part of HNL)	Kalaeloa Harbor
Kauai	Lihue Airport (LIH)	Nawiliwili Harbor

A15.1.3.1 Minimal Inspection Facility Requirements

HDOA has determined its minimal inspection facility requirements, and the document detailing these requirements is in preparation. The minimal inspection facility requirements include: enclosed cargo inspection areas, including equipment for washing and sterilizing cargo if needed, with adequate lighting and temperature control; computer equipment; refrigerated storage, with adequate volume to hold "pending" items awaiting action; treatment facilities, such as freezers, autoclaves, and garbage disposals; kennels, if dogs teams are at that port; and passenger inspection stations.

The size of each port's inspection facility would need to be based on the expected volume of incoming cargo. Ports receiving high-risk commodities would have provisions for various treatment facilities. For export inspection, large-volume shipments will be inspected and certified at the point of origin, e.g., in packing houses and greenhouses, and not at the port. Inspection of small-volume export cargo will be conducted at the ports; therefore, inspection and consolidation areas are a necessity. Depending on the commodity, the consolidation areas should be properly equipped to maintain quality and quarantine security.

A15.1.3.2 Existing Facilities

Not a single port in Hawai'i meets the minimal facility requirements for PQ inspection and quarantine purposes. None of the ports, except Kahului Airport, has adequate facilities to destroy incoming infested commodities. None of the ports has enclosed inspection areas.

HDOA does not have fumigation (methyl bromide) chambers or an incineration facility to destroy infested commodities under quarantine supervision. Methyl bromide fumigation is outsourced to a private, certified pesticide applicator based on the applicators' availability. Incineration is provided by a private company without PQ supervision.

A15.1.3.3 Facilities Proposed and Under Construction

HDOA has begun discussions with various regulatory agencies in Hawai'i on a proposal for a multiagency-use facility at Honolulu International Airport (HNL). HDOA contends that multiagency-use facilities would enhance information sharing and collaboration among federal and state plant quarantine agencies in Hawai'i.

New facilities are being constructed at the Kahului Airport to optimize the interdiction of alien species on Maui. These facilities will house two fully-enclosed inspection rooms, a screened inspection area for low-risk commodities, a laboratory, plant and animal holding rooms, kennels, and office space for HDOA, USDA, and DHS CBP personnel.

The HNL Master Plan has identified a probable location for a joint inspection facility in the cargo area, which, if realized, would provide space for HDOA, APHIS-PPQ, USFWS, and CBP. This planned multi-agency facility would be co-located with the major international air cargo carriers. A smaller satellite facility is planned for inter-island and domestic cargo inspection. The HNL Master Plan will include an irradiation facility, both for quarantine treatment of fruits and vegetables for export and for imported commodities moving within-state that have insect infestations or diseases.

The proposed HNL inspection facility would have a size of about 1 hectare under roof, with enclosed inspection rooms, refrigeration, freezer, autoclave, offices, kennels, and space for other support functions. The master planning process has just begun for the Kona International Airport Master Plan. Kona's is the second busiest international airport in the state, and accommodates a number of overseas domestic and international flights; thus, a joint inspection facility is considered a necessity. Treatment and disposal of garbage are a particular concern at the Kona airport.

At Honolulu and Kahului Harbors, the volume of cargo is immense, the ports handling over 10 million and 2 million tonnes, respectively, per year (HDOT 2002; Anonymous 2006). At both ports, space is a primary concern, as there is no room for expansion and immediate solutions are not available. Construction of new cargo facilities has been proposed.

A15.1.4 Staffing

A15.1.4.1 Existing Personnel

Table A15-2 shows pre-2006 staff and 2007 staffing levels. The 2007 staffing levels indicate increases in staff resulting from increased funding through the Biosecurity Program Initiative. 2007 staffing levels are not current levels. In 2009 there was a large reduction in force size by Hawai'i Department of Agriculture. The discrepancy between 2007 and current numbers is not addressed in this section. The current number of front line inspectors is lower than that expressed for 2007. Of special notice is that HDOA currently has no canine program whereas in 2007 there were 6 dog handlers.

Table A15-2: Pre-2006 and 2007 Staff of the Plant Quarantine Branch of the HDOA

Position	Pay schedule	Pre-2006	2007
Supervisor, Plant Quarantine Inspector V	SR-24	4	4
Master Journeyman, Plant Quarantine Inspector IV	SR-22	9	10
Inspector, Plant Quarantine Inspector III	SR 20	39	62
Dog Handler, Plant Quarantine Inspector III	SR 20	3	6
Technician	SR-11		
Administrative		0	1
Operations		1	14
Dog		0	1
Specialist		1	3
Subject Matter Specialist, Plant Quarantine Inspector V	SR-24	5	7
Accountant		0	1
Management Analyst		0	1
Total		**62**	**110**

At the 2007 level of staffing, PQ had begun to implement Phase I of its Biosecurity Program, which if and when completed would result in:

- Systematic, intense inspection of all high-risk pathways and spot checks of low-risk pathways
- Quarterly quality/efficiency assessments (so-called risk assessments or "blitzes")
- Compliance agreements
- Rule changes
- Control programs for the little fire ant, nettle caterpillar, and coqui frog
- Military and private jet inspections
- Inter-island inspections
- Shared data management with other regulatory agencies
- Nursery monitoring and assistance

- Regular monitoring and surveillance of all air- and seaports for the RIFA

A15.1.4.2 Proposed Levels

Based on the port efficiency and overall staffing evaluations conducted by HDOA, PQ will be seeking an additional 111 positions for administrative, diagnostic, and inspection functions (these are positions above and beyond the 2007 levels, current levels are lower). The additional inspection staff will be servicing the airport and the harbor facilities state-wide. New identifiers and diagnosticians will provide support to the branch's inspection and monitoring efforts.

A15.1.5 Biosecurity Program

Session Laws of Hawai'i 2006, Act 160, established HDOA's Biosecurity Program by appropriating $2.9 million to hire new staff and enhance the invasive species program. The 2006 legislative session provided general funds to implement Phase I of the program, i.e., hiring new staff and providing support for statewide pest detection, prevention of spread of incipient infestations, and control programs for incipient and established invasive pest populations. Phase II of the program has the objective of developing strategies to prevent the intentional or unintentional introduction of invasive species at ports-of-entry or, once introduced, to reduce their impacts.

The program incorporates HDOA's mandates, rules, and regulations into a comprehensive program to protect the state's agriculture and natural resources from invasive pest species and to facilitate trade by providing export compliance as required by Hawai'i's trading partners.

A15.1.5.1 Components

The program weaves together various components of the traditional aspects of alien species interdiction known as pre-entry, port-of-entry, rapid response, and eradication, with the development of replacement and export crops to facilitate economic growth. The program's elements are:

- Prevention
- Diagnostics
- Detection
- Rapid response
- Monitoring
- Biological sampling
- Restoration
- Research and development
- Educational outreach
- Partnerships and cooperative activities

- Information management
- Quality control programs
- Quarantine treatment facilities
- Permitting
- Compliance and enforcement
- Export programs

A15.1.5.2 Increasing Capacity for Preventing Intentional Introductions or Reducing their Impacts

Emergency response capability is an integral component of HDOA's Biosecurity Program. The proposed additional staff, particularly inspectors and diagnosticians, will allow for effective interagency coordination with CBP and APHIS. Incident Command Training is being implemented cooperatively at federal and state levels. HDOA sought the support of Hawai'i's congressional delegation for the proposed multi-agency use inspection facility at HNL. HDOA has also proposed construction of a treatment and destruction facility for commodities or articles detected at the ports with pest infestation or disease infection, or both. Currently, destruction and treatment of detected pests and pathogens are extremely limited and not easily available to CPB, APHIS, and HDOA.

A15.1.5.3 Increasing Capacity for Preventing Unintentional Introductions

Preventing invasive species from entering and establishing in Hawai'i is vital to protecting the environment, public health, and economy; invasive species have direct, negative impacts on agricultural industries and tourism.

Hawai'i is dependent on imported food, construction materials, medical supplies, and other commodities; this dependency demands essential transportation infrastructure. However, Hawai'i's ports have not kept pace with current infrastructural demands and those anticipated in the future. To counter the overcapacity at the harbors, steps are being taken to release containers at the ports for immediate inspection at transitional facilities partially to resolve the capacity problem. HDOA is currently working with the carriers and importers to investigate the use of electronic manifests that will allow quick release of commodities and other articles at the docks without compromising the efficacy of pest detection.

A15.1.5.3.1 Brown Treesnake and Red Imported Fire Ant

During the past few years, HDOA has been attuned to the need to address the heightened risks posed by introduction of certain targeted invasive pest species, such as BTS and RIFA. Intensified military activities in the Pacific have substantially increased BTS risk, challenging the state's capacity to prevent its entry. Should it become established in Hawai'i, the potential economic impact of BTS has been conservatively estimated at $485 million annually, resulting from power outages, medical costs, lost tourism revenue, and devastation of native species (HDOA unpublished data). A subsequent detailed study by Swiff et al. (2010) which examined the economic impact of BTS establishing in the State of Hawai'i in regards to medical treatment, power outages and decreases in tourism placed the total annual damage to Hawai'i at between $593 million and $2.14 billion. Accordingly, training specifically for detection of, and rapid response to, BTS introductions should be strengthened. The program for BTS interdiction will be augmented significantly by the proposed additional inspectors and detector dogs in the canine unit.

RIFA's geographic distribution has expanded from the Americas to Asia and parts of the Pacific, further increasing its threat to Hawai'i. RIFA is both an agricultural pest and a pest of medical concern. The potential impact to Hawai'i's economy resulting from RIFA establishment has been estimated at $197 million annually (HDOA unpublished data). To counter the threat, HDOA works with CPB and APHIS to intercept ants from foreign and U.S. mainland sources. The proposed increase in staffing will allow increased scrutiny of high-risk commodities and articles from RIFA-infested geographic areas.

A15.1.5.3.2 Port of Honolulu

The large volume of goods coming into the state cannot be adequately inspected by the present level of port staffing. For maritime cargo, a lack of harbor space also contributes significantly to PQ's inability to perform adequate inspections.

With ever-increasing numbers of aircraft and ships arriving, it is envisioned that Honolulu port operations will become a 24-hour, 7-day-a-week activity; currently the airport operates for 20 hours every day. Maritime inspection is currently an 8-hour, 5-day-per-week operation. The future cargo inspection workload will include inspections at approved transitional facilities.

The Honolulu staff will be divided into shifts that will work at the airport and maritime offices on a rotational basis. Workload will include meeting aircraft at the gates, which has not been done due to lack of staff, and using detector dogs to interdict undeclared items, including cargo at baggage claim areas; UPS, FedEx, and other express mail carrier inspection stations; and commercial and military flights from the South Pacific and Guam that are considered high-risk for BTS.

At seaports, the maritime inspection workload will increase with the required inspection of the Superferry's inter-island cargo. Inspection at transitional facilities should help alleviate problems associated with increasing ship traffic.

A15.1.5.3.3 Port of Maui

The majority of quarantine inspections are performed at Kahului Airport and Kahului Harbor, which, by volume, are the second busiest airport and third busiest harbor in the state (HDOT 2002). Other ports in the county include Kaulamapau Harbor (Lanai), Lanai Airport, Kalaupapa Harbor (Molokai), Kalaupapa Airport (Molokai), and Kaunakakai Harbor (Molokai). Kahului Airport was the site of a risk assessment, conducted as part of the State Department of Transportation's (DOT) Alien Species Action Plan, which identified cargo as a high-risk pathway (HDOA 2002).

Although PQ staffing on Maui has increased with the addition of DOT-funded PQ positions, these positions have been staffed only at the airport.

A15.1.5.3.4 Port of Kona

HDOA is collaborating with DOT in the planning and design of improvements in infrastructure at Kona International Airport and Kawaihae Harbor to enhance both quarantine and export capabilities. The new facilities will include adequate space for offices, inspection stations, and commodity treatment.

The number of commercial flights, passengers, and private jets, and the volume of cargo arriving at Kona International Airport have increased steadily over the years (HDOT 2002). The increased traffic at this airport and Kawaihae Harbor have overwhelmed the current staff, preventing effective inspection and monitoring. Ships, aircraft, or cargo may go uninspected, depending on the current inspection priority. The proposed increase in staff should help to mitigate the risks of alien species introduction at the Port of Kona.

A15.1.5.3.5 Port of Hilo

Hilo Port aims to expand export certification capabilities for agricultural commodities, as exports are a major contributor to Hilo's economy. The proposed additional PQ staff will perform the necessary inspections at nurseries prior to movement of propagative and non-propagative plants through the port.

A15.1.5.3.6 Port of Kauai

This port includes Lihue Airport, Nawiliwili Harbor, and Port Allen Harbor. Lihue is the only commercial airport on the island, and receives incoming direct international, domestic, and inter-island flights. Nawiliwili Harbor is the larger of two commercial harbors, and receives the majority of goods shipped into Kauai. Current staffing is inadequate to cover the basic plant quarantine functions, especially as the number of direct overseas flights to the island increases. HDOA has proposed additional staff for the Port of Kauai.

A15.1.6 HDOA Regulations and Federal Pre-emption

USDA-APHIS-PPQ enforces regulations under the authority of the Plant Protection Act of 2000 to safeguard agriculture and natural resources from the risks associated with the entry, establishment, and spread of harmful foreign pests, noxious weeds, and plant diseases. Since March 2003, CBP, under a Memorandum of Agreement between USDA and DHS, has the mandate to inspect and clear foreign passengers and non-propagative agricultural commodities. PPQ continues to perform the inspection and release functions for propagative plant materials. APHIS has the principal responsibility of preserving the marketability of U.S. agricultural products by stopping and controlling the movement of harmful invasive pests that enter the country.

HDOA enforces regulations under various plant and non-domestic animal quarantine statutes to prevent the introduction and establishment in Hawai'i of any organism that is harmful to agriculture, animal or public health, or natural resources, including native biota. Hawai'i is quarantined with respect to the U.S. mainland primarily due to the occurrence of pestiferous tephritid fruit fly populations.

Under the Plant Protection Act of 2000, 7 USC §7756 subdivision (a), "[no] State or political subdivision of a State may regulate in foreign commerce any article, means of conveyance, plant, biological control organism, plant pest, noxious weed, or plant product in order (1) to control a plant pest or noxious weed; (2) to eradicate a plant pest or noxious weed; or (3) to prevent the introduction or dissemination of a biological control organism, plant pest, or noxious weed."

HDOA has argued that conflicts in regulation and enforcement exist between it, USDA, and DHS. HDOA further contends that Hawai'i will always be vulnerable to incursions by invasive pests because of inherent safeguarding weaknesses resulting from the federal pre-emption of state quarantine regulations.

A15.2 UNITED STATES DEPARTMENT OF HOMELAND SECURITY, BUREAU OF CUSTOMS AND BORDER PROTECTION

A15.2.1 Overview of Regulatory Authority

Historically, APHIS-PPQ agricultural quarantine inspection (AQI) was responsible for preventing the introduction of harmful, alien agricultural pests and diseases into the United States. With the establishment of DHS, the Homeland Security Act of 2002 transferred the foreign import inspection duties from USDA to DHS. A MOU between USDA and DHS, signed in 2003, articulated the details of responsibilities, operating procedures, working relationships, communication, and framework necessary for APHIS and CBP successfully to perform their agricultural inspection missions (USDA 2003b). Among the agricultural import inspection functions transferred from USDA to DHS are the following:

- Reviewing passenger declarations and cargo manifests, and, utilizing USDA pest risk data, targeting for inspection high-risk passengers or cargo
- Inspecting international passengers, luggage, cargo, mail, and means of conveyance
- Holding cargo and articles of suspected quarantine significance
- Referring propagative and other designated materials to USDA for inspection, control, and disposition
- Seizing materials in violation of USDA regulations, safeguarding them to prevent pest escape, and destroying or re-exporting them
- Collecting and preparing or preserving pest and disease samples for analysis
- Submitting to USDA intercepted pest and disease specimens for identification
- Collecting, submitting, and reporting program information
- Maintaining, monitoring, and enforcing existing compliance agreements
- Monitoring transit shipments and verifying exit
- Reviewing import permits and certificates for validity and compliance

Among the agricultural inspection and trade functions retained by USDA are:

- Providing risk analysis guidance and setting inspection protocols

- Applying remedial measures other than destruction and re-exportation
- Providing specialized inspection of propagative plant material and pest identification services at plant inspection stations and other facilities
- Conducting inter- and intra-state inspection of passengers, commodities, and conveyances, including pre-clearance of passengers in Hawai'i destined to the U.S. mainland
- Performing inspection and related activities, such as compliance with requirements of agricultural protocols and systems, in connection with the pre-clearance of commodities in foreign countries
- Verifying compliance with trade protocols, including, but not limited to, conducting domestic market and transit surveys and outreach to the private sector as part of the APHIS SITC programs
- Investigating and adjudicating AQI violations
- Issuing phytosanitary (plant health) and animal by-product certificates for U.S. agricultural exports
- Developing regulations, policy, and procedures to establish and enhance coordination between USDA and DHS
- Managing the AQI performance measurement system in consultation with DHS

Tables A15-3 and A15-4 show the number of agricultural inspection staff of APHIS-PPQ and CBP, respectively, in Hawai'i. PPQ has offices at five ports in Hawai'i: Honolulu, Maui, Kauai, Hilo, and Kona. CBP has Agriculture Specialists in Honolulu and Kona.

Table A15-3: APHIS-PPQ Staff in the Ports of Honolulu, Maui, Kauai, Hilo, and Kona

Staff	Position	Number of permanent, full time employees[a]
Administrator	State Plant Health Director	1
SOSO	State Operational Support Officer	2
Administrative Assistants		11
Supervisors	Port Directors, Port Supervisors	21
Specialists	Pest Survey Specialist, Pest Identifiers, Export Certification Specialist	6
Inspectors	PPQ Officers and Plant Health Safeguarding Specialists	88
Technicians	Permanent and Temporary[b]	98
SITC	SITC Manager and Officers	3
Total		**230**

[a] As of March 2007.
[b] Converted to number of permanent, full-time equivalents.

Table A15-4: CBP Agriculture Specialists in the Ports of Honolulu and Kona

Position	Number of permanent, full time employees[a]
Chief Agriculture Specialist	2
Supervisory Agriculture Specialist	5
Agriculture Specialist (agricultural inspection)[b]	47
Total	**54**

[a] As of May 2007.
[b] CBP Officers are cross-trained to perform agricultural inspection to assist Agriculture Specialists on an as-needed basis.

A15.2.2 Quarantine and Inspection Activities

At U.S. ports-of-entry (including Honolulu), CBP Agriculture Specialists and cross-trained CBP Officers inspect air and sea cargo, air and sea carriers, and international mail, and clear air and sea passengers, crew, and their luggage arriving from foreign countries to detect prohibited articles (including plant and animal products); ensure that regulated articles comply with federal regulations; treat and dispose of regulated garbage; and intercept regulated pests and diseases. CBP has broader powers of search and seizure than many agencies involved in pest detection and interdiction. For example, the agency does not need a search warrant or to show probable cause to carry out its duties, such as inspection of foreign mail. All packages mailed from outside the United States must have customs declarations that clearly state the nature of the contents. CBP can inspect any mail from foreign points of origin. (Domestic first-class mail may not be inspected without a federal search warrant.) All foreign mail arrives at a central mail facility in Honolulu. CBP conducts inspections at all military installations in Hawai'i when vessels or aircraft arrive from foreign points of origin.

A percentage of incoming air passenger baggage, air cargo, maritime cargo, and mail from foreign countries undergoes actual inspection at Hawai'i's international ports-of-entry. The various manuals furnished by USDA determine the percentage of cargo for examination and the risk management principles for use in determining inspections. Items are chosen for inspection based on risks, as determined by risk assessments, past interceptions, and other available information. Articles are inspected for pests and diseases, and may be released, treated based on quarantine requirements prior to release, re-exported, or confiscated and destroyed. The primary aims of quarantine and inspection are to prevent entry of agricultural pests and diseases and to intercept these threats at ports-of-entry while facilitating and promoting worldwide agricultural trade and travel. Any penalties levied are based on the applicable statutes and regulations of USDA, CBP, and USFWS.

CBP Agriculture Specialists and cross-trained CBP Officers follow procedures outlined in the Manual for Agricultural Clearance (USDA 2006c) and other applicable USDA manuals. For example, the Fresh Fruits and Vegetables Import Manual (USDA 2007c) lists by country fruits and vegetables that are admissible into the United States, including the required quarantine treatments, if any, and the methods of sampling and inspection intensity. Thus, commercial non-propagative fruits and vegetables arriving at the ports are inspected and cleared by CBP according to the language and stipulations of the Fresh Fruits and Vegetables Import Manual.

CBP makes referrals to the HDOA for pests not covered by quarantines enforced by CBP. These have included ticks, spiders, and reptiles.

CBP in Hawai'i collaborates with a Pest Risk Committee (PRC) with two subcommittees covering animal diseases and plant pests. Meetings are attended by both state and federal agencies and departments. Activities of the PRC have included many special operations conducted jointly by CBP, APHIS-PPQ, USDA Food Safety and Inspection Service, FDA, and USFWS involving certain kinds of cargo making entry, with the aim of collecting pest information on particular commodities, interdicting potential smuggling, responding to national alerts, identifying high-risk commodities, and enforcing applicable regulations. The PRC distributes information on pests and diseases known to be of interest to the State of Hawai'i; emerging animal diseases and changing disease status for various countries, state, and federal pest and plant material seizures; and extends outreach to other federal and state agencies. CBP uses this information in its targeting of cargo, and adjusts tactics when new information becomes available.

CBP requires a manifest from the shipping agent for all incoming cargo. Cargo entering the United States by way of Honolulu is held by the shipper against a bond. CBP inspects certain types of cargo, such as fresh fruit and vegetables, handicrafts, seeds, animal products and by-products, cut flowers and greenery, heavy equipment and farm machinery for soil, household goods, certain kinds of stone and containers for hitchhiking snails, and other agricultural or food items before granting entry. Other cargo, such as new automobiles, are rarely inspected. When conducting inspections, CBP scrutinizes wood packaging material (WPM) branding and enforces WPM regulations, re-exporting non-compliant materials in accordance with national guidelines. CBP also enforces the CITES, inspecting and seizing non-living CITES-regulated plant shipments and, following safeguarding procedures, delivering living CITES-regulated plants to the APHIS Plant Inspection Station. Through its computerized tracking system, CBP classifies all cargo to determine its rate of duty and to track import quotas and other items of concern. This system stores any special information about an item and identifies those items requiring inspection or approval by any other federal agency. USDA and USFWS have the opportunity to review all incoming plant or animal materials for CBP.

CBP uses the Automated Commercial System and the Automated Targeting System for cargo and passengers to identify certain regulated, high-risk agricultural cargo, or passengers with previous violations. Various targeting criteria can identify potential violators, smugglers, and other anomalies that could result in examinations. Holds on cargo can be initiated automatically both nationally and locally. CBP also uses USDA databases for data input and analysis. These include Work Accomplishment Data System (WADS), AQIM, EANs, 280s, and Pest ID. Use of all systems and databases provides CBP detailed information to identify potential cargo, passengers, aircraft, or vessels for examination. CBP has dedicated Agriculture Specialists performing agriculture targeting for the air cargo, sea cargo, and passenger pathways. These efforts are augmented by CBP Officers performing targeting duties at the same locations. In 2006, through such operations, CBP prevented the entry of nearly 50 tonnes of animal products and by-products into Honolulu.

Even before the creation of DHS, the former Customs Service of the U.S. Department of the Treasury, in 1991, inaugurated a policy that facilitated minimal inspection of incoming passengers arriving from certain low-risk areas or countries. Passengers who have visited high-risk areas of the world (e.g., those in which highly significant pests or diseases occur, or associated with the smuggling of drugs and other contraband) receive a more careful examination.

A15.2.3 APHIS-PPQ's Agricultural Quarantine Inspection Monitoring and CBP

The purpose of the AQIM program is to gather data regarding AQI effectiveness (USDA 2006a). The data are used to define and document various pest risk pathways, determine the likelihood for agricultural pests and diseases to enter the United States through various identified routes, and communicate to CBP those agricultural risks that require its attention. At each selected airport (including HNL) and mail facility, CBP officers each year conduct random inspections of passenger baggage and mail. At cargo facilities, various types of cargo shipments are randomly selected each year for complete inspection. Results of passenger baggage inspections are used to estimate the rate of quarantine material arriving at each port. This estimate is used to gauge program effectiveness. For cargo, results are used to estimate the rate of cargo shipments requiring action as they arrive at a port, and the percentage of units approaching with significant pests. Such estimates can be used by ports to gauge their effectiveness in managing pest risk in cargo, and to evaluate the relative risks of various known pest entry pathways.

A16 AIRLINE PASSENGERS

It is worth noting that the information in the section is based on data from prior to 2008.

A16.1 OBJECTIVE

The objective of this chapter is to estimate the likelihood of quarantine plant materials and pests entering Hawai'i with airline passenger baggage, thereby providing a basis for decision making towards phytosanitary improvements, as well as a starting point for discussion and further analysis. It should be noted that data used in this section is not current but comes from a variety of sources, the most recent being a 2007 compilation.

A16.2 ANALYSIS METHODS

AQIM data collected by the DHHS CBP were used to estimate approach rates of quarantine plant and animal materials (QMs) and pests. If sampling procedures are followed correctly, AQIM data are collected through a detailed inspection of randomly selected sampling units. This means that, in contrast to regular, targeted quarantine inspections, AQIM sampling is unbiased and is therefore suitable for risk quantification. Details on AQIM data sets and sampling protocols can be found in the USDA AQIM Handbook (USDA 2006a).

AQIM data were available only for HNL, which accounts for the majority of all international airline traffic into Hawai'i. In order to minimize the effects of sampling protocol inconsistencies, we used only the two most recent complete data sets (FY 2005 and FY 2006). The available data set pertains only to international airline passenger baggage; no comparable information was available for visitors from the U.S. mainland.

The QM approach rate is defined as the proportion of sampling units in which plant QMs were found. The sampling unit in this case was the group of airline passengers (one to many individuals) traveling together under one U.S. Customs manifest. In order to express the level of uncertainty associated with QM approach rate estimates, they are presented as 95% binomial confidence intervals, i.e., the limits within which the actual approach rates lie with 95% certainty (Steel et al. 1997). For small sample sizes, the uncertainty associated with the approach rate estimate is large (i.e., the binomial confidence intervals become wide). For sample sizes under 20, assumptions regarding statistical distributions may not be accurate (Jones 2007), and uncertainty is so high that these cases are not included in either the discussion of results, or in the figures and tables.

We calculated approach rates by country of passenger origin, by travel reason, and by calendar month of travel using the RELIABILITY, MEANS, TABULATE and SQL procedures in SAS® 9.1.3 (SAS Institute 2007). The data for FY 2005 and FY 2006 were combined to increase the sample sizes. In order to arrive at an estimate of the total number of QMs that annually enter Hawai'i, we multiplied approach rates by the average number of QMs per interception (source: AQIM data) and the average number of passenger groups entering annually. This last number was calculated by dividing the number of annual visitors by the average passenger group size indicated by AQIM data. The annual number of visitors was obtained from the 2005 Annual Visitors Research Report of the Hawai'i Department of Business, Economic

Development and Tourism (HDBEDT), referred to as the "DBEDT data set" throughout this document (HDBEDT 2005b).

Because the DBEDT data set provided country-specific visitor numbers for only some of the countries in the AQIM data set (those considered major market areas for Hawai'i), we estimated the number of visitor groups for the remaining countries by multiplying the number of passengers sampled during AQIM data collection by 140. This number (with a standard deviation of 97) represents the average ratio of

$$\frac{\text{(number of international passenger groups entering Hawai'i)}}{\text{(number of international passenger groups sampled during AQIM)}}$$

for those countries where visitor numbers were available from the DBEDT data set. As AQIM data are based on a random sampling scheme, this ratio should be approximately constant among countries (though the high standard deviation indicates that this may not be the case). However, for lack of more reliable data, we used this estimate to extrapolate the number of visitor groups for those countries of origin that are not included in the DBEDT data set, and presented the results as point estimates together with their associated standard deviations. The values that are based on this extrapolation are shaded grey in Table B5-1 (below).

For the analysis by travel reason, some categories had to be combined, both in the AQIM and in the DBEDT data set in order to make the two data sets match each other. The categories "Business/Work" and "Uniformed crew" of the AQIM data set were combined into one category that was considered equivalent to "MC&I, and Other Business" in the DBEDT data set. The category "Government/Military" in the DBEDT data set was treated as equivalent to "Military" in the AQIM data set. The categories "Visit friends" and "Family visit" of the AQIM data set were combined into one category that was considered equivalent to "Friends and relatives" in the DBEDT data set. The categories "Pleasure" (which includes the sub-categories "Vacation," "Honeymoon," and "Wedding") and "Sports events" of the DBEDT data set were combined into one category that was considered equivalent to the combined categories "Tourism" and "Other" of the AQIM data set.

For estimates of pest approach rates, we used a combination of different source data sets, each of which was associated with some uncertainty: AQIM data, USDA-APHIS-PPQ Pest ID, which contains records of all pest interceptions made by PPQ or CBP at U.S. ports-of-entry since 1985 (USDA 2007a), and the DHS CBP WADS, which provides information on the number of certain tasks (e.g., inspections) performed by port inspectors (USDA 2007b). For this analysis, a pest is defined as a species of arthropod, mollusc, weed, nematode, or plant pathogen that is injurious to plants or plant products.

A16.3 RESULTS AND DISCUSSION

A16.3.1 International Passengers by Country of Origin

QM approach rates for the various countries of origin ranged between zero and approximately 25% (Table B5-1, Figure B5-1). In many cases, the 95% binomial confidence intervals were rather large, due to small sample sizes. For Malaysia, Indonesia, New Zealand, Fiji, and Taiwan, the binomial confidence intervals included zero (i.e., the approach rates were not significantly different from zero). The lower 95% binomial confidence limit (i.e., the estimated minimum approach rate) was highest for Guam, followed by Thailand. Japan, the origin for approximately 70% of all international Hawai'i visitors (HDBEDT 2005b), had a QM approach rate of 1.7%, which was significantly lower than those of Guam, Thailand, and Australia. In spite of its moderate QM approach rate, Japan is the source of the highest number of QMs, due to the large number of visitors from Japan. Approximately 16,000 to 25,000 QMs from Japan, 3,400 to 9,700 QMs from Australia, and 1,200 to 4,000 QMs from Guam are estimated to enter Hawai'i per year; most other countries contribute 2,000 or fewer QMs annually. Most frequent among the plant QMs intercepted from Japan during AQIM data collection (Table B5-5) were species of *Citrus*, which represent a risk of introducing various quarantine pests, especially scales such as *Unaspis yanonensis* (Kuwana) (Homoptera: Diaspididae) and the plant bacterial pathogen *Xanthomonas axonopodis pv. citri* (Hasse) Vauterin et al. In fact, during FYs 2005 and 2006, *U. yanonensis* had been intercepted more than 20 times in Japanese air passenger baggage at Hawai'i ports-of-entry (USDA 2007a).

A16.3.2 International Passengers by Travel Reason

Due to a relatively small sample size, the category "Military" has a very large confidence interval (2 to 18%), which is not extremely informative. It can be said, however, that military travel is associated with QM approach rates that are significantly different from zero. Apart from military travel, the category "Visit friends and family" was associated with the highest QM approach rates (Table B5-2, Figure B5-3). This corroborates the intuitive assumption that international passengers visiting friends and family are more likely than tourists or business travelers to carry QMs because they bring food items as gifts. The QM approach rates for the categories "Tourism" and "Business/Work" were quite similar to each other (though "Tourism" had a narrower 95% binomial confidence interval because of a larger sample size).

As tourists represent the majority of all travelers to Hawai'i (i.e., their approach rate is multiplied by the largest number of passengers), they are the group that introduces by far the most QMs into the islands. It must be noted that AQIM and DBEDT data are not in agreement with regard to the numbers of visitors in the various categories. Based on AQIM data, there should be approximately four times as many tourists as there are people visiting friends or family. However, according to DBEDT data, the number of tourists is 18 times higher than the number of people visiting friends or family. We are not sure about the reasons for this discrepancy; our estimates are based on DBEDT data.

A16.3.3 International Passengers by Month

Overall QM approach rates in September were significantly higher than in May (Table A16-3, Figure A16-5). Otherwise, QM approach rates were not significantly different between months. As the number of travelers is more or less constant among months (Table A16-3), the estimated number of QMs entering (Figure B3-5) is proportional to the respective QM approach rates (Figure A16-6).

A16.3.4 All International Passengers

In total, there were 2,114,064 international visitors to Hawai'i in 2005 (HDBEDT 2005b), with an overall QM approach rate of 0.022 to 0.027 (95% binomial confidence interval). This leads to an estimate of 40,369 to 54,458 QMs per year being brought into the islands by international airline passengers (Table B5-4). Based on WADS data, an annual average of 17,000 QMs were intercepted by CBP during FYs 2005 and 2006 (USDA 2007b), which means that only 31 to 42% of all QMs were intercepted by CBP. This would leave approximately 23,000 to 37,500 QMs entering Hawai'i undetected every year. This estimate of interception efficiency is higher than those from other, similar analyses (e.g., Meissner et al. 2003).

A16.3.5 Pest Approach Rates

In the AQIM data set we analyzed, there were no plant pest interceptions recorded for the over 7,000 passenger groups sampled. This means that an estimated 0 to 0.04% (95% binomial confidence limits) of all international air passenger groups brought plant pests into Hawai'i. As 1,360,120 passenger groups visited the state during 2005 and 2006 (Table B5-4), between 0 and 540 plant pests would have arrived with them. We know that, contrary to AQIM sampling guidelines (USDA 2006a), searching for pests is often not performed during AQIM data collection. It may therefore be assumed that the above pest approach rate is a substantial underestimate. From Pest ID data (USDA 2007a), we know that pests are reaching Hawai'ian ports-of-entry; therefore, an estimate of zero for the pest approach rate must be inaccurate. In fact, 426 pests are recorded in the Pest ID database for FYs 2005 and 2006, during which time approximately 4 million international air passengers entered Hawai'i. Based on the calculations above, only about 20% of all QMs are intercepted by CBP. For pests, the interception efficiency likely is considerably lower, since they may not be detected on intercepted QMs, either because they are hidden (e.g., internal feeders) or because the inspector discards the QM without looking for pests. If, therefore, we generously assume that 5% of all pests that are present in air passenger baggage actually are detected and recorded in the Pest ID database, we arrive at an estimate of 8,520 pests entering per 4 million passengers (i.e., 4,275 pests per year). This would translate into a pest approach rate of 0.2% (versus the 0 to 0.04% predicted by AQIM data). The probability of establishment after introduction is a function of both the rate of entry and the population size required for persistence (Bartell and Nair 2003), and will be different for each pest species. A general and often cited estimate is that about 10% of all non-indigenous insect species introduced into a new range become established (NRC 2002). However, based on Bartell and Nair (2003), this estimate may be too high for some species, so we are here conservatively assuming that between 0.1% and 1% of the arriving pests manage to establish populations in Hawai'i within 25 years of first introduction. Thus, we would expect approximately four 4 to 40 pest establishments per year as a result of international air travel alone.

In addition to the 2 million international travelers, Hawai'i received about 5.3 million visitors from the U.S. mainland in 2005. It is impossible to quantify the risks associated with the domestic visitors because no randomly collected data are available. However, quarantine inspections by the HDOA have resulted in over 300 pest interceptions in domestic air passenger carry-on baggage between 1995 and 2006 (HDOA 2007c) (Table A16-6), demonstrating that visitors entering by air from the U.S. mainland may be a significant pathway for the introduction of exotic pests. One of the more frequently intercepted species was the Argentine ant, *L. humile*, an extremely invasive tramp species, which has become established and is wreaking ecological havoc in Hawai'i (Cole et al. 1992). Due to a number of biological traits, this and other ant species have a high probability of introduction, so that establishment may easily result from a small number of individuals, provided that a reproductive female (gyne) is among them. Given the low interception efficiency of CBP on international visitors and the relatively small workforce HDOA has available to prevent exotic introductions, it is unlikely that the existing pest risk associated with international and domestic airline passengers can be mitigated effectively under present conditions.

A16.3.6 Summary

- For all countries of passenger origin with a sample size of 20 or more, estimated plant QM approach rates were between 0 and 25%. Differences in approach rates between countries of origin were complex, with no country being significantly different from all other countries.
- For the different travel reasons with a sample size of 20 or more, estimated plant QM approach rates from foreign countries were between 0.4 and 12%. All travel reasons had QM approach rates that were significantly different from zero.
- For the different months of the year, estimated plant QM approach rates from foreign countries were between 1 and 7%. All months had QM approach rates that were significantly different from zero. December and January were associated with higher approach rates than the summer months.
- There was not a single pest interception recorded in the AQIM data set. Based on other available information, this seems to be a data quality problem.
- More than 4,000 plant pest organisms may be entering Hawai'i with foreign airline passengers every year, which may translate into between 4 and 40 pest establishments annually.
- The percentage of arriving pest species already established in Hawai'i is unknown.
- The international airline passenger pathway presents a significant pest risk to Hawai'i.
- Although the pest risk associated with domestic airline passengers cannot be quantified due to a lack of data, it likely is significant.

Table A16-1 details AQIM of international air passengers arriving at HNL in FYs 2005 and 2006 by country of passenger origin. The table shows only countries for which the AQIM sample size was at least 20. The sampling unit is the group of passengers traveling together under one U.S. Customs manifest. The table shows the country of origin,[10] the number of passenger groups that were found to have quarantine materials (QMs),[11] the number of passenger groups inspected,[12] the estimated proportion of

[10] AQIM data for FYs 2005 and 2006.
[11] Ibid, p. B-57

passenger groups that carry QMs, and the lower and upper 95% binomial confidence limits for this estimate. It also lists the total number of QMs detected by country,[13] the average number of QMs per interception,[14] the total annual number of passengers entering Hawai'i,[15] the average number of passengers per group,[16] and the annual number of groups entering Hawai'i. Finally, it shows the lower and upper confidence limits for the estimated total annual number of QMs entering Hawai'i. Shaded fields indicate that the number of passengers entering was estimated.

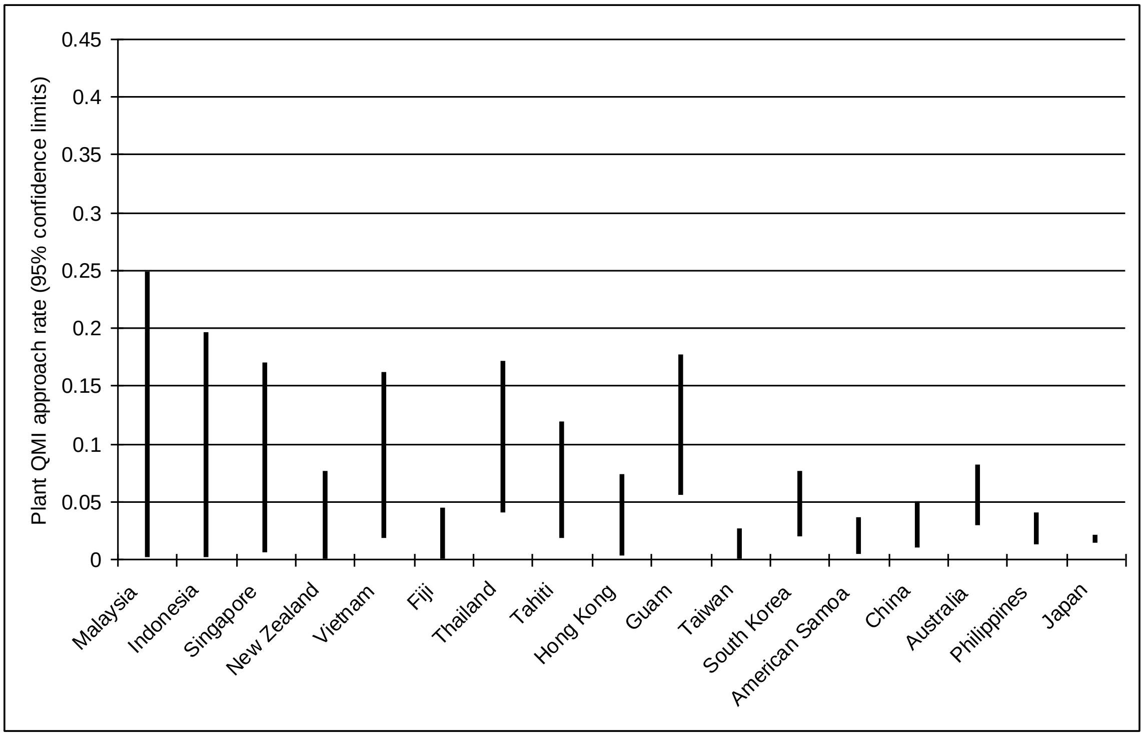
[12] Ibid.
[13] Ibid.
[14] Ibid.
[15] 2005 Annual Visitors Research Report of the Hawai'i Department of Business, Economic Development, and Tourism (DBEDT data set).
[16] AQIM data for FYs 2005 and 2006.

Table A16-1: Results of Agricultural Quarantine Inspection Monitoring of International Air Passengers Arriving at Honolulu International Airport during FYs 2005 and 2006 by Country of Passenger Origin

Country of Origin	Pax groups where QMs found	Pax groups inspected	Approach rate (proportion of groups with QMs)	Lower 95% confidence limit of approach rate	Upper 95% confidence limit of approach rate	QMs detected	QMs per interception	Pax entering	Average Pax per group	Pax groups entering	Lower 95% confidence limit of QMs entering	Upper 95% confidence limit of QMs entering
Malaysia	1	20	0.05	0.0013	0.2487	1	1.00	No data	1.30	2,800	4	696
Indonesia	1	26	0.0385	0.001	0.1964	1	1.00	No data	1.54	3,640	4	715
Singapore	2	40	0.05	0.0061	0.1692	2	1.00	4,050	1.55	2,613	16	442
New Zealand	0	47	0	0	0.0755	0	0	19, 451	1.49	13, 060	0	986
Vietnam	4	60	0.0667	0.0185	0.162	5	1.25	No data	1.50	8,400	194	1,701
Fiji	0	81	0	0	0.0445	0	0	No data	1.32	11,340	0	505
Thailand	8	88	0.0909	0.0401	0.1713	9	1.13	No data	1.32	12,320	556	2,374
Tahiti	5	95	0.0526	0.0173	0.1186	6	1.20	No data	1.57	13,300	276	1,893
Hong Kong	2	96	0.0208	0.0025	0.0732	2	1.00	5, 363	1.43	3,758	9	275
Guam	12	114	0.1053	0.0556	0.1767	17	1.42	No data	1.56	15,960	1,257	3,995
Taiwan	1	215	0.0047	0.0001	0.0256	1	1.00	20,174	1.35	14,905	1	382
South Korea	9	220	0.0409	0.0189	0.0762	12	1.33	35,008	1.60	21,942	553	2,229
American Samoa	4	287	0.0139	0.0038	0.0353	5	1.25	No data	1.69	40, 180	191	1,773
China	7	287	0.0244	0.0099	0.0469	7	1.00	42,526	1.48	28,718	284	1,424
Australia	15	299	0.0502	0.0283	0.0814	22	1.47	122,940	1.50	82,051	3,406	9,796
Philippines	13	549	0.0237	0.0127	0.0402	14	1.08	No data	1.73	76,860	1,051	3,327
Japan	76	4509	0.0169	0.0133	0.0211	97	1.28	1,517,439	1.64	925,318	15,707	24,919

Note: Pax=passenger; QM=quarantine plant and animal materials

Figure A16-1: 95% Confidence Intervals of Plant QM Approach Rates for Airline Passenger Baggage by Country of Passenger Origin



Note: Only countries, for which AQIM sample size was at least 20, are shown.

Figure A16-2: 95% Confidence Intervals of Estimated Annual Number of Plant QMs entering Hawai'i in Airline Passenger Baggage by Country of Passenger Origin

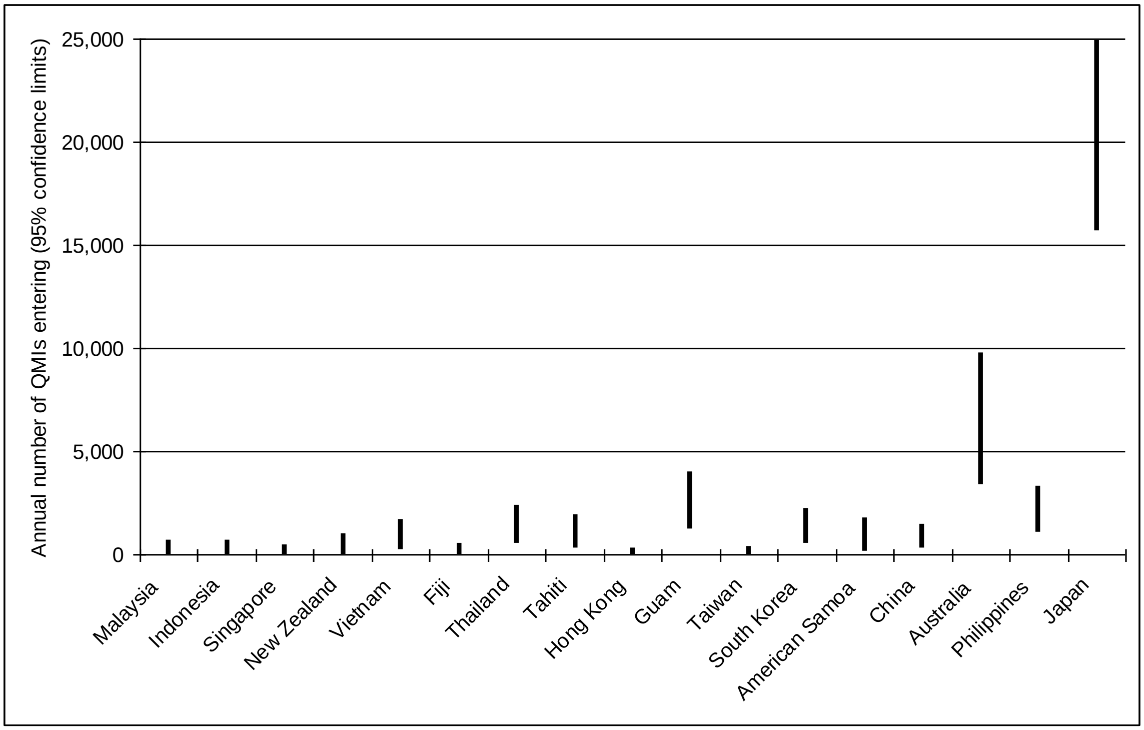


Table A16-2 shows the results of AQIM of international air passengers arriving at HNL during FYs 2005 and 2006 by travel reason. The sampling unit is the group of passengers traveling together under one U.S. Customs manifest. The table shows the travel reason,[17] the number of passenger groups that were found to have QMs, the number of passenger groups inspected,[18] the estimated proportion of passenger groups that carry QMs, and the lower and upper 95% binomial confidence limits for this estimate. It also lists the total number of QMs detected by travel reason,[19] the average number of QMs per interception,[20] the total annual number of passengers entering Hawai'i,[21] the average number of passengers per group,[22] and the annual number of groups entering Hawai'i. Finally, it shows the lower and upper confidence limits for the estimated total annual number of QMs entering Hawai'i.

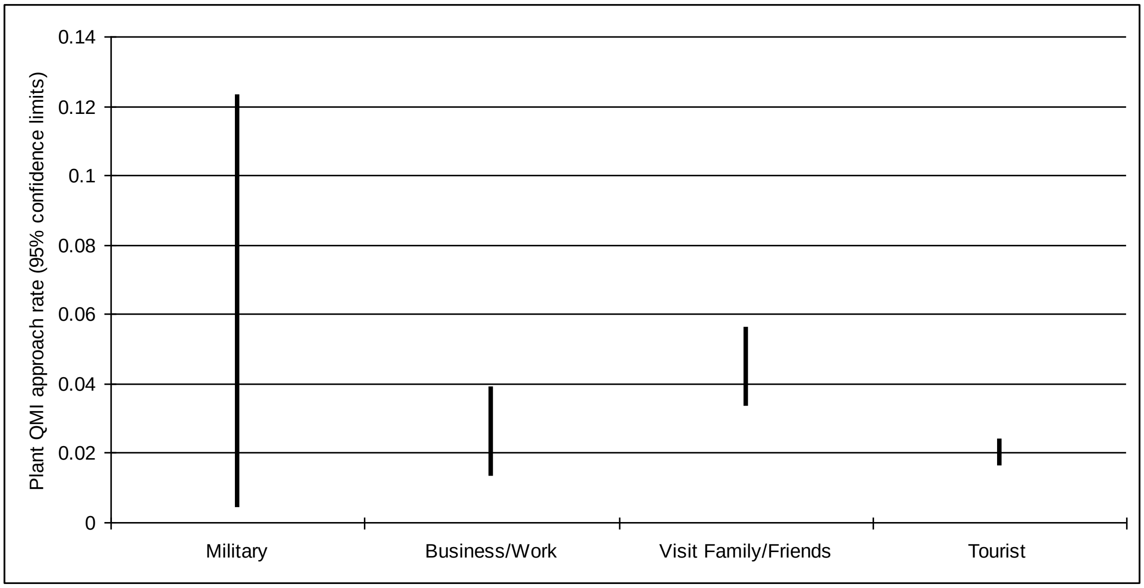
[17] AQIM data for FYs 2005 and 2006.
[18] Ibid
[19] Ibid
[20] Ibid
[21] 2005 Annual Visitors Research Report of the Hawai'i Department of Business, Economic Development, and Tourism (DBEDT data set).
[22] AQIM data for FYs 2005 and 2006.

Table A16-2: Results of AQIM of International Air Passengers Arriving at HNL during FYs 2005 and 2006 by Travel Reason

Reasons for Travel	School	Military	Business/Work	Visit Family/Friends	Tourism
Pax groups where QMs found	0	2	15	58	102
Pax groups inspected	2	56	630	1,322	5,154
Approach rate (Proportion of groups with QMs)	0	0.0357	0.0238	0.0439	0.0198
Lower 95% confidence limit of approach rate	0	0.0044	0.0134	0.0335	0.0162
Upper 95% confidence limit of approach rate	0.7764	0.1231	0.039	0.0564	0.024
QMs detected	0	4	21	77	123
QMs per interception	0	2.00	1.40	1.33	1.21
Pax entering	7,749	35,019	224,997	109,495	2,165,169
Average Pax per group	1.5	1.25	1	1.64	1.69
Pax groups entering	5,166	28,015	224,997	66,765	1,281,165
Lower 95% confidence limit of QMs entering	.	247	4,221	2,969	25,028
Upper 95% confidence limit of QMs entering	.	6,897	12,285	4,999	37,078

Note: Pax=passenger; QM=quarantine plant and animal materials

Figure A16-3: 95% Confidence Intervals of Plant QM Approach Rates for Airline Passenger Baggage by Travel Reason



Note: Only travel reasons, for which AQIM sample size was at least 20, are shown.

Figure A16-4: 95% Confidence Intervals of Estimated Annual Number of Plant QMs Entering Hawai'i in Airline Passenger Baggage by Travel Reason

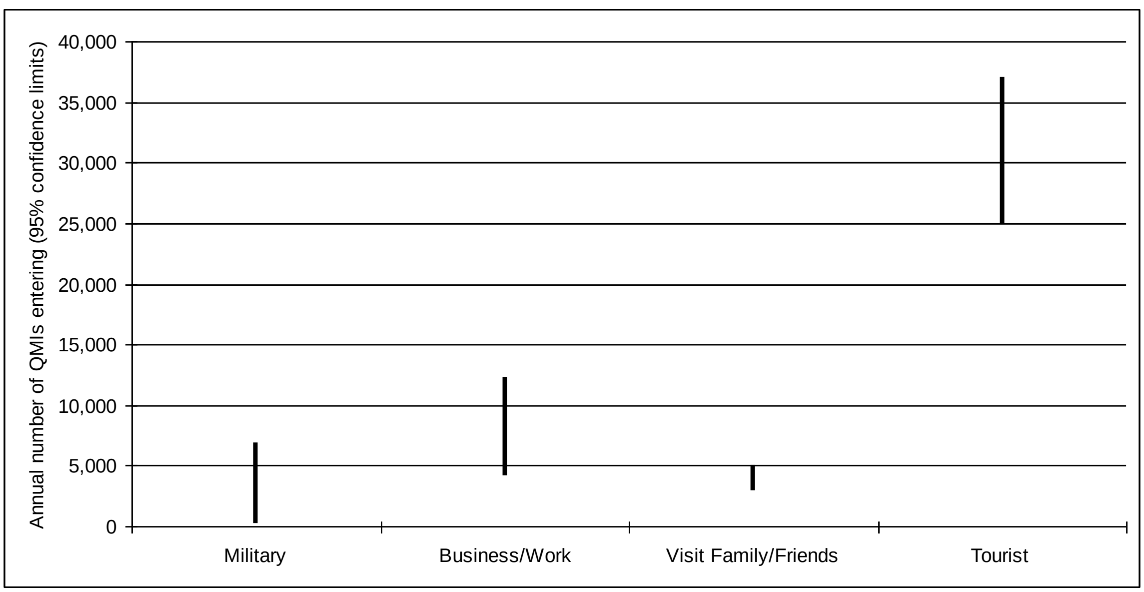


Table A16-3 shows the results of AQIM of international air passengers arriving at HNL during by calendar month in FYs 2005 and 2006. The sampling unit is the group of passengers traveling together under one U.S. Customs manifest. The table shows the month of travel, the number of passenger groups that were found to have QMs, the number of passenger groups inspected, the estimated proportion of passenger groups that carry QMs, and the lower and upper 95% binomial confidence limits for this estimate. It also lists the total number of QMs detected by country, the average number of QMs per interception, the total annual number of passengers entering Hawai'i, the average number of passengers per group, and the annual number of groups entering Hawai'i. Finally, it shows the lower and upper confidence limits for the estimated total annual number of QMs entering Hawai'i.

Table A16-3: Results of AQIM of International Air Passengers Arriving at HNL during FYs 2005 and 2006 by Calendar Month

Month	Pax groups where QMs found	Pax groups inspected	Approach rate (proportion of groups with QMs)	Lower 95% confidence limit of approach rate	Upper 95% confidence limit of approach rate	QMs detected	QMs per interception	Pax entering	Average Pax per group	Pax groups entering	Lower 95% confidence limit of QMs entering	Upper 95% confidence limit of QMs entering
Jan.	23	612	0.0376	0.024	0.0559	27	1.17	215,498	1.7	126,764	3,571	8,318
Feb.	8	522	0.0153	0.0066	0.03	9	1.13	196,209	1.5	130,806	971	4,415
Mar.	15	602	0.0249	0.014	0.0408	18	1.20	212,479	1.6	132,799	2,231	6,502
Apr.	12	601	0.02	0.0104	0.0346	15	1.25	176,396	1.6	110,248	1,433	4,768
May.	12	604	0.0199	0.0103	0.0344	16	1.33	185,965	1.6	116,228	1,596	5,331
Jun.	8	576	0.0139	0.006	0.0272	11	1.38	189,819	1.6	118,637	979	4,437
Jul.	12	603	0.0199	0.0103	0.0345	18	1.50	212,113	1.7	124,772	1,928	6,457
Aug.	11	606	0.0182	0.0091	0.0322	16	1.45	220,421	1.8	122,456	1,621	5,735
Sep.	12	602	0.0199	0.0103	0.0346	15	1.25	207,531	1.5	138,354	1,781	5,984
Oct.	19	603	0.0315	0.0191	0.0488	23	1.21	213,259	1.6	133,287	3,082	7,874
Nov.	16	617	0.0259	0.0149	0.0418	21	1.31	191,555	1.5	127,703	2,497	7,006
Dec.	29	616	0.0471	0.0318	0.0669	36	1.24	233,542	1.7	137,378	5,423	11,409

Note Pax=passenger; QM=quarantine plant and animal materials

Table A16-4 shows the results of AQIM of international air passengers arriving at HNL during FYs 2005 and 2006. The sampling unit is the group of passengers traveling together under one U.S. Customs manifest. The table shows the number of passenger groups that were found to have QMs, the number of passenger groups inspected, the estimated proportion of passenger groups that carry QMs, and the lower and upper 95% binomial confidence limits for this estimate. It also lists the total number of QMs detected, the average number of QMs per interception, the total annual number of passengers entering Hawai'i, the average number of passengers per group, and the annual number of groups entering Hawai'i. Finally, it shows the lower and upper confidence limits for the estimated total annual number of QMs entering Hawai'i.

Table A16-4: Results of AQIM of International Air Passengers Arriving at HNL during FYs 2005 and 2006

Pax groups where QMs found	Pax groups inspected	Approach rate (proportion of groups with QMs)	Lower 95% confidence limit of approach rate	Upper 95% confidence limit of approach rate	QMs detected	QMs per interception	Pax entering	Average Pax per group	Pax groups entering	Lower 95% confidence limit of QMs entering	Upper 95% confidence limit of QMs entering
177	7,164	0.0247	0.0212	0.0286	247	1.40	2,144,064	1.55	1,360,120	40,369	54,459

Note: Pax=passenger; QM=quarantine plant and animal materials

Figure A16-5: 95% Confidence Intervals of Plant QM Approach Rates for Airline Passenger Baggage by Calendar Month of Travel

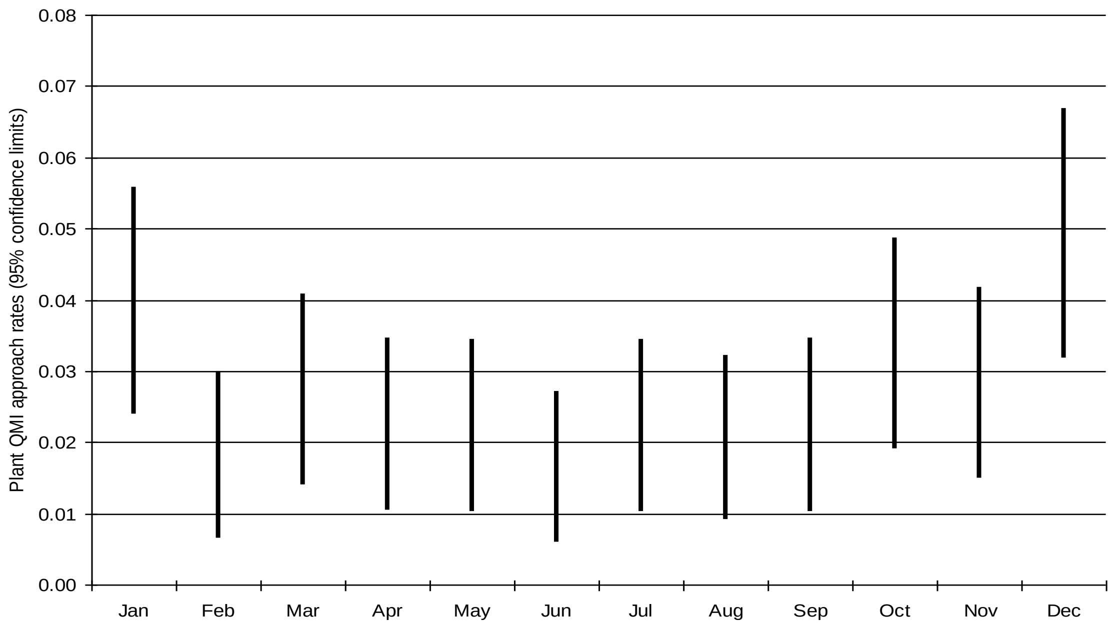


Figure A16-6: 95% Confidence Intervals of Estimated Annual Number of Plant QMs Entering Hawai'i in Airline Passenger Baggage by Calendar Month of Travel

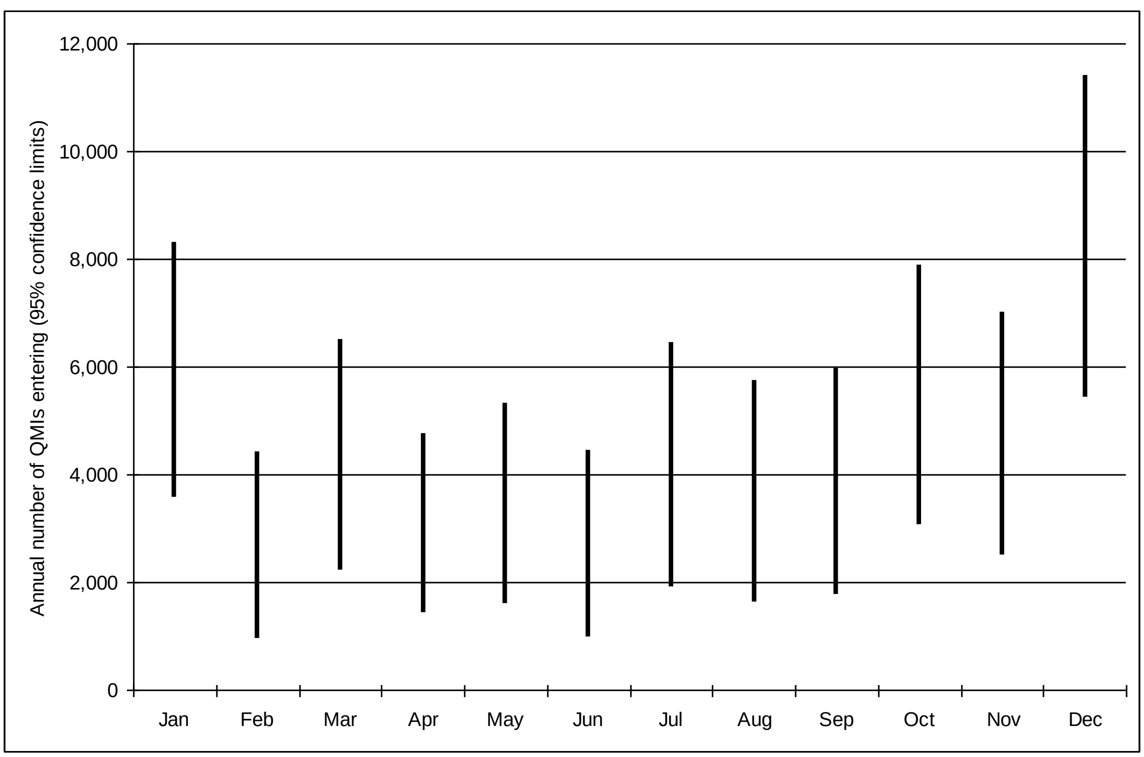


Table A16-5 lists the country of origin of the inspected airline passengers, the type and number of QM intercepted, and potential (not actually intercepted) pests of the QM that occur in the country of origin, as well as references for the pest information.

Table A16-5: Plant QMs that have been Seized during AQIM Sampling in FY 2005 through 2006

Country of Origin	QM	Number of QMs	Potential pests of importance[a]	References[a]
American Samoa	Apple	1	*Bactrocera kirki* (Froggatt) (Diptera: Tephritidae)	Manson 1980; CABI 2006
	Breadfruit	1	*Bactrocera distincta* (Malloch), *B. xanthodes* (Broun) (Diptera: Tephritidae)	White and Elson-Harris 1992; CABI 2006
	Citrus, Orange	1	*Bactrocera kirki* (Froggatt) (Diptera: Tephritidae); *Sphaceloma fawcettii* var. *scabiosa* (McAlpine and Tryon) Jenk. (Ascomycetes: Myriangiales)	White and Elson-Harris 1992; Brooks 2006; Farr et al. 2006
	Coconut	1	*Aspidiotus pacificus* Williams and Watson (Homoptera: Diaspididae)	Ben-Dov et al. 2006
	Grapes	1	*Gibberella intricans* Wollenw. (Ascomycetes: Hypocreales)	Brooks 2006; CABI 2006
Australia	Apple	10	*Bactrocera aquilonis* (May) (Diptera: Tephritidae)	White and Elson-Harris 1992
	Banana	3	*Bactrocera musae* (Tryon) (Diptera: Tephritidae)	White and Elson-Harris 1992
	Citrus, Lemon	1	*Bactrocera aquilonis* (May); *B. neohumeralis* (Hardy); *B. tryoni* (Froggatt) (Diptera: Tephritidae)	White and Elson-Harris 1992
	Citrus, Orange	3	*Bactrocera tryoni* (Froggatt) (Diptera: Tephritidae)	White and Elson-Harris 1992
	Cucumber	1	*Bactrocera cucumis* (French) (Diptera: Tephritidae)	White and Elson-Harris 1992
	Pear	3	*Bactrocera jarvisi* (Tryon); *B. neohumeralis* (Hardy); *B. tryoni* (Froggatt) (Diptera: Tephritidae)	White and Elson-Harris 1992
	Tomato	1	*Bactrocera aquilonis* (May); *B. cucumis* (French); *B. neohumeralis* (Hardy); *B. tryoni* (Froggatt) (Diptera: Tephritidae)	White and Elson-Harris 1992
Bangladesh	Seeds	1	NA	NA
Bhutan	Szechuan Peppercorns (*Zanthoxylum* spp.)	1	NA	NA

Country of Origin	QM	Number of QMs	Potential pests of importance[a]	References[a]
China	Citrus, Peel	2	*Alternaria citri* Ellis and N. Pierce (Ascomycetes: Pleosporales); *Guignardia citricarpa* Kiely (Ascomycetes: Dothideales); *Xanthomonas axonopodis* pv. *citri* (Hasse) Vauterin et al. (Xanthomonadales)	CABI/EPPO 1997f Timmer et al. 2000; Schubert and Sun 2003; CABI 2006; Farr et al. 2006
	Citrus, Pomelo	1	*Alternaria citri* Ellis and N. Pierce (Ascomycetes: Pleosporales); *Bactrocera minax* (Enderlein); *B. tau* (Walker) (= *Dacus hageni* de Meijere) (Diptera: Tephritidae); "*Candidatus* Liberobacter asiaticum" Jagoueix *et al*. (Rhizobiales); *Guignardia citricarpa* Kiely (Ascomycetes: Dothideales); *Xanthomonas axonopodis* pv. *citri* (Hasse) Vauterin et al. (Xanthomonadales)	Kapoor 1989; White and Elson-Harris 1992; CABI/EPPO 1997d; f; Timmer et al. 2000; Schubert and Sun 2003; CABI 2006; Farr et al. 2006
	Citrus, Tangerine	1	*Alternaria citri* Ellis and N. Pierce (Ascomycetes: Pleosporales); *Bactrocera minax* (Enderlein); *B. tsuneonis* (Miyake) (Diptera: Tephritidae); "*Candidatus* Liberobacter asiaticum" Jagoueix *et al*. (Rhizobiales); *Guignardia citricarpa* Kiely (Ascomycetes: Dothideales); *Xanthomonas axonopodis* pv. *citri* (Hasse) Vauterin et al. (Xanthomonadales)	White and Elson-Harris 1992; CABI/EPPO 1997d; f; k; Timmer et al. 2000; Schubert and Sun 2003; CABI 2006; Farr et al. 2006
	Peach	1	*Adoxophyes orana* (Fischer von Röeslerstamm) (Lepidoptera: Tortricidae); *Aonidiella orientalis* (Newstead) (Homoptera: Diaspididae)	Meijerman and Ulenberg 2000; Watson 2005
	Pear	1	*Adoxophyes orana* (Fischer von Röeslerstamm) (Lepidoptera: Tortricidae); *Diaspidiotus ostreaeformis* (Curtis) (Homoptera: Diaspididae)	Meijerman and Ulenberg 2000; Watson 2005
China	Szechuan Peppercorns	1	NA	NA
Germany	Apple	1	*Adoxophyes orana* (Fischer von Röeslerstamm) (Lepidoptera: Tortricidae)	Meijerman and Ulenberg 2000; CABI 2006
	Citrus, Orange	1	None[b]	NA
	Plant, Seedlings	1	NA	NA
Guam	Apple	1	None[c]	NA

Country of Origin	QM	Number of QMs	Potential pests of importance[a]	References[a]
	Banana	1	*Aonidiella aurantii* (Maskell) (Homoptera: Diaspididae); *Icerya aegyptiaca* (Douglas) (Homoptera: Margarodidae)	Beardsley 1955; Nafus and Schreiner 1999; Watson 2005; CABI 2006
	Eggplant	1	*Paracoccus marginatus* Williams and Granara de Willink (Homoptera: Pseudococcidae)	Ben-Dov et al. 2006; CABI 2006
	Leaves	1	NA	NA
	Mango	2	*Bactrocera frauenfeldi* (Schiner) (Diptera: Tephritidae)	White and Elson-Harris 1992; CABI 2006
	Nectarine	1	None[c]	NA
	Nut, Betel w/ Husk (*Areca catechu*)	6	*Colletotrichum arecae* Syd. and P. Syd. (Ascomycetes: Phyllachorales)	Farr et al. 2006
	Plant, Seedlings	1	NA	NA
	Plum	1	None[c]	NA
	Santol (*Sandoricum koetjape*)	1	*Bactrocera frauenfeldi* (Schiner) (Diptera: Tephritidae)	SPC 2002a; CABI 2006
	Tomato	1	*Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae)	CABI/EPPO 1997g
Hong Kong	Citrus, Peel	2	*Alternaria citri* Ellis and N. Pierce (Ascomycetes: Pleosporales); *Guignardia citricarpa* Kiely (Ascomycetes: Dothideales); *Xanthomonas axonopodis* pv. *citri* (Hasse) Vauterin et al. (Xanthomonadales)	CABI/EPPO 1997k; Timmer et al. 2000; Schubert and Sun 2003; CABI 2006; Farr et al. 2006
India	Apple	1	*Bactrocera zonata* (Saunders) (= *Dacus zonatus* [Saunders]) (Diptera: Tephritidae); *Dyscerus malignus* Mshl., *D. fletcheri* Mshl. (Coleoptera: Curculionidae); *Ulodemis trigrapha* Meyrick (Lepidoptera: Tortricidae)	Nair 1975; White and Elson-Harris 1992
Indonesia	Sand Pear	1	*Planococcus minor* (Maskell), *Pseudococcus comstocki* (Kuwana) (Homoptera: Pseudococcidae)	Agnello et al. 1992; Ooi et al. 2002; Ben-Dov et al. 2006
Japan	Apple	6	*Adoxophyes orana* (Fischer von Röeslerstamm), *Grapholita molesta* (Busck) (Lepidoptera: Tortricidae)	Shiraki 1952; Meijerman and Ulenberg 2000; CABI 2006
	Banana	5	*Icerya aegyptiaca* (Douglas) (Homoptera: Margarodidae)	Beardsley 1955; Ben-Dov et al. 2006; CABI 2006
	Carrot	1	*Alternaria radicina* Meier *et al.* (Ascomycetes: Pleosporales); *Pratylenchus thornei* Sher and Allen, *P. vulnus* Allen and Jensen (Pratylenchidae); *Psila rosae* (F.) (Diptera: Psilidae)	Gotoh and Ohshima 1963; Ellis and Holliday 1972; CABI 2006

Country of Origin	QM	Number of QMs	Potential pests of importance[a]	References[a]
	Citrus, Grapefruit	1	*Aonidiella citrina* (Coquillett), *Unaspis yanonensis* (Kuwana) (Homoptera: Diaspididae); "*Candidatus* Liberobacter asiaticum" Jagoueix *et al*. (Rhizobiales); *Guignardia citricarpa* Kiely (Ascomycetes: Dothideales)	CABI 1997; CABI/EPPO 1997d; Ben-Dov et al. 2006; CABI 2006; Farr et al. 2006
	Citrus, Orange	19	*Alternaria citri* Ellis and N. Pierce (Ascomycetes: Pleosporales); *Aonidiella citrina* (Coquillett) (Homoptera: Diaspididae); *Bactrocera tsuneonis* (Miyake) (Diptera: Tephritidae); "*Candidatus* Liberobacter asiaticum" Jagoueix et al. (Rhizobiales); *Geotrichum candidum* Link (Saccharomycetes: Saccharomycetales)	White and Elson-Harris 1992; CABI/EPPO 1997d; Plaza et al. 2004; Ben-Dov et al. 2006; CABI 2006
Japan	Citrus, Peel	1	*Alternaria citri* Ellis and N. Pierce (Ascomycetes: Pleosporales); *Geotrichum candidum* Link (Saccharomycetes: Saccharomycetales)	Plaza et al. 2004; CABI 2006
	Citrus, Tangerine	28	*Alternaria citri* Ellis and N. Pierce (Ascomycetes: Pleosporales); *Bactrocera tsuneonis* (Miyake) (Diptera: Tephritidae); "*Candidatus* Liberobacter asiaticum" Jagoueix *et al*. (Rhizobiales); *Geotrichum candidum* Link (Saccharomycetes: Saccharomycetales); *Unaspis yanonensis* (Kuwana) (Homoptera: Diaspididae)	White and Elson-Harris 1992; CABI/EPPO 1997d; Plaza et al. 2004; CABI 2006
	Cucumber	3	*Phytophthora melonis* Katsura, *Pythium cucurbitacearum* Takimoto (Oomycetes: Pythiales)	Takimoto 1941; Farr et al. 2006
	Fruit, Fresh	4	NA	NA
	Fruit, Salad	1	NA	NA
	Garlic	1	*Aceria tulipae* (Keifer) (Acari: Eriophyidae); *Delia antiqua* (Meigen) (Diptera: Anthomyiidae); *Urocystis magica* Pass. (= *U. cepulae* Frost) (Ustilaginomycetes: Urocystales)	Schneider et al. 1985; CABI 2006; Farr et al. 2006
	Grapes	1	*Brevipalpus lewisi* McGregor (Acari: Tenuipalpidae)	James and Whitney 1993; CABI 2006
	Guava	2	*Conogethes* (= *Dichocrocis*) *punctiferalis* (Guenée) (Lepidoptera: Pyralidae); *Planococcus lilacinus* (Cockerell) (Homoptera: Pseudococcidae)	Shiraki 1952; Mani 1995; Kaul and Kesar 2003; Ben-Dov et al. 2006

Country of Origin	QM	Number of QMs	Potential pests of importance[a]	References[a]
	Kiwi	2	*Lobesia botrana* (Denis and Schiffermüller) (Lepidoptera: Tortricidae)	Moleas 1988; Meijerman and Ulenberg 2000
	Lettuce	1	*Autographa gamma* (L.) (Lepidoptera: Noctuidae); *Chromatomyia horticola* (Goureau), *Liriomyza bryoniae* (Kaltenbach) (Diptera: Agromyzidae)	Whittle 1986; CABI/EPPO 1997h; Dempewolf 2004
	Medicine	1	NA	NA
	Melon	1	NA	NA
	Mustard Greens	1	NA	NA
	Onion	1	*Aceria tulipae* (Keifer) (Acari: Eriophyidae); *Delia antiqua* (Meigen) (Diptera: Anthomyiidae); *Phytophthora porri* Foister (Oomycetes: Pythiales); *Urocystis magica* Pass. (= *U. cepulae* Frost) (Ustilaginomycetes: Urocystales)	Schneider et al. 1985; CABI 2006; Farr et al. 2006
	Onions, Green	1	*Burkholderia cepacia* (ex Burkholder) Yabuuchi *et al*. (Burkholderiales); *Stemphylium vesicarium* (Wallr.) Simmons (Dothideomycetes: Pleosporales)	Saddler 1994; Cho and Yu 1998; Ozawa et al. 2003; Farr et al. 2006
	Persimmon	3	*Conogethes punctiferalis* (Guenée) (Lepidoptera: Pyralidae); *Eriococcus lagerstroemiae* Kuwana (Homoptera: Eriococcidae); *Lepidosaphes cupressi* Borchsenius (Homoptera: Diaspididae); *Pestalotiopsis acaciae* (Thümen) Yokoyama and Kaneko (Ascomycetes: Xylariales); *Stathmopoda masinissa* Meyrick (Lepidoptera: Oecophoridae); *Tenuipalpus zhizhilashviliae* Reck (Acari: Tenuipalpidae)	Clausen 1931; Tomomatsu et al. 1995; Kim et al. 1997; Umeya and Okada 2003; Yasuda et al. 2003; Ben-Dov et al. 2006
	Plant, Seedlings	1	NA	NA
	Plum	1	*Adoxophyes orana* (Fischer von Röeslerstamm) (Lepidoptera: Tortricidae); *Carposina niponensis* (Walsingham) (= *C. sasakii* Matsumura) (Lepidoptera: Carposinidae)	Shiraki 1952; Anonymous 1958; Meijerman and Ulenberg 2000

Country of Origin	QM	Number of QMs	Potential pests of importance[a]	References[a]
Japan	Potato	1	*Globodera rostochiensis* (Wollenweber) Behrens (Heteroderidae); *Pratylenchus thornei* Sher and Allen (Pratylenchidae); *Ralstonia solanacearum* race 3 (Smith) Yabuuchi *et al*. (Burkholderiales); *Streptomyces scabies* (ex Thaxter) Lambert and Loria (Actinomycetales)	Gotoh and Ohshima 1963; Hooker 1988; Brodie 1993; CABI/EPPO 1997e; CABI 2006; Farr et al. 2006
	Potato, Sweet	2	*Ralstonia solanacearum* race 3 (Smith) Yabuuchi *et al*. (Burkholderiales)	CABI 2006
	Seeds	2	NA	NA
	Tomato	3	*Geotrichum candidum* Link (Saccharomycetes: Saccharomycetales); *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae)	CABI/EPPO 1997g; Nakamura et al. 2001; Sharma et al. 2006
	Vegetable	2	NA	NA
	Wheat Product	1	NA	NA
South Korea	Apple	2	*Carposina sasakii* Matsumura (Lepidoptera: Carposinidae); *Conogethes punctiferalis* (Guenée) (Lepidoptera: Pyralidae); *Grapholita molesta* (Busck) (Lepidoptera: Tortricidae); *Monilinia fructigena* Honey ex Whetzel (Ascomycetes: Helotiales); *Venturia inaequalis* (Cooke) Winter (Ascomycetes: Pleosporales)	Sivanesan and Waller 1974; Honda et al. 1988; Choi et al. 2004; Kang et al. 2004; Farr et al. 2006
	Banana	1	None[d]	NA
	Citrus, Tangerine	2	*Aonidiella citrina* (Coquillett), *Unaspis yanonensis* (Kuwana) (Homoptera: Diaspididae); *Guignardia citricarpa* Kiely (Ascomycetes: Dothideales)	Catling et al. 1977; CABI 1997; CABI/EPPO 1997a; Watson 2005; CABI 2006; Farr et al. 2006
	Fruit, Fresh	1	NA	NA
	Nut, Chestnut	2	*Conogethes punctiferalis* (Guenée) (Lepidoptera: Pyralidae)	Li et al. 1989; Kang et al. 2004
	Persimmon	1	*Asiacornococcus kaki* (Kuwana in Kuwana and Muramatsu) (Eriococcidae); *Conogethes punctiferalis* (Guenée) (Lepidoptera: Pyralidae); *Phyllactinia kakicola* Sawada (Ascomycetes: Erysiphales); *Ponticulothrips diospyrosi* Haga and Okajima (Thysanoptera: Phlaeothripidae)	Kim et al. 1997; Lee et al. 2002; Kwon and Han 2003; Farr et al. 2006
	Potato, Sweet	1	*Helicobasidium mompa* Tanaka (Urediniomycetes: Helicobasidiales)	Clark and Moyer 1988; Farr et al. 2006

Country of Origin	QM	Number of QMs	Potential pests of importance[a]	References[a]
	Tomato	2	*Bactrocera depressa* (Shiraki) (Diptera: Tephritidae); *Mamestra brassicae* (L.) (Lepidoptera: Noctuidae); *Sclerotinia minor* Jagger (Ascomycetes: Helotiales)	Okadome 1962; Han et al. 1994; Rojas et al. 2001; CABI 2006; Farr et al. 2006
Malaysia	Citrus, Orange	1	*Aonidiella aurantii* (Maskell), *A. citrina* (Coquillett) (Homoptera: Diaspididae); *Bactrocera papayae* Drew and Hancock (Diptera: Tephritidae); "*Candidatus* Liberobacter asiaticum" Jagoueix et al. (Rhizobiales)	Yunus and Ho 1980; White and Elson-Harris 1992; CABI/EPPO 1997a; d; Song et al. 2006
Micronesia	Fruit, Fresh	1	NA	NA
	Nut, Betel	1	NA	NA
	Nut, Betel w/ Husk	1	NA	NA
Palau	Leaves	3	NA	NA
	Nut, Betel	2	*Bactrocera frauenfeldi* (Schiner) (Diptera: Tephritidae)	SPC 2002a
	Nut, Betel w/ Husk	6	*Bactrocera frauenfeldi* (Schiner) (Diptera: Tephritidae)	SPC 2002a
Philippines	Apple	1	None[e]	NA
	Banana	3	*Icerya aegyptiaca* (Douglas), *I. seychellarum* (Westwood) (Homoptera: Margarodidae); *Penicillium waksmanii* Zaleski (Ascomycetes: Eurotiales); *Tiracola plagiata* (Walk.) (Lepidoptera: Noctuidae)	Weddell 1930; Beardsley 1955; CAB 1972; Alvindia et al. 2002; Ben-Dov et al. 2006
	Corn	1	*Conogethes punctiferalis* (Guenée) (Lepidoptera: Pyralidae); *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae)	CABI/EPPO 1997g; CABI 2006
Philippines	Fruit, Fresh	1	NA	NA
	Mango	3	*Aonidiella citrina* (Coquillett) (Homoptera: Diaspididae); *Bactrocera occipitalis* (Bezzi), *B. philippinensis* Drew and Hancock (Diptera: Tephritidae); *Sternochetus frigidus* (F.) (Coleoptera: Curculionidae)	Hill 1983; White and Elson-Harris 1992; Basio et al. 1994; CABI/EPPO 1997a
	Onions, Green	1	*Liriomyza huidobrensis* (Blanchard) (Diptera: Agromyzidae);[f] *Peronospora destructor* (Berk.) Casp. (= *P. schleideni* Unger) (Oomycetes: Peronosporales); *Urocystis cepulae* Frost (Ustilaginomycetes: Urocystales)	CAB 1978; 1984; CABI/EPPO 1997i; CABI 2002; Farr et al. 2006
	Potato, Sweet	1	*Fusarium pallidoroseum* (Cooke) Sacc. (Ascomycetes: Hypocreales)	Ray and Ravi 2005; Farr et al. 2006

Country of Origin	QM	Number of QMs	Potential pests of importance[a]	References[a]
	Rice Straw	1	*Sclerotium oryzae* Catt. (Basidiomycetes: Agaricales)	Cintas and Webster 2001; Farr et al. 2006
	Taro	2	*Caliothrips striatopterus* (Kobus) (Thysanoptera: Thripidae); *Phyllosticta colocasiae* Höhn. (Ascomycetes: Dothideales); Taro feathery mosaic virus (= taro feathery mottle virus?) (Potyviridae)	Palomar et al. 1983; Reyes and Rillon 1994; CABI 2006; Farr et al. 2006; Hoddle et al. 2006
Russia	Tomato	1	*Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae); *Monilinia fructigena* Honey ex Whetzel (Ascomycetes: Helotiales)	Schlosser 1975; CABI/EPPO 1997g; CABI 2000; Talekar et al. 2006
Singapore	Apple	1	None[g]	NA
	Banana	1	*Bactrocera carambolae* Drew and Hancock, *B. papayae* Drew and Hancock (Diptera: Tephritidae)	White and Elson-Harris 1992; Drew and Hancock 1994
Tahiti	Banana	1	*Bactrocera kirki* (Froggatt), *B. tryoni* (Froggatt) (Diptera: Tephritidae); *Icerya aegyptiaca* (Douglas), *I. seychellarum* (Westwood) (Homoptera: Margarodidae)	Beardsley 1955; Leblanc and Putoa 2000; Ben-Dov et al. 2006
	Citrus, Tangerine	1	*Bactrocera kirki* (Froggatt), *B. tryoni* (Froggatt) (Diptera: Tephritidae)	Leblanc and Putoa 2000
	Kiwi	1	*Aonidiella aurantii* (Maskell) (Homoptera: Diaspididae)	CAB 1968; Morton 1987
	Lettuce	1	*Icerya seychellarum* (Westwood) (Homoptera: Margarodidae)	Ben-Dov et al. 2006; CABI 2006
	Plum	1	*Bactrocera tryoni* (Froggatt) (Diptera: Tephritidae)	White and Elson-Harris 1992; Leblanc and Putoa 2000
	Seeds	1	NA	NA
Taiwan	Plant, w/o Roots	1	NA	NA
Thailand	Banana	3	*Bactrocera correcta* (Bezzi), *B. papayae* Drew and Hancock (Diptera: Tephritidae); *Icerya aegyptiaca* (Douglas), *I. seychellarum* (Westwood) (Homoptera: Margarodidae)	Beardsley 1955; White and Elson-Harris 1992; Allwood et al. 1999; Ben-Dov et al. 2006
	Bulb, Plant/Flower	1	NA	NA
	Citrus, Orange	1	*Aonidiella aurantii* (Maskell), *A. citrina* (Coquillett) (Homoptera: Diaspididae); *Bactrocera papayae* Drew and Hancock, *B. zonata* (Saunders) (Diptera: Tephritidae); "*Candidatus* Liberobacter asiaticum" Jagoueix *et al*. (Rhizobiales)	White and Elson-Harris 1992; CABI/EPPO 1997d; Ben-Dov et al. 2006

Country of Origin	QM	Number of QMs	Potential pests of importance[a]	References[a]
	Mangosteen	1	*Bactrocera carambolae* Drew and Hancock, *B. papayae* Drew and Hancock (Diptera: Tephritidae); *Exallomochlus hispidus* (Morrison), *Hordeolicoccus nephelii* (Takahashi) (= *Phenacoccus nephelii* Takahashi), *Pseudococcus aurantiacus* Williams (Homoptera: Pseudococcidae); *Pestalotiopsis flagisettula* (Guba) Stey. (Ascomycetes: Xylariales)	White and Elson-Harris 1992; Allwood et al. 1999; Lim and Sangchote 2003; Williams 2004; Ben-Dov et al. 2006; PIN 309[h]
	Mushroom	1	NA	NA
	Plant	1	NA	NA
Thailand	Rice Straw	1	*Phoma leveillei* Boerema and Bollen (Ascomycetes: Pleosporales)	Kinsey 2002
Tonga	Coconut, Plant	1	*Dysmicoccus cocotis* (Maskell) (Homoptera: Pseudococcidae); *Icerya seychellarum* (Westwood) (Homoptera: Margarodidae); *Tirathaba rufivena* (Walker) (Lepidoptera: Pyralidae)	Zelazny 1985; FAO 1987; Ben-Dov et al. 2006
	Guava	1	*Aonidiella aurantii* (Maskell) (Homoptera: Diaspididae); *Bactrocera facialis* (Coquillett), *B. kirki* (Froggatt), *B. passiflorae* (Froggatt), *B. xanthodes* (Broun) (Diptera: Tephritidae)	White and Elson-Harris 1992; Ben-Dov et al. 2006
United Kingdom	Apple	1	*Acetobacter pasteurianus* (Hansen) Beijerinck and Folpmers (= *Pseudomonas pomi* Cole) (Clostridiales); *Cydia pomonella* (L.)	Carter 1984; Bradbury 1986
Vietnam	Citrus, Orange	1	*Aonidiella aurantii* (Maskell) (Homoptera: Diaspididae); *Bactrocera tsuneonis* (Miyake) (Diptera: Tephritidae); "*Candidatus* Liberobacter asiaticum" Jagoueix *et al*. (Rhizobiales); *Xanthomonas axonopodis* pv. *citri* (Hasse) Vauterin et al. (Xanthomonadales)	White and Elson-Harris 1992; CABI/EPPO 1997b; d; k; Ben-Dov et al. 2006
	Leaves, Infested	1	NA	NA
	Nut, Betel	1	*Pestalotiopsis palmarum* (Cooke) Steyaert (Ascomycetes: Xylariales)	Mordue and Holliday 1971; Farr et al. 2006
	Pear	1	*Erwinia amylovora* (Burrill) Winslow *et al*. (Enterobacteriales)	CAB 1979; Cao-Van and Chau 1999
	Seeds	1	NA	NA

Notes:
[a] NA: Information not available or not applicable.
[b] There is no citrus production in Germany (Lieberz 2005).
[c] There appears to be little or no production of this commodity in Guam (e.g., Morton 1987; NASS 2007).
[d] There appears to be little or no banana production in Korea (FAO 2006a).
[e] There appears to be little or no apple production in the Philippines (FAO 2006a).

[f] Records for Hawai'i are considered misidentifications of a related species, L. langei Frick (Scheffer andand Lewis 2001).
[g] There appears to be little or no apple production in Singapore (FAO 2006b).
[h] Records from the APHIS-PPQ Port Information Network (PIN 309) database. Last access: May 2007.

Table B5-6 Plant Pests Intercepted by the Hawai'i Department of Agriculture on the Carry-on Baggage of Airline Passengers Coming from the U.S. Mainland, 1995-2006

Pest Taxon	Scientific Name of Pest	Number of Times Intercepted
Acaridae	*Tyrophagus* sp.	1
Agromyzidae	*Cerodontha dorsalis*	1
Aleyrodidae	*Bemisia tabaci*	1
	Paraleyrodes minei	1
Anthocoridae	*Orius insidiosus*	1
Anthomyiidae	*Delia radicum*	2
Anyphaenidae	*Anyphaena* sp.	1
Anystidae	Unknown sp.	2
Aphelinidae	*Aphelinus asychis*	1
	Coccophagus sp.	1
Aphididae	*Aphis fabae*	1
	Aphis sp.	1
	Brachycaudus cardui	2
	Brevicoryne brassicae	1
	Cerataphis orchidearum	1
	Chaetosiphon fragaefolii	2
	Macrosiphum euphorbiae	1
	Melanaphis sorghi	1
	Myzus sp.	1
	Rhopalosiphum maidis	1
	Rhopalosiphum padi	2
	Schizaphis graminum	1
	Sitobion luteum?	1
	Unknown sp.	1
	Utamphorophora humboldti ?	1
	Wahlgreniella nervata	1
Araneidae	Unknown sp.	2
Arctiidae	Unknown sp.	2
Bedellidae	Unknown sp.	2
Berytidae	*Acanthophysa* sp.	1
Blatellidae	*Blatella germanica*	1
	Blattella sp.	1
Blattidae	Unknown sp.	2
Braconidae	Unknown sp.	2
Bradybaenidae	*Bradybaena similaris*	1
	Bradybaena sp.	1
Carcinophoridae	*Euborellia annulipes*	1
Cerambycidae	*Neoclytus acuminatus*	1

Pest Taxon	Scientific Name of Pest	Number of Times Intercepted
	Plectromerus deutipes	1
Chloropidae	Unknown sp.	1
Chrysomelidae	*Diabrotica* sp.	1
	Diabrotica u. undecimpunctata	1
	Glyptina sp.	1
	Microtheca ochroloma	1
	Unknown sp.	1
Cicadellidae	Unknown sp.	2
Cimicidae	*Cimex lectularius*	1
Clubionidae	*Clubiona* sp.?	1
Coccidae	*Coccus hesperidium*	4
	Milriscutulus sp.	1
	Saisettia oleae	1
	Saissetia coffeae	5
	Saissetia sp.	1
	Unknown sp.	1
Coccinellidae	*Coccinella californica*	1
	Hippodamia californica	1
	Hippodamia convergens	3
	Mulsantina picta	1
	Scymnus sp.	1
	Unknown sp.	2
Coreidae	*Chelinidea vittiger*	1
	Unknown sp.	1
Cucujidae	*Ahasversus advena*	2
Curculionidae	Brachyderinae	1
	Otidocephalinae	1
	Achrastenus griseus	1
	Otiorhynchus sp.	1
	Unknown sp.	3
Dermestidae	*Anthrenus verbasci*	1
	Trogoderma glabrum	1
Diaspididae	*Abgrallaspis cyanophylli*	1
	Aondiella aurantii	24
	Aspidiotus nerii	3
	Chionaspis pinifoliae	1
	Chrysomphalus aonidum	3
	Diaspdiotus pernicious	1
	Diaspis boisduvalii	1
	Lepidosaphes beckii	7
	Selenaspis articulatus	1
	Unknown sp.	1
Diptera	Unknown sp.	1
Drosophilidae	Unknown sp.	3
Dysderiidae	Unknown sp.	1
Elateridae	Agrypninae	1

Pest Taxon	Scientific Name of Pest	Number of Times Intercepted
Encyrtidae	*Anagyrus* sp.	1
	Unknown sp.	1
Entomobryidae	Unknown sp.	1
Forficulidae	*Forficula auricularia*	1
	Unknown sp.	1
Formicidae	*Camponotus* sp.	2
	Crematogaster sp.	1
	Dolichoderus sp.	1
	Formica sp.	1
Formicidae	*Linepithema humile*	25
	Leptogenys falcigera	1
	Leptothorax muscorum	1
	Monomorium destructor	1
	Paratrechina longicornis	1
	Pheidole sp.	2
	Plagiolepis alluaudi	1
	Solenopsis geminata	1
	Solenopsis molesta	1
Gelechiidae	*Anarsia lineatella*	1
Gracillaridae	*Marmara gulosa*	15
	Marmara sp.	1
Gryllidae	Nemobiinae	1
	Acheta domestica	2
Helicidae	*Helix aspersa*	2
Hemerobiidae	Unknown sp.	1
Ichneumonidae	Unknown sp.	1
Ixodidae	*Amblyomma* sp.	1
	Dermacentor variabilis	1
Labiidae	Unknown sp.	1
Lampyridae	*Photinus* sp.	2
Largidae	*Largus* sp.	1
Latridiidae	Unknown sp.	2
Leiodidae	*Agathidium* sp.	1
Linyphiidae	Unknown sp.	4
Liposcelidae	*Liposcelis* sp.	1
Lumbicidae	*Fiscenia foetida*	1
Lygaeidae	*Cnemodus* sp.?	2
	unknown	1
Miridae	*Diplozona collaris*	1
	Lygus sp.	1
	Unknown sp.	3
Mordellidae	Unknown sp.	1
Mycetophagidae	*Typhaea stercorea*	3
Nabidae	*Nabis* sp.	1
Nitidulidae	*Carpophilus* sp.	2
	Haptoncus mundus	1

Pest Taxon	Scientific Name of Pest	Number of Times Intercepted
	Unknown sp.	5
Noctuidae	*Agrotis ipsilon*	1
	Autograph californica	1
	Euxoa auxiliaris	2
	Helicoverpa zea	15
	Unknown sp.	3
None	None	1
Oonopiidae	Unknown sp.	1
Oribatida	Unknown sp.	1
Oxychilidae	*Ocychilus alliarius*	1
	Oxychilus sp.	1
Pentatomidae	*Brochymena arborea*	1
	Brochymena cariosa	1
Phalangidae	Unknown sp.	1
Phlaeothripidae	Unknown sp.	1
Phoridae	*Megaselia* sp.	1
Pseudococcidae	*Ferrisia consobrina*	1
	Planococcus citri	5
	planococcus sp.	1
	Pseudococcus affinis	10
	Pseudococcus calceolariae	3
	Pseudococcus longispinus	18
	Pseudococcus sp.	1
	Pseudococcus viburni	13
	Unknown sp.	1
	Unknown sp.	1
Psocidae	Unknown sp.	3
Pyralidae	*Amyelois transitella*	1
	Cactoblastis cactorum	1
	Galleria mellonela	1
	Ostrinia nubilalis	5
	Plodia interpunctella	2
	Unknown sp.	1
Pyrrhocoridae	*Dysdercus* sp.	1
Reduviidae	*Haematoloecha rubescens*	1
	Unknown sp.	2
Rhopalidae	*Arhyssus* sp.	1
	Leptocoris trivittatus	1
Salticidae	*Salticus* sp.	1
Scarabaeidae	*Protaetia orientalis*	1
Sciaridae	Unknown sp.	1
Scolytidae	Unknown sp.	1
Staphylinidae	Unknown sp.	3
Succineidae	*Succinea* sp.	1
Syrphidae	*Syrphus* sp.	1
Tenebrionidae	*Alphitobius diaperinus*	1

Pest Taxon	Scientific Name of Pest	Number of Times Intercepted
	Blapstinus histricus	1
	Tenebrio molitor	1
	Zophobas sp.	1
Tenuipalpidae	*Tenuipalpus pacificus*	1
Tetranychidae	*Tetranychus* sp.	1
Theridiidae	Unknown sp.	1
Thomisidae	*Coriarachne versicolor*	1
Thripidae	*Chirothrips* sp. (poss. *manicatus*)	1
	Frankliniella occidentalis	3
	Heliothrips haemorrhoidalis	2
	Thrips sp.	1
Thripidae	*Thrips tabaci*	1
Tineidae	Unknown sp.	1
Tipulidae	Unknown sp.	2
Tortricidae	*Cydia deshaisiana*	10
	Cydia pomonella	3
	Spilonota ocellana	1
	Unknown sp.	5
Vespidae	*Vespula squamosa*	1
Zonitidae	*Retinella* sp.	1

1

A17 CARGO

This chapter summarizes statistics on foreign and domestic imports of fresh agricultural commodities into Hawai'i and discusses them in the context of the associated pest risk. It should be noted that data used to develop this section does not necessarily reflect the current situation. The most recent data sources used for this section are from a 2007 compilation.

As Hawai'i is an island state, both international and domestic cargo arrives either by ship or—to a much lesser degree—by aircraft. Approximately 80% of all goods (agricultural and non-agricultural) in Hawai'i have to be imported, and 98% of these arrive in ocean vessels (Figures B6-1 and B6-2) (HDBEDT 2005a; Hawai'iWeb 2007). According to official statistics, Hawai'i received 4.5 million tonnes of sea cargo from domestic trade and 8 million tonnes from foreign trade in 2005 (U.S. Army Corps of Engineers 2005b). However, these numbers do not tell the whole story, as the overwhelming majority of all foreign cargo is not shipped from the exporting country directly to Hawai'i, but makes entry on the U.S. mainland first and is then shipped from there to Hawai'i as domestic cargo (Kosciuk 2007). Information on the true origin of much of this cargo gets lost. Furthermore, on arrival in Hawai'i, it becomes subject to a different set of phytosanitary inspections than directly-shipped foreign cargo. This is because all foreign imports are cleared by the DHS CBP at Honolulu Harbor or HNL on the island of Oahu (Kosciuk 2007), whereas domestic shipments (including shipments of foreign origin arriving from the U.S. mainland) are cleared by the HDOA. HDOA clears cargo at the following locations: Honolulu Harbor and HNL; Hilo Harbor, Kawaihae Harbor, Hilo International Airport, and Kona International Airport at Keahole on the island of Hawai'i; Kahului Harbor and Kahului Airport on the island of Maui; and Nawiliwili Harbor and Lihue Airport on the island of Kauai (HDOA 2007b).

Figure B6-1: Honolulu Harbor

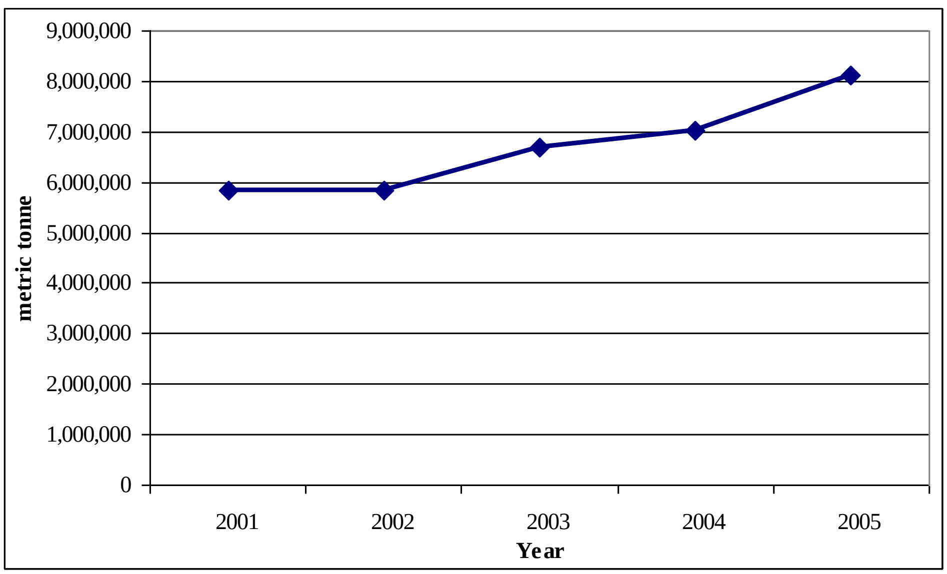
Source: Hawai'i Department of Transportation, http://www.hawaii.gov/dot/publicaffairs/index.htm

The volume of foreign imports to Hawai'i has been increasing over recent years (Figure B6-2) (HDBEDT 2005a). The majority of all containerized cargo enters Hawai'i through Honolulu Harbor (Table B6-1)

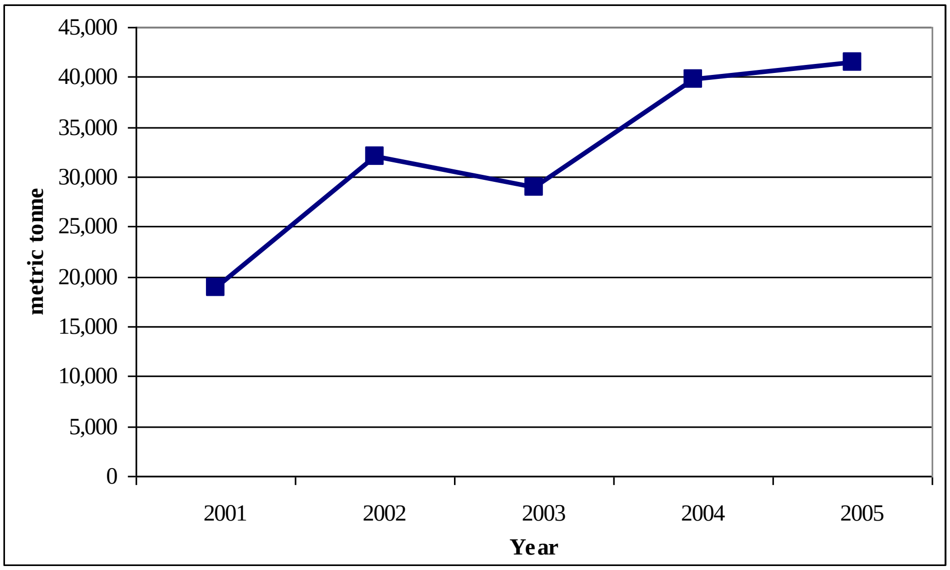
(HDOT 2006), which, in 2005, received 4,395 inbound vessels ranging in draft[23] and type (e.g., dry cargo, tanker, tow or tug). Of these, only 444 were of foreign origin, whereas 3,951 arrived from the U.S. mainland (Table A17-1) (U.S. Army Corps of Engineers 2005a); not all of them were carrying commercial cargo. One source reported that in 2005 the harbor received 1,121 overseas vessels carrying commercial cargo (HDBEDT 2005a).

Most of the commercial cargo arriving by aircraft makes entry at HNL (Table A17-2), which receives the bulk of both foreign and domestic air cargo, as well as foreign and domestic air mail (HDBEDT 2005a; Kosciuk 2007). In 2005, over 9,000 international flights carried freight into the state, 94% of which was received at HNL (Bureau of Transportation Statistics 2006); no statistics were available on the number of domestic flights. Of domestic freight arriving in 2005, 94% entered through HNL (Table B6-2) (Bureau of Transportation Statistics 2007).

Figure A17-1: Foreign Cargo (in Tonnes) Arriving in Hawai'i between 2000 and 2005 via Maritime Vessels (top) and Aircraft (bottom)



[23] Draft is defined as the depth of water necessary to float a vessel, and is usually measured in feet (U.S. Army Corps of Engineers, Navigation Data Center, U.S. Waterway Data, Data Dictionary, available at http://www.iwr.usace.army.mil/NDC/data/dictionary.htm. Last accessed 22 June 2007.)



Source: HDBEDT 2005a

Table A17-1: Foreign and Domestic Commercial Traffic Arriving at Hawai'ian Maritime Ports in 2005

Harbor	Number of Vessels Inbound[a]		Total Vessels Inbound	Cargo (tonnes)[b]		Total Cargo (tonnes)
	Foreign	Domestic		Foreign	Domestic	
Honolulu	444	3,951	4,395	5,625,453	12,440,224	18,065,677
Hilo	92	887	979	23,587	1,787,154	1,810,741
Kawaihae	5	872	877	0	2,010,321	2,010,321
Kahului	30	1,390	1,420	69,853	3,678,634	3,748,487
Barbers Point	73	1,264	1,337	1,956,798	3,601,523	5,558,321
Nawiliwili	79	659	738	1,814	1,791,690	1,793,504
Grand total	**723**	**9,023**	**9,746**	**7,677,505**	**25,309,546**	**32,987,051**

Source: U.S. Army Corps of Engineers 2005a

[a] Inbound self-propelled and non-self-propelled vessels, which include dry cargo, tanker, and tow or tug vessels ranging in draft.

[b] Cargo includes agricultural and non-agricultural freight. Numbers were rounded.

Table A17-2: Number of Aircraft and Passengers, and Amount of Cargo and Mail Arriving at Hawai'ian Airports in 2005

Airport	Number of Aircraft		Number of Passengers		Cargo (tonnes)[f]		Mail (tonnes)[f]	
	Foreign Origin[a, c]	Domestic Origin	Foreign Origin[b, c]	Domestic Origin[d, e]	Foreign Origin[c]	Domestic Origin[d, e]	Foreign Origin[c]	Domestic Origin[d, e]
Honolulu	8,899	NA	2,067,067	781,897	63,736	42,919	354	4,696
Kahului	399	NA	52,741	315,530	4	2,191	0	0.24
Kona	389	NA	84,585	96,353	935	355	0	0.05
Grand Total	**9,687**	**NA**	**2,204,393**	**1,193,780**	**64,675**	**45,465**	**354**	**4,696.29**

NA Information not available.
[a] Flights into Hickam Air Force Base and Marine Corps Base Hawai'i were excluded. The total number of aircraft that carried freight was 9,116, of which 8,912 carried both freight and passengers and 204 carried freight only. The number of domestic flights was not available.
[b] Passengers in transit (100,172 passing through Honolulu International Airport) were excluded.
[c] Data source: Bureau of Transportation Statistics (2006).
[d] Data source: Bureau of Transportation Statistics (2007).
[e] Inter-island aircraft were excluded.
[f] Cargo includes agricultural and non-agricultural freight. Numbers were rounded.

When evaluating the risk of pest introduction through the import of agricultural commodities, it is useful to know the country of origin and the quantity of arriving commodities, as well as the types of pests associated with them and the likelihood that these pests are present on them. For this analysis, it was impossible to obtain much of this information due to a lack of suitable or reliable data.

Agricultural commodity imports from foreign origins are recorded by CBP in the USDA-APHIS-PPQ Fruit and Vegetables database (AQAS 2007). This database contains information on the type of commodity imported, number of shipments, quantity (with unit of measure), and country of origin. This database records only imports from foreign countries that have first made entry at a U.S. port; these imports, now classified as domestic (as mentioned above), fall outside the scope of the database. Beyond its scope are also all non-agricultural shipments (which nevertheless may present a considerable risk by harboring hitchhiking pests or pests in WPM; see Chapters B7 and B8). Regarding the quantity of commodity imports, the unit of measure differs depending on the commodity type. For example, for cut flowers the unit is usually number of stems, and more rarely kilograms; the unit is also kilograms for fruits and vegetables, whereas for propagative material, it may be number of plant units, or number of flasks. As these units are not interconvertable, any quantitative comparison among commodity types becomes impossible. The situation is even more difficult regarding number, size, and commodity type in domestic shipments, for which barely any information exists.

Although a greater number of shipments of agricultural commodities arrives in Hawai'i by aircraft as compared to maritime transport, these shipments are typically smaller in volume and weight as compared to agricultural shipments arriving by sea (discussed in more detail below) (AQAS 2007). Comparisons among the numbers of shipments from foreign origin entering Hawai'i does not take into account the size or weight of the shipment. For example, cut flower shipments accounted for about half of the agricultural shipments entering Hawai'i from foreign origin, yet these shipments are in general smaller (shipments varied from fewer than 100 stems to over 1,000 stems) than fruit and vegetable and propagative plant shipments.

For pest interceptions on foreign shipments, a database, Pest ID, is maintained by APHIS-PPQ (USDA 2007a). From this database, it is possible to determine the kinds of pests that have been intercepted. However, the information cannot be used for quantitative analysis because only pest interceptions are recorded, leaving the number of inspected units and the inspection procedures unknown. Once a quarantine pest is found in a commodity, the inspection is usually terminated, so that the severity of the infestation, as well as additional pest species that may be present, remain unknown. Of special relevance to this analysis is the fact that foreign shipments undergo phytosanitary inspection at the U.S. port of first entry; this means that pest interceptions on foreign shipments that make entry at a U.S. mainland port before being shipped to Hawai'i are recorded in the database under the name of that port, making it impossible to identify them as ultimately being destined for Hawai'i.

Pest interceptions made by HDOA are recorded in one of two databases maintained by the HDOA Plant Quarantine Branch (HDOA 2007c). These interceptions pertain to domestic shipments almost exclusively; however, on occasion, HDOA inspects shipments of foreign origin, and, if interceptions are made, they are recorded in the same databases. One database contains records for pathogens, the other stores records for arthropods (Oishi 2007).

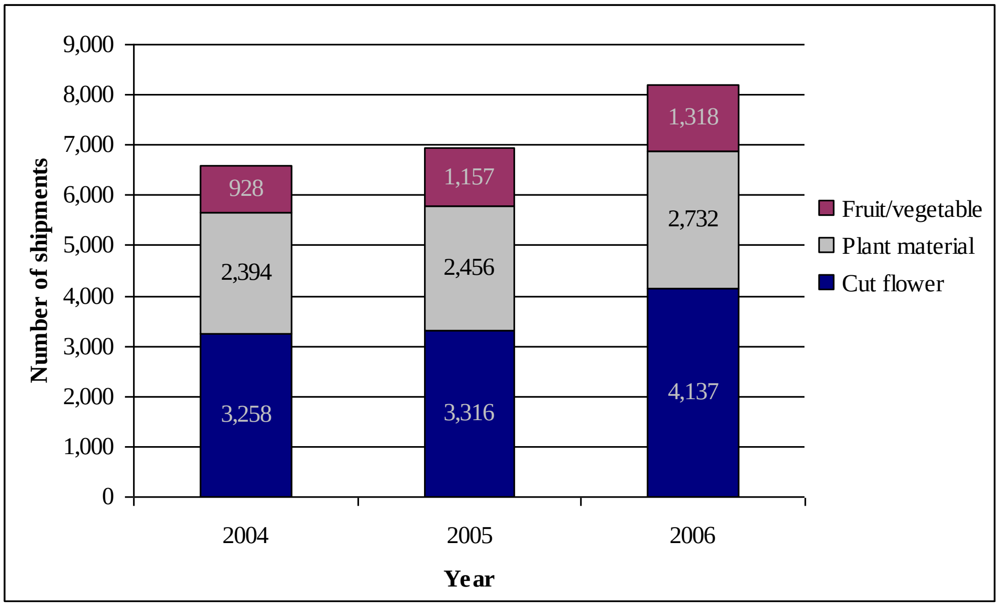
A17.1 FOREIGN IMPORTS

This section provides an overview of shipments of fresh agricultural commodities imported into Hawai'i from foreign origins between January 1, 2004 and December 31, 2006. It should be noted that the data presented here are an incomplete reflection of the actual import situation, because foreign imports are commonly cleared at a port-of-entry on the U.S. mainland before proceeding to Hawai'i (Kosciuk 2007). The commodities involved may undergo repackaging, and are often combined with commodities produced in the United States (Kosciuk 2007), making it difficult to determine their true origin.

Such practices allow trade to circumvent the commodity risk assessment process (e.g., USDA 2000), the purpose of which is to identify and mitigate pest risks associated with foreign imports. Perhaps for reasons of expedience, Hawai'i is often neglected when risks to the United States associated with importation of foreign commodities are assessed. Any rules or regulations resulting from these assessments are likely not to pertain to Hawai'i, and the commodities are not permitted to be imported directly into the state. However, under current practices, a commodity that was deemed a low pest risk for the U.S. mainland, although representing a high risk for Hawai'i, would be enterable into the mainland without undergoing any phytosanitary treatments, and subsequently could be sent on to Hawai'i as part of a domestic shipment.

Between 2004 and 2006, almost 22,000 shipments of fresh agricultural commodities for consumption (an average of approximately 7,000 shipments/year) arrived from 56 different countries at Hawai'ian ports-of-entry (AQAS 2007). During this period, the number of shipments imported increased for each major commodity category (Figure B6-3). Nearly 330 of these consignments were destroyed or re-exported due to the presence of an actionable pest, a contaminant, or a discrepancy with the phytosanitary certificate.

Figure B6-3: Shipments of Fresh Agricultural Commodities Imported into Hawai'i between 2004 and 2006, by Commodity Type



Source: AQAS 2007

Thailand, Japan, Indonesia, Canada, and Taiwan accounted for 90% of all incoming foreign agricultural shipments (Figure A17-4). In addition to these nations, each of the following countries exported 100 or more agricultural shipments to Hawai'i: Australia, China, the Cook Islands, Fiji, Malaysia, New Zealand, the Philippines, Singapore, and South Korea. This comparison does not take into account the quantities of the commodities received, as an inconsistency of units made a comparison across commodity types impossible (Figure B6-5) (AQAS 2007). Thailand accounted for 54% of the total number of foreign agricultural shipments; Japan, Indonesia, Canada, and Taiwan accounted for approximately 13%, 11%, 9%, and 3% of the agricultural shipments, respectively. The other 49 countries or territories exporting to Hawai'i each accounted for less than 1% of the number of agricultural shipments (AQAS 2007).

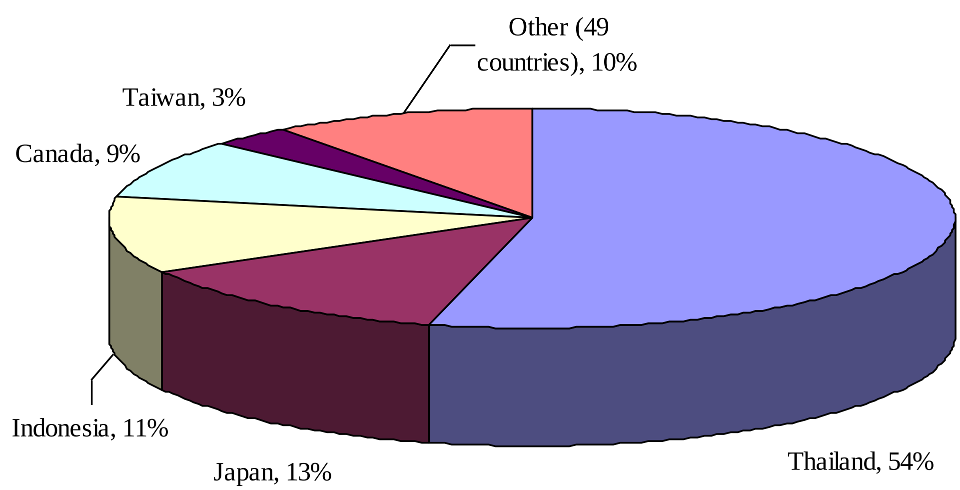
Of the total number of agricultural shipments of foreign origin imported into Hawai'i, about half were cut flowers originating from twelve countries (Figure A17-6). The majority of them (94%) came from Thailand, with Japan and the Cook Islands each accounting for about 2%. The nine other countries, from which cut flowers were imported, each accounted for less than 1% of the shipments. All cut flower shipments arrived by aircraft (AQAS, 2007).

Shipments of propagative material, originating in 47 different countries, accounted for 35% of the total number of agricultural shipments imported from foreign origins (Figure A17-6). The majority of these shipments came from Indonesia (about 30%), Canada (about 26%), and Thailand (about 23%), whereas

Taiwan and Singapore accounted for 6% and 3%, respectively. The other 42 countries and territories each accounted for less than 2% of the total number of shipments. The majority of the propagative material shipments (about 90%) entered Hawai'i by aircraft (AQAS 2007).

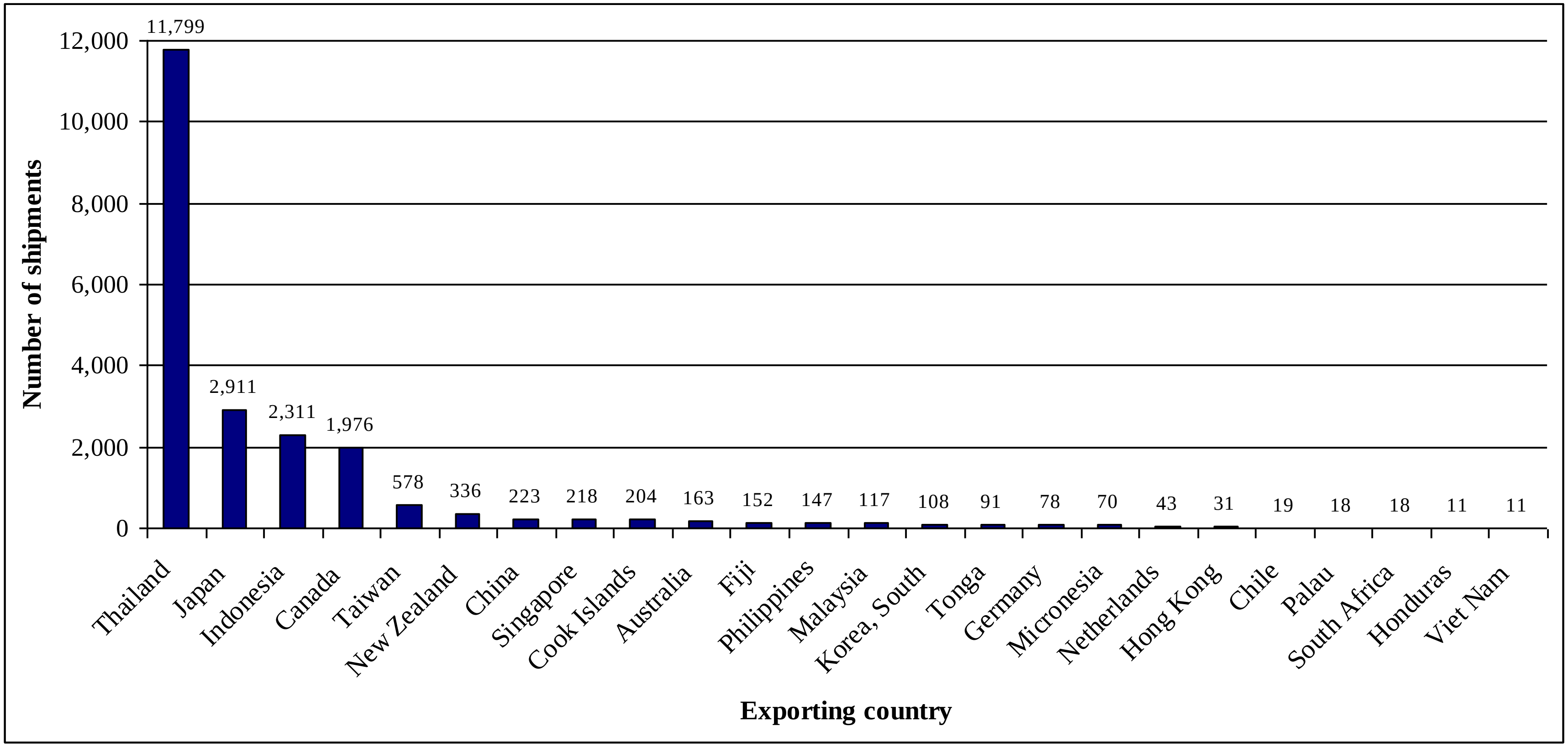
Shipments of fruits and vegetables, originating in 15 different countries, accounted for about 16% of the agricultural shipments imported from foreign areas (Figure A17-5). The majority of these shipments (about 75%) came from Japan. China, Fiji, New Zealand, South Korea, and Taiwan each contributed between 3% and 7% of the imports. The other nine countries, from which fruit and vegetables were imported, each accounted for less than 1% of the shipments. Most of these shipments (about 84%) arrived via aircraft (AQAS 2007).

Figure A17-4. Thailand, Japan, Indonesia, Canada, and Taiwan Accounted for 90% of the Fresh Agricultural Shipments Entering Hawai'i between 2004 and 2006



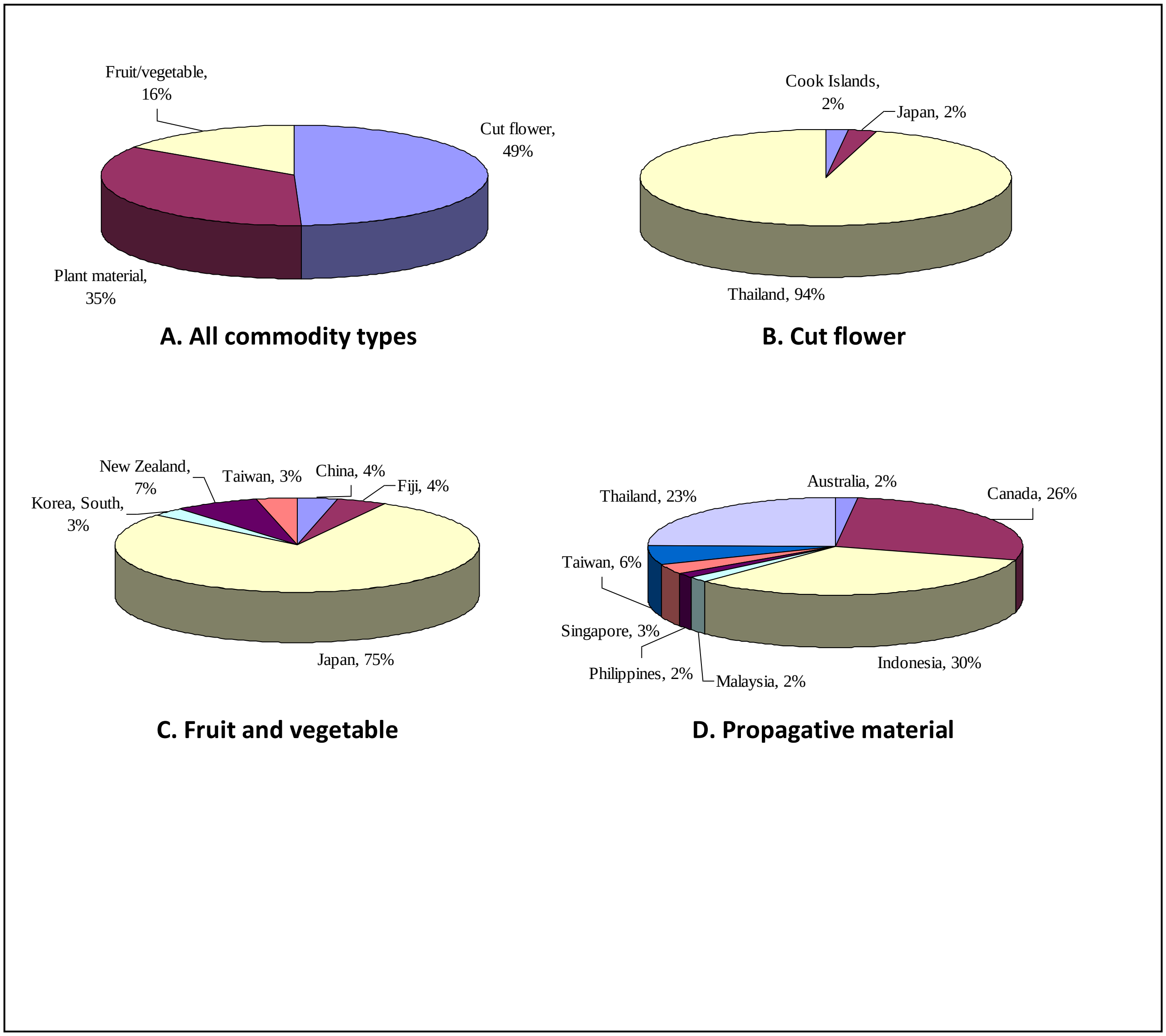
Source: AQAS 2007

Figure A17-5: Number of Shipments (Air and Maritime) of Fresh Agricultural Commodities Exported to Hawai'i between January 2004 and December 2006



Source: AQAS 2007
Note: Only countries that shipped a total of ten or more shipments during this period are included.

Figure A17-6: Number of Shipments of Fresh Agricultural Commodities of Foreign Origin



Imported into Hawai'i, January 1, 2004 to December 31, 2006

Source: AQAS 2007
A=Percentage of shipments by commodity type.
B=Percentage of cut flower shipments by country of origin.
C=Percentage of fruit and vegetable shipments by country of origin.
D=Percentage of propagative material shipments by country of origin.

A17.1.1 Imports from Thailand

Fifty-four percent (54%) of the agricultural shipments arriving in Hawai'i between 2004 and 2006 originated in Thailand (Figure A17-4). All of these shipments arrived by aircraft (AQAS 2007). Cut flowers, mostly orchids (*Dendrobium* spp.), accounted for 85% of the shipments from Thailand. Most of the remaining 15% of the shipments contained over 100 different genera of plant propagative material. Fruit and vegetable shipments (mostly fresh mushrooms) accounted for less than 1% of the shipments (See Tables A25-1 and A25-2, at the end of this document).

During the same period, 229 reportable[24] pests were intercepted by CBP on agricultural commodities from Thailand (Tables A25-1 and A25-2) (USDA 2007a). Of these interceptions, 215 (94%) were on cut flowers, mostly orchids (*Dendrobium* spp.). The mollusc, *Succinea tenella* Morelet (Stylommatophora: Succineidae), was the most commonly intercepted reportable pest from Thailand, entering on cut flower shipments of *Dendrobium* spp. and other species in the orchid family (Orchidaceae). (This snail was also the pest most frequently intercepted on agricultural cargo of foreign origin, in general, entering Hawai'i.) Other reportable or actionable[25] pests intercepted included: *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae) on cut flowers of *Dendrobium* spp., other species of Orchidaceae, and the lotus, *Nelumbo nucifera* Gaertn.; *Thrips palmi* Karny (Thysanoptera: Thripidae) (which is established in Hawai'i) (Nishida 2002) on cut flowers of *Dendrobium* spp.; and *Sinoxylon conigerum* Gerstaeker (Coleoptera: Bostrichidae) (also established, but actionable, in Hawai'i) on various non-agriculture items.

A17.1.2 Imports from Japan

Thirteen percent (13%) of the agricultural shipments arriving in Hawai'i between 2004 and 2006 originated in Japan (Figure A17-4). The majority of the shipments (95%) arrived by aircraft (AQAS 2007). Twenty-six different fruit and vegetable commodities accounted for 88% of the total shipments exported from Japan. Cut flowers of 6 plant genera and other plant material of 40 genera accounted for approximately 9% and 3%, respectively, of the agricultural shipments from Japan (Tables A25-1 and A25-2).

All of the 14 reportable insect pests intercepted on agricultural cargo from Japan between 2004 and 2006 occurred in air shipments (USDA 2007a). Most of the pests were identified only to the family level. Pests in the orders Lepidoptera and Thysanoptera, the families Aphididae, Plutellidae, Pyralidae (Pyraustinae), Syrphidae, and Tortricidae, and the genera *Delia* and *Listroderes* were intercepted on shipments of *Raphanus* (radish). A species belonging to the Crambidae (Pyralidae auct.) was intercepted on a single shipment of cucumber, *Cucumis sativus*. Consignments of *Solanum* spp. harbored pests in the Aphididae and Thripidae (Tables A25-1 and A25-2).

A17.1.3 Imports from Indonesia

Eleven percent (11%) of the agricultural shipments arriving in Hawai'i between 2004 and 2006 originated in Indonesia (Figure A17-4). Almost all of these shipments contained plant material, with over 100 genera being represented. Two shipments of lumber products (less than 1% of the total shipments from Indonesia) were exported to Hawai'i (Tables A25-1 and A25-2) (AQAS 2007).

All but 1 of the 83 reportable pests intercepted on agricultural shipments from Indonesia were found in air cargo; only *Cryptotermes* sp. (Isoptera: Kalotermitidae) was found in maritime cargo, in a shipment of

[24] A reportable pest is one for which USDA–APHIS–PPQ may or may not require a treatment.
[25] An actionable pest is one for which PPQ always requires treatment.

Tectona grandis L. f. (teak). Species of Colletotrichum, Phoma, and Cercospora were commonly intercepted fungal pathogens. A majority of the insect pests were not identified to the genus level; they included pests in the Aleyrodidae, Aphididae, Pseudococcidae, other Homoptera, and Tortricidae. *Succinea* sp. and other unidentified molluscs were also intercepted on agricultural shipments from Indonesia (Tables A25-1 and A25-2) (USDA 2007a).

A17.1.4 Imports from Canada

Nine percent (9%) of the agricultural shipments arriving in Hawai'i between 2004 and 2006 originated in Canada (Figure A17-4). These shipments contained mainly plant material (about 100 genera, accounting for 98% of Canada's agricultural shipments), with the remaining 2% being fruit and vegetables (Tables A25-1 and A25-2) (AQAS 2007).

No reportable or actionable pests were intercepted on cargo coming from Canada between 2004 and 2006 (USDA 2007a).

A17.1.5 Imports from Taiwan

Three percent (3%) of the agricultural shipments arriving in Hawai'i between 2004 and 2006 originated in Taiwan (Figure A17-4). Plant material from approximately 50 genera accounted for about 80% of the exports from Taiwan. The other 20% were fruit and vegetable products, such as bamboo, burdock, and mushrooms (Tables A25-1 and A25-2) (AQAS 2007).

No reportable pests were intercepted on commercial cargo from Taiwan between 2004 and 2006 (USDA 2007a).

A17.1.6 Pest Approach Rates in Foreign Shipments of Perishable Cargo Arriving by Aircraft

AQIM data collected by CBP and containing records for the period October 2005 to April 2007, were used to estimate the pest approach rate on perishable air. The data were collected at HNL following port-specific standard operating procedures (Area Port of Honolulu 2005; 2006), as well as general instructions in the USDA AQIM handbook (USDA 2006a). Two shipments were inspected per week. During FY 2005, cut flowers were not included in the samples, whereas during FY 2006, cut flowers represented half of the samples. The samples were selected based on a random sampling scheme. Table B6-3 lists the relative frequencies of the countries of origin of the sampled shipments. Japan was the origin of 65% of the shipments. Several other countries contributed small percentages of the shipments. Most shipments were mixed, with several different commodities being listed on the manifests.

Of the 165 inspections that were recorded in the AQIM data set, 6 resulted in interceptions of pests (Table B6-4). This yields an estimate of between 1.4% and 7.8% of air cargo shipments arriving at the port of Honolulu accompanied by live pests. With one exception, *Thrips tabaci* Lindeman, which is known to occur in Hawai'i (Nishida 2002), the intercepted pests were not identified to species.

Table A17-3: Countries of Origin of Randomly Selected Samples of Air Cargo Entering Hawai'i, October 2005 to April 2007

Country of Origin	Number of Samples	Percent of Total Samples
Australia	2	1.2
Canada	4	2.4
China	2	1.2
Fiji	3	3.6
Japan	108	65
Korea, South	1	0.6
New Zealand	14	8.4
Philippines	5	6.0
Taiwan	12	7.2
Thailand	13	7.8
USA	1	0.6
Grand Total	**165**	**100**

Source: AQIM

Table A17-4: Pests Intercepted on Air Cargo during AQIM at HNL between October 2005 and April 2007

Date	Origin	Infested Commodity	Pest
25-Oct-05	Japan	Eggplant	Thysanoptera, species of
28-Feb-06	Taiwan	Oriental Radish	Thysanoptera, species of
4-Oct-06	New Zealand	Asparagus	*Thrips tabaci*; *Apterothrips* sp.
23-Oct-06	New Zealand	Asparagus	Acari, species of
7-Nov-06	Japan	Eggplant	Thysanoptera, species of
19-Dec-06	Japan	Strawberry	Lygaeidae, species of; Aphididae, species of

Note: Total sample size: 165.

A17.2 DOMESTIC IMPORTS

A large portion of the shipments of fresh agricultural products entering Hawai'i comes from the U.S. mainland (Table A25-3, at the end of this document). As mentioned previously, foreign shipments may be cleared on the U.S. mainland and then shipped domestically (Kosciuk 2007). These shipments may be repackaged and even mixed with commodities of U.S. origin (Kosciuk 2007). Such practices may compromise Hawai'i's phytosanitary security and increase risks of pest introduction. HDOA has authority to inspect agricultural commodities only, which means that its PQ inspectors are not allowed to hold mixed shipments manifested as "freight of all kinds" for inspection. In the absence of an explicit mention of agricultural commodities on the manifest, PQ inspectors can inspect a shipment only if it is referred to them by other agencies (Oishi 2007). Moreover, PQ does not have authority to hold shipments containing wood packaging material for inspection unless the manifest indicates the presence of agricultural commodities (Oishi 2007). Shipments transported by commercial carriers, such as FedEx and UPS, are often cleared at facilities on the mainland prior to entering Hawai'i (Oishi 2007). Frequently, the U.S. state, from which a commodity originated, is unknown, especially since commodities may be combined at distribution centers. Thus, it is difficult to ascertain the true origin of agricultural shipments.

As noted above, PQ maintains two databases, that record arthropods and pathogens, intercepted on commodities arriving from the U.S. mainland (HDOA 2007c). PQ inspectors typically do not inspect agricultural commodities of foreign origin. However, on rare occasions when such inspections are performed on foreign shipments, any pest interceptions made are recorded in the databases (Oishi 2007). From these databases, data were extracted only for pests intercepted on or in the following sources: domestic and foreign air cargo, domestic and foreign ship cargo, amnesty programs (commodities surrendered voluntarily upon arrival), baggage from domestic and foreign flights, private ship's stores, air express, military air carriers, FedEx and UPS packages, and U.S. mail or post office facilities. Although the pest status (present or absent) in Hawai'i was provided with each interception record, the status was briefly re-evaluated by consulting databases maintained by the B.P. Bishop Museum in Honolulu (http://hbs.bishopmuseum.org/hbsdb.html), other online databases, and the scientific literature, and adjustments were made as needed. The summary of pest interceptions discussed below does not include all of the pests PQ intercepted between 2004 and 2006; rather, only those interception records that pertained to the source categories specified above were used.

PQ Specialists intercepted 1,583 specimens of plant pests (arthropods and pathogens), representing at least 140 species not known to occur in Hawai'i, on shipments arriving from the U.S. mainland between 2004 and 2006 (Table B6-5, Table A25-3) (HDOA 2007c). Many of the pests intercepted (about 290 records) were not identified to genus or species, and it is likely that at least some of them are not present in Hawai'i. Pests were intercepted on agricultural commodities shipped domestically, which actually originated in a foreign country (Table B6-6, Table A25-3). Although their authority to inspect mail facilities is limited (Oishi 2007), between 2004 and 2006, PQ Specialists intercepted 35 pests (identified to species) not yet established in Hawai'i on the mail pathway, which includes the categories FedEx, Air Express, and USPS (Table A17-7, Table A25-3).

In order to calculate approach rates of pests associated with commodities or conveyances (e.g., ships, aircraft, containers) from the U.S. mainland, data concerning the total number of conveyances or commodities inspected and the total number contaminated with a pest are needed. These data were not available for the domestic pathways.

Table A17-5: Number of Pests Not Known to Occur in Hawai'i Intercepted on Various Pathways by HDOA PQ Specialists between January 1, 2004 and December 31, 2006

Pathway	Number of Pests[a] Intercepted
Air cargo[b]	1,249
Amnesty bin[c]	2
Baggage[d]	25
Container yard[e]	3
FedEx, Air Express[f]	34
Military air cargo	1
Private ship's stores, domestic	1
Ship's cargo[g]	267
USPS	1
Total	**1,583**

Source: HDOA 2007c

[a] Only records, in which the pest was identified to species, are included in this table. It is possible that some of the pests not identified to species are not present in Hawai'i; however, since this cannot be verified, those records were omitted.

[b] Air cargo = cargo arriving by aircraft from the U.S. mainland.

[c] Amnesty bin = pests found on commodities surrendered voluntarily by aircraft passengers on domestic flights.

[d] Baggage = pests found on an agricultural commodity carried in air passenger baggage.

[e] Container yard = pests intercepted on agricultural commodities awaiting distribution.

[f] FedEx, Air Express = pests intercepted from packages containing agricultural commodities transported by this commercial carrier.

[g] Ship's cargo = pests intercepted on agricultural commodities transported by ship from the U.S. mainland. This category combines records under the database fields 'ship cargo' and 'routine overtime,' since routine overtime records are interceptions made on ship's cargo.

Table A17-6: Pests Not Known to Occur in Hawai'i that were Detected Entering the State through Domestic Pathways with Commodities of Foreign Origin between January 1, 2004 and December 31, 2006

Origin	Origin Specified on the Package	Where Intercepted	Pest[a]	Number of Records
Australia	Not specified	Protea (cut flower)	*Aspidiotus nerii*	2
Colombia	California, Florida, not specified	Carnation	*Cladosporium echinulatum*	4
	California, Florida, Georgia, not specified	*Solidago* sp.	*Coleosporium asterum*	8
	California	Aster	*Coleosporium asterum*	2
Colombia (suspected)	California	*Solidago* sp.	*Coleosporium asterum*	1
Ecuador	Not specified	Banana	*Dysmicoccus texensis*	2
	Florida	*Solidago* sp.	*Coleosporium asterum*	1
	Georgia	Carnation	*Cladosporium echinulatum*	2
	California, Florida, Ecuador	*Hypericum* sp.	*Uromyces triquetrus*	7
Guam	Not specified	Not specified	*Protaetia pryeri*	1
Italy	Not specified	Citrus	*Aonidiella aurantii*	2
Japan	Guam (Anderson Air Force Base)	Cargo deck	*Popillia japonica*	1
Mexico	Not specified	Papaya	*Papaya ring spot virus*	1
	California, not specified	Pepper	*Bactericera cockerelli*	2
	California	Citrus	*Aonidiella aurantii*	2
			Marmara gulosa	1
South America	California	*Solidago* sp.	*Coleosporium asterum*	2
South or Central America	Not specified	Banana	*Dysmicoccus texensis*	1
Total				**32**

Source: HDOA 2007c

[a] Only records, in which the pest was identified to species, are included in this table. It is possible that some of the pests not identified to species are not present in Hawai'i; however, since this cannot be verified, those records were omitted.

Table A17-7: Pests Not Known to Occur in Hawai'i that were Detected Entering the State via the Mail Pathway (FedEx, Air Express, USPS) between January 1, 2004 and December 31, 2006

Pathway	Origin	Package Labeled From	Where Intercepted	Pest Intercepted[a]	Number of Records
Air Express	Not specified	Not specified	Hypericum	*Uromyces triquetrus*	2
			Impatiens	*Myrothecium roridum*	1
		California	Bouquet, mixed	*Puccinia helianthi*	1
			Sunflower	*Puccinia helianthi*	1
		Florida	*Solidago* sp.	*Coleosporium asterum*	1
	California	California	*Solidago* sp.	*Coleosporium asterum*	1
			Sunflower	*Puccinia helianthi*	7

Pathway	Origin	Package Labeled From	Where Intercepted	Pest Intercepted[a]	Number of Records
			Hypericum	*Uromyces triquetrus*	1
		Nevada	Sunflower	*Puccinia helianthi*	1
	Ecuador	Florida	Hypericum	*Uromyces triquetrus*	1
	Florida	Not specified	Aster	*Coleosporium asterum*	1
			Hypericum	*Uromyces triquetrus*	1
		Florida	Anthurium	*Myrothecium roridum*	1
			Gladiolus	*Uromyces transversalis*	1
			Hypericum	*Uromyces triquetrus*	1
			Salal	*Phyllosticta gaultheriae*	2
			Solidago sp.	*Coleosporium asterum*	1
	Illinois	Illinois	Impatiens	*Myrothecium roridum*	2
FedEx	California	California	Basil	*Diabrotica undecimpunctata*	1
	Florida	Not specified	Greens	*Cameraria gaultheriella*	1
			Salal	*Cameraria gaultheriella*	3
U.S. Mail	Texas	Not specified	Box	*Centruroides vittatus* (scorpion)	1
Total					**35**

Source: HDOA 2007c

[a] Only records, in which the pest was identified to species, are included in this table. It is possible that some of the pests not identified to species are not present in Hawai'i; however, since this cannot be verified, those records were omitted.

A17.3 SUMMARY

- Hawai'i imports approximately 80% of its goods (both agricultural and non-agricultural).
- Between 2004 and 2006, over 21,000 shipments of fresh agricultural commodities for consumption from 56 countries arrived at ports-of-entry in Hawai'i.
- Cut flowers accounted for half of the agricultural shipments arriving from foreign areas of origin.
- Most foreign and domestic shipments of fresh agricultural commodities arrive by aircraft.
- Consignments of agricultural commodities of foreign origin may be cleared at a port-of-entry on the U.S. mainland then shipped to Hawai'i manifested as domestic cargo.
- Hawai'i imports many of its fresh agricultural commodities from the U.S. mainland.
- Quarantine pests are routinely intercepted on foreign imports.
- HDOA PQ has intercepted pests not known to occur in Hawai'i on domestic shipments of fresh agricultural commodities. Some of these imports were actually of foreign origin.
- PQ does not have authority to inspect domestic shipments manifested as "freight of all kinds" or WPM accompanying non-agricultural shipments.

A18 "HITCHHIKERS"

In the context of this analysis, a hitchhiker pest is defined as a pest present on a conveyance or shipping container, but not directly associated with a commodity. Hitchhiker pests may have originally entered the conveyance or container on a commodity and remained behind after unloading, or may have entered the cargo hold on their own, e.g., an insect flying in during loading (Caton 2003; Caton et al. 2006). Loading at night has been found to lead to higher pest incidence in aircraft cargo holds than loading during daytime, primarily because pests are attracted to lights at night (Caton 2003).

The scientific literature mentions numerous cases of hitchhiker pests that have arrived in new areas in cargo holds, aircraft cabins, or shipping containers (e.g., Dale and Maddison 1984; Smith and Carter 1984; Takahashi 1984; Gadgil et al. 2000; Gadgil et al. 2002). For example, four species of Noctuidae and several species of Coleoptera and Homoptera are thought to have arrived in Guam in the 1980s as hitchhikers in the holds or cabins of aircraft (Schreiner 1991); the oriental fruit fly is believed to have been brought to Hawai'i in military aircraft from the Mariana Islands during World War II (Swain 1952); and the psyllid, *Heteropsylla cubana* Crawford, was introduced into Hawai'i in the holds of cargo planes (Schreiner 1991).

The objective of this chapter is to evaluate the likelihood that exotic hitchhiker pests arrive in Hawai'i on air or maritime cargo conveyances or containers. A lack of suitable data made quantitative analysis difficult; therefore, risk is discussed mainly in qualitative terms.

Pest survival in conveyances and containers depends on the combined effects of various conditions, such as temperature, relative humidity, and duration of transport. In modern commercial aircraft, cargo holds are pressurized and heated, generally maintaining a temperature of about 15°C (60°F) (Anonymous airline pilots ("Answerer 8" and "Answerer 11") 2007). Even when not actively heated, hold temperatures after about 8 hours flying at altitude are approximately 7°C in some types of aircraft (Anonymous airline pilots ("Answerer 8" and "Answerer 11") 2007). Similar information for commercial maritime vessels was not available, but in cargo holds that contain fresh fruits or vegetables, or live plants, the temperature would obviously have to be above freezing.

Most insect pests would be able to survive these conditions for several hours, as is corroborated by the fact that APHIS-PPQ and CBP have intercepted over 1,000 live reportable pests in aircraft cargo holds or cabins[26] at U.S. airports since 1990 (Table A25-4, at the end of the document) (USDA 2007a), and hitchhiker pests intercepted in aircraft cargo holds and stores make up 3% of quarantine-significant pests intercepted on aircraft (including interceptions in cargo and passenger baggage) nationwide (Caton et al. 2006; USDA 2007a). A study by Russell (1987) reported very high survival rates of mosquitoes (*Culex quinquefasciatus* Say), house flies (*Musca domestica* L.), and flour beetles (Tribolium confusum Jacquelin Du Val) in unpressurized wheel bays of modern Boeing 747B aircraft at altitudes greater than 10,500 meters. The study found that the temperature in the wheel bays ranged from 8°C to 25°C, even though the outside temperature was between -42° and -54°C. Aircraft disinfection, while

[26] Aircraft may have been passenger aircraft or cargo aircraft, or a combination of the two. Unreliable records and records for military aircraft were excluded.

employed by some countries to reduce the spread of mosquitoes and other human disease vectors (Centers for Disease Control 2007), is not performed by the United States on arriving flights (Kosciuk 2007).

At Hawai'ian airports, eight live reportable pests—all adult insects—have been intercepted in aircraft cargo holds or cabins of international flights since 1990 (Table A18-1) (USDA 2007a). Between 2003 and 2005, an average of approximately 26 international flights[27] arrived in Hawai'i every day (Bureau of Transportation Statistics 2006). However, the proportion of flights, where the cargo holds were thoroughly inspected by APHIS-PPQ or CBP, is unknown. Given the fact that the total sample size for interceptions is unknown, and several other significant data quality problems associated with PPQ/CBP pest interception records, the available information does not lend itself to reliable quantitative analysis.

Flights from the mainland carrying cargo of U.S. origin are not pre-cleared by APHIS and are not inspected by CBP upon arrival (Kosciuk 2007). At the same time, HDOA's PQ does not routinely inspect aircraft cargo holds or cabins (Oishi 2007). Thus, there are no interception records or other data that could help quantify the pest risk posed by this pathway.

A number of scientific publications report finds of live quarantine pests in aircraft cabins (e.g., Evans et al. 1963; Goh et al. 1985) and air cargo holds (e.g., Evans et al. 1963; Caton 2003; Dobbs and Brodel 2004). Goh et al. (1985) found that 17% of 330 arriving aircraft examined at Changi International Airport, Singapore, harbored mosquitoes and other insects in the cabin. In a 5-year study at the Manila International Airport in the Philippines, Basio et al. (1970) inspected over 14,000 airplanes, detecting more than 700 pests, including live mosquitoes. Evans et al. (1963) found an average of one pest per baggage compartment (cargo hold) and 19 pests per cabin on aircraft arriving in Honolulu, and Rainwater (1963) found live agricultural pests on 16 of 2,662 aircraft arriving in Hawai'i from foreign countries. At the Miami International Airport, Florida (MIA), inspections of the cockpit, galleys, exterior of palletized cargo, and cargo holds of 730 aircraft resulted in the detection of 151 insects from 33 families in five orders, along with one plant pathogen (*Xanthomonas axonopodis* pv. *citri* [Hasse] Vauterin et al.) (Dobbs and Brodel 2004). The estimated pest approach rate for foreign cargo aircraft arriving at MIA was 10.4% (Dobbs and Brodel 2004). Caton (2003) reported an average of two flights daily arriving at MIA from Central and South America with quarantine pests in their cargo holds, estimating that one pest species per year would become established in Florida (escape detection and control, find a host plant, and produce offspring) from flights originating from Central America.

[27] Flights arriving at Hickam Air Force Base and Marine Corps Base Hawai'i were omitted.

Table A18-1: Reportable Pests Intercepted at Ports-of-entry in Hawai'i in Cargo Holds or Cabins of Aircraft of Foreign Origin, January 1, 1990–June 19, 2007

Port-of-entry	Origin	Destination	Reportable Pest Intercepted
HI Honolulu PIS PPQ	Guam	--	*Adoretus sinicus* Burmeister (Scarabaeidae)
HI Honolulu PIS PPQ	Korea, South	Hawai'i	*Anomala* sp. (Scarabaeidae)
HI Honolulu PIS PPQ	Japan	--	*Spodoptera* sp. (Noctuidae)
HI Honolulu PIS PPQ	Japan	--	*Melolontha* sp. (Scarabaeidae)
HI Honolulu PIS PPQ	Guam	Hawai'i	Pyralidae, species of
HI Honolulu PIS PPQ	Japan	--	Cicadidae, species of
HI Honolulu PIS PPQ	Unknown	Hawai'i	Lepidoptera, species of
HI Kailua-Kona CBP	Mexico	Hawai'i	*Calligrapha* sp. (Chrysomelidae)

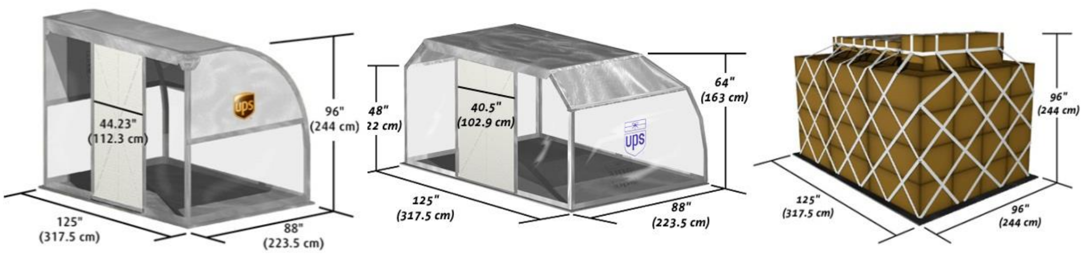
Source: USDA 2007a
Note: Unreliable records and records pertaining to military aircraft were omitted.

In addition to the conveyances themselves, shipping containers may also harbor hitchhikers. Shipping containers vary in size and shape, and may be composed of plastic, metal, or other materials (or a combination of materials) (Figures A18-1 and A18-2). A single container may contain multiple shipments. Pests, including arthropods, molluscs, and weeds, have been found on the outside, as well as the inside, of shipping containers.

Figure A18-1: Commercial Shipping Containers

Source: Gallmeister Internationale Spedition, http://www.ingo-gallmeister.de
Note: Both 20-foot- and 40-foot-long containers are depicted.

Figure A18-2: Examples of Some Shipping Containers Used for Commercial Shipments via Aircraft



Source: USPS at http://www.ups.com
Note: Air shipping containers differ in size and shape (left and center), and may not be completely enclosed (right).

Gadgil et al. (2000) inspected the exterior of 3,681 shipping containers arriving at New Zealand maritime ports and found that approximately 39% were contaminated, with soil on the container bottoms being the most common contaminant (31% of the containers). Fungi of taxa containing plant pathogens were isolated from 83% of the soil samples; species of *Fusarium* were commonly isolated. Nematodes, of which 4% were quarantine organisms for New Zealand, were isolated from 81% of the soil samples. Foliage and woody material were the next common contaminants. Also, egg masses of gypsy moth, *Lymantria dispar* (L.), were found on shipping containers. The authors estimated that containers from South Africa had the highest rate of contamination (50%), followed by the Pacific islands (47.5%). Containers from the Far East (Japan and elsewhere in East Asia) had a contamination rate of 13%. An annual minimum of 36,000 contaminated containers was estimated to be entering New Zealand.

In another study, involving sea cargo containers arriving at Australian ports, Stanaway et al. (2001) surveyed wooden components of the containers for pests, in particular, timber-infesting insects. A total of 7,861 arthropods was found on or in the 3,001 containers inspected. Although no live exotic timber-feeding insects were found in the containers' wooden floors, insects with the potential to infest timber were found in 3.5% of the containers. In addition, 11% of the containers had insects considered stored-product pests that were quarantine organisms for Australia. The authors concluded that the risk associated with untreated wooden components of containers is not negligible because of the high volume of container traffic and the frequency with which containers come into contact with timber pests.

After inspecting 991 air cargo containers arriving at airports in New Zealand, Gadgil et al. (2002) determined that the exterior, including the bottom, of the containers was generally clean, whereas, on the inside, they found contaminants, mostly fresh leaves and twigs, in 24% of the cases. Fungi were found in soil contaminating 3% of the examined containers. The detection of fresh plant material containing pests, coupled with the fact that newly introduced pests have been found in close vicinity to airports, led the authors to conclude that air cargo containers may provide a pathway by which exotic organisms can become established.

In 2006, Hawai'i received more than 1.4 million twenty-foot equivalent containers, loaded or empty, at its maritime ports from foreign or domestic origins (Table A18-2). We do not have any information on the number of air cargo containers received, which would also include most FedEx and UPS shipments.

If we assume a contamination rate of 10%, with 1% of the contaminants being or including quarantine organisms, and 1% of these organisms being able to establish populations in Hawai'i, we arrive at an estimate of 13 pest establishments per year from sea cargo containers alone.

Table A18-2: Number of Containers Arriving from Foreign and Domestic Origins at Hawai'i Maritime Ports in 2006

Port	Number of TEU[a]	Number of Boxes[b]	Containerized Cargo (tonnes)
Hilo	64,499	38,380	424,286
Honolulu	1,113,789	647,755	6,171,258
Kahului	140,147	84,053	933,715
Kaunakakai	2,984	2,413	16,133
Kawaihae	102,897	58,884	620,499
Total	**1,424,316**	**831,485**	**8,165,891**

Source: American Association of Port Authorities 2006
[a] TEU=Twenty-foot equivalent units (loaded and empty).
[b] Containers regardless of length.

A18.1 SUMMARY

- Aircraft cargo holds and cabins, as well as shipping containers, can harbor pests.
- Aircraft have been implicated in introducing pests into new areas.
- Inspections of aircraft cargo holds and cabins are not a common practice by either APHIS-PPQ or HDOA PQ.
- PQ inspectors do not have authority to inspect containers (neither the container surfaces nor the shipments within the container) transporting only non-agricultural commodities unless the presence of BTS is suspected or CBP refers a container to them.
- Cargo containers used in maritime shipments also are a viable pathway for the introduction of pests.
- As many as 13 pest establishments from sea cargo containers alone may occur in Hawai'i every year.

A19 WOOD PACKAGING MATERIAL

Wood packaging material (also known as solid-wood packing material or WPM), including dunnage, crating, pallets, packing blocks, drums, cases, and skids, is used all over the world in shipments of both agricultural and non-agricultural products. As it is not mandatory for importers to indicate the presence of WPM on shipping manifests, port officers have to rely almost exclusively on their experience and on random checks when selecting shipments, especially of non-agricultural commodities, for WPM inspection (Meissner et al. 2003). Because WPM is routinely re-used and re-conditioned, its origin is not necessarily the same as the origin of the commodity with which it is imported (e.g., WPM in a shipment from Canada could easily have originated in some other country, such as Australia). On September 16, 2005, the United States started enforcing the International Plant Protection Convention's standard ISPM #15, "Guidelines for Regulating Wood Packaging Material in International Trade" (IPPC 2006). This standard requires fumigation or heat treatment for all WPM entering the United States. While it is the purpose of ISPM #15 to reduce the pest risk posed by WPM, there are no conclusive data available showing that this objective is actually being met.

Hawai'i receives a variety of imports with WPM from numerous countries. It is difficult to quantify exactly how much WPM is arriving and from where. The only information available for this purpose was an AQIM data set containing records for the period between October of 2005 and April 2007. These data represent the results of WPM inspections in maritime cargo. They were collected at the Honolulu maritime port following port-specific standard operating procedures (Higa 2004) and general instructions in the USDA AQIM Handbook (USDA 2006a). Two shipments were inspected per week. The samples were selected by choosing one container from the first two entries each Monday. Sampling was not limited to agricultural commodities, but included non-agricultural shipments as well. As the selection of samples was thus randomized, the relative frequency of countries of origin (Table A19-1) and commodities (Table A19-2) represented in the AQIM data set should be similar to their relative frequency in the entire population of shipments entering the port of Honolulu. Almost 40% of the shipments with WPM originated in China, and about 20% came from Indonesia. Peru was represented by 8% and Turkey by about 5% of the shipments. A number of other countries contributed small percentages of the shipments. Of the commodities, furniture was the most common with about 15%; most of the other commodities were stone or stone-like products.

Table A19-1: Countries of Origin of Randomly Selected Samples of Maritime Cargo Entering Hawai'i with WPM, October 2005 to April 2007

Country of origin	Number of samples	Percent of total samples
China	63	38.0
Indonesia	32	19.3
Peru	14	8.4
Turkey	9	5.4
India	7	4.2
Vietnam	6	3.6
Brazil	5	3.0
Italy	5	3.0
Thailand	5	3.0
Hong Kong	3	1.8
Philippines	3	1.8
Portugal	3	1.8
Egypt	2	1.2
Israel	2	1.2
New Zealand	2	1.2
Japan	1	0.6
South Korea	1	0.6
Mexico	1	0.6
Pakistan	1	0.6
Singapore	1	0.6
Total	**166**	**100**

Source: AQIM

Table A19-2: Manifested Contents of Randomly Selected Samples of Maritime Cargo of Foreign Origin Entering Hawai'i with WPM, October 2005 to April 2007

Manifested as	Number of shipments	Percent of total shipments
Bamboo	1	0.6
Ceramic tile	2	1.2
Countertop	2	1.2
Furniture	26	15.7
Furniture, Bamboo stake	1	0.6
Glass, Louver	3	1.8
Granite	16	9.6
Granite product	3	1.8
Granite slab	13	7.8
Granite tile	3	1.8
Handicraft	8	4.8
Handicraft, Stone statue	1	0.6
Housing assembly	2	1.2
Limestone	4	2.4
Marble	1	0.6
Marble slab	5	3.0

Manifested as	Number of shipments	Percent of total shipments
Marble tile	10	6.0
Pottery	2	1.2
Quartzite	2	1.2
Slate	10	6.0
Squash	1	0.6
Stone	11	6.6
Stone slab	6	3.6
Stone slate	4	1.8
Stone statue	10	6.0
Tile, Roof	3	1.8
Travertine	15	9.0
Wood packing material, Other	1	0.6
Grand Total	**166**	**100**

Source: AQIM

Of the 166 inspections that were recorded in the AQIM data set, 6 resulted in interceptions of pests. However, it must be noted that port personnel were instructed to "Inspect thoroughly at least 50 percent of the external surface of the [WPM] for live pests" (Higa 2004). In other words, half of the wood surface may have been left unsearched; inspectors may not have looked for pests hidden inside the wood; and finds of dead pests were not recorded. Further, considering the general difficulty of detecting pests in or on WPM, the true number of infested shipments was almost certainly higher than six. Using 10 as a more realistic number, between 3% and 11% (95% binomial confidence interval) of all shipments with WPM arriving at the port of Honolulu are infested with live pests. This is a disturbingly high number, especially considering that it is occurring in spite of ISPM #15 regulations.

Unfortunately, there are no data available to determine how much WPM is entering Hawai'i; therefore, it is not possible to estimate the number of pest species that may have been, and will be, introduced into Hawai'i on this pathway. However, it is certain that this number must be far from negligible.

According to the USDA Agricultural Quarantine Activity System Pest ID database (USDA 2007a), APHIS-PPQ or CBP inspectors in Honolulu intercepted 29 pests on wood material associated with maritime cargo during regular phytosanitary inspections (not AQIM data collection) between October 2005 and April 2007. All of these interceptions were insects, and the large majority of them were beetles (Table A19-3). Only nine of the insects were reportable pests. It is interesting to note that the latest interception date recorded was December of 2006, and there are no records for the time between then and April 2007.

Table A19-3: Pests Intercepted on or in Wood Materials During Regular Phytosanitary Inspections of Maritime Cargo at the Port of Honolulu between October 2005 and April 2007

Interception date	Origin	Inspected host	Pest name	Pest reportable?
1/23/2006	Peru	Granite	Bostrichidae, species	yes
5/2/2006	Indonesia	Furniture	*Cryptotermes* sp.	yes
4/11/2006	Peru	Tiles	*Cryptotermes* sp.	yes
4/20/2006	Peru	Tiles	*Cryptotermes* sp.	yes
3/23/2006	Peru	Tiles	*Cryptotermes* sp.	yes
3/22/2006	Indonesia	*Tectona grandis*	*Cryptotermes* sp.	yes
1/11/2006	China	Furniture	Scolytidae, species	yes
12/20/2006	China	Wood	*Xyleborus* sp.	yes
11/28/2005	China	Granite	*Xyleborus* sp.	yes
10/25/2006	China	Tiles	Anobiidae, species	no
4/25/2006	China	Furniture	Anobiidae, species	no
4/17/2006	China	Tiles	Anobiidae, species	no
12/9/2005	China	Tiles	*Arhopalus* sp.	no
11/15/2005	China	Tiles	Bostrichidae, species	no
11/15/2005	China	Tiles	Cleridae, species	no
4/17/2006	China	Tiles	Corticariidae, species	no
10/26/2006	India	Marble	Cryptophilini, species	no
4/17/2006	China	Tiles	*Cryptophilus* sp.	no
6/1/2006	Peru	Tiles	Erotylidae, species	no
3/30/2006	Peru	Tiles	*Heterobostrychus aequalis*	no
4/25/2006	China	Furniture	Nitidulidae, species	no
4/20/2006	Peru	Tiles	Nitidulidae, species	no
6/7/2006	India	Slate	Psocoptera, species	no
4/25/2006	China	Furniture	Psocoptera, species	no
9/21/2006	Indonesia	Wood	Silvanidae, species	no
11/28/2005	China	Granite	Silvanidae, species	no
10/27/2006	India	Marble	*Silvanus* sp.	no
12/7/2005	Turkey	Tiles	*Stephanopachys quadricollis*	no
2/8/2006	China	Tiles	*Typhaea stercorea*	no

Note: Not AQIM data collection.

It is more difficult to determine how many WPM-associated pests were intercepted by HDOA inspectors, because the HDOA database of pest interceptions does not indicate clearly if a pest was associated with WPM or not. Filtering for the hosts “wood” and “crates” as indicators of an association with WPM, there were zero interception records for the period between October 2005 and April 2007, whereas for the entire period between 1990 and 2006, a mere 24 interceptions are listed (out of a total of 17,356 interceptions on any host) (Table A19-4) (HDOA 2007c). Most of the pests intercepted on wood and crates are already established in Hawai’i. However, some of them (e.g., the odorous house ant, *Tapinoma sessile* [Say]) do not yet occur in Hawai’i, and have the potential to be aggressive invaders. In contrast to CBP, HDOA does not have any authority to put on hold non-agricultural shipments for the purpose of WPM inspection. This means that HDOA can inspect WPM only in agricultural shipments, or on non-agricultural shipments that have been referred to it by another agency.

Table A19-4: Pests Intercepted on "Wood" or "Crates" during Phytosanitary Inspections by HDOA on any Pathway between January 1990 and October 2006

Taxon	Family	Country of origin	Number of times intercepted	Status in Hawai'i
Cryptorhynchinae	Curculionidae	Indonesia	1	n/a
Camponotus pennsylvanicus	Formicidae	Texas	1	not yet established
Camponotus sp.	Formicidae	California	1	n/a
		Oregon	2	n/a
		Hawai'i	1	n/a
Cryptotermes brevis	Kalotermitidae	Midway Island	1	introduced
Gnathaphanus picipes	Carabidae	Hawai'i	1	introduced
Ornithonyssus sylviarum	Macronyssidae	California	2	introduced
		Midway Island	1	introduced
Philonthus turbidus	Staphylinidae	Thailand	1	introduced
Sinoxylon conigerum	Bostrichidae	California	1	introduced
Solenopsis geminata	Formicidae	Indonesia	1	introduced
		Oregon	1	
Tapinoma sessile	Formicidae	Indonesia	1	not yet established
Vollenhovia sp.	Formicidae	Indonesia	1	not yet established
Xyleborus affinis	Scolytidae	China	1	introduced
Xylopsocus flavipes	Bostrichidae	Hawai'i	1	not yet established
Unidentified species	Brentidae	Hawai'i	1	n/a
Total			20	

It is likely that the APHIS-PPQ, CBP, and HDOA interceptions represent only a fraction of the pests that were actually present. Other studies have estimated that port inspections intercept only 30% or fewer of the incoming pests (Meissner et al. 2003). A recent HDOA report confirms this: "Even during the Oahu risk assessment, only about 10% of the volume was inspected, but the numbers of interceptions were about 10 times greater than the normal inspection of all of the HNL [Honolulu] cargo during that same period" (HDOA 2007d). WPM is especially difficult to inspect; pests are often hidden inside the wood, and a large part of the incoming WPM never gets inspected because it is not associated with agricultural commodities. It is also quite common that port inspectors are not sufficiently trained to detect wood-boring pests. Training provided to port inspectors along the Mexican border in 2002 made this very obvious. This training focused on methods for detecting wood-boring beetles of the family Scolytidae, and resulted in an immediate and dramatic increase in WPM pest interceptions (Table A19-5). For example, at Pharr and San Diego, the average number of intercepted scolytid specimens increased from ≤ 1 to over 100 per month as a result of the training, indicating that large numbers of scolytid pests entering the United States had gone undetected by APHIS-PPQ at these ports. Similar breaches of quarantine security probably hold true for most U.S. ports-of-entry, including Honolulu, and also apply to many non-scolytid pests associated with WPM. For example, the Honolulu interceptions do not include any snails (Table A19-4), whereas nationwide, snails represent almost 10% of all WPM interceptions (Table A19-6), and a snail was found during AQIM data collection in a sample of only 166 (Table A19-7).

Table A19-5: Monthly Average Number of Scolytid Specimens Found on Solid WPM before and after a Scolytid Detection Training at Four Major Southern Border ports in 2002

Port	Before Training	After Training
Brownsville, TX	0	12
Laredo, TX	26	73
Pharr, TX	0.4	108
San Diego, CA	1	124

Table A19-6: Pest Types Intercepted on or in Wood Materials during Regular Phytosanitary Inspections of Maritime Cargo Nationwide between January 1985 and May 2007

Pest type	Number of interceptions
Diseases	64
Insects	17,008
Mites	42
Molluscs	1,323
Nematodes	4
Weeds	178
Grand Total	18,619

Note: Not AQIM data collection.

Specifically, pest finds recorded in the AQIM data set for Honolulu (Table B8-7) included a member of the snail family Bradybaenidae, the cerambicid, *Xylotrechus magnicollis* (Fairmaire), an unidentified member of each of the beetle families Bostrichidae and Cerambycidae, a species of *Cryptotermes*, and an unidentified noxious weed. No taxonomic information was provided for one of the interceptions. The pests were intercepted on marble slabs, granite, and stone from China, and on furniture from Indonesia. Apart from pest interceptions, there were five cases of WPM entering without proof of phytosanitary treatment (ISPM#), as required by ISPM #15, and one case of contamination with soil.

Table A19-7: Pests on WPM or WPM Lacking Proof of Phytosanitary Treatment Intercepted during AQIM at the Honolulu Maritime Port between October 2005 and April 2007

Origin	Infested commodity	Interception
China	Marble slab	Bostrichidae
China	Stone statue	WPM no ISPM#
China	Furniture	WPM no ISPM#
China	Slate	Soil
China	Granite	Cerambycidae
China	Stone	*Xylotrechus magnicollis*, *Bradybaenidae* sp.
Hong Kong	Furniture	WPM no ISPM#
Indonesia	Furniture	*Cryptotermes* sp.
Indonesia	Furniture	WPM no ISPM#
Indonesia	Furniture	Unidentified noxious weed
Philippines	Stone	WPM no ISPM#
Turkey	Tile, Roof	Unidentified pest

Note: Total sample size=166.

Table A19-8 lists all pests intercepted on wood at any U.S. port-of-entry since 1985, demonstrating the great taxonomic variety (Table B8-9) of organisms associated with WPM. Snails were frequently found as hitchhikers on WPM. Snail invasions may have serious economic and environmental consequences. For example, *Bradybaena ravida* (Benson), which is not known to occur in Hawai'i, was rated as a high-risk quarantine pest in a USDA risk assessment for penjing from China (Cave and Redlin 1996).

Table A19-8: Reportable Pests Intercepted on or in Wood Materials during Regular Phytosanitary Inspections of Maritime Cargo Nationwide between January 1985 and May 2007

Taxon	Number of times intercepted
Pathogens	
Ascochyta sp.	1
Cladosporium sp.	2
Cytospora sp.	1
Didymella sp.	1
Graphiola sp.	1
Gymnosporangium sp.	1
Lophodermium sp.	1
Mycospharella fijiensis	1
Pestalotiopsis sp.	2
Phoma sp.	5
Phomopsis sp.	4
Puccinia sp.	7
Insects	
Acalles sp.	1

Taxon	Number of times intercepted
Acanthocephala sp.	1
Acanthocinus sp.	4
Acanthoscelides sp.	1
Acheta hispanicus	12
Acheta sp.	2
Acmaeodera sp.	1
Acrididae, species	4
Acroleucus bromelicola	1
Acrolophus sp.	2
Acrosternum millierei	9
Acyphoderes sp.	1
Adoretus sinicus	12
Aelia acuminata	5
Aeolus sp.	2
Aethus indicus	1
Agallia laevis	2

Taxon	Number of times intercepted
Agallia sp.	2
Agapanthia irrorata	1
Agrilus sp.	35
Agrilus sulcicollis	1
Agriotes aequalis	1
Agriotes lineatus	1
Agriotes sp.	3
Agromyzidae, species	2
Agrotis exclamationis	1
Agrotis sp.	1
Agrypninae, species	1
Alaus sp.	2
Altica oleracea	3
Altica sp.	22
Alydus sp.	2
Amitermes sp.	2
Amphiacusta azteca	1
Amphicerus sp.	5
Anaceratagallia venosa	2
Anacridium aegyptium	23
Anasa sp.	1
Anastrepha sp.	3
Anelaphus sp.	1
Anomala ceramopyga	1
Anomala sp.	2
Anoplophora glabripennis	6
Anoplophora sp.	31
Anthaxia sp.	22
Anthomyiidae, species	1
Anthonomus sp.	3
Anthribidae, species	1
Anticarsia irrorata	1
Anurogryllus sp.	1
Apate sp.	1
Aphanus rolandri	8
Aphididae, species	6
Aphthona sp.	2
Apidae, species	1
Apion sp.	41
Apionidae, species	1
Apis mellifera	11
Apis sp.	1
Apocrita, species	3
Apriona sp.	1
Aradidae, species	9

Taxon	Number of times intercepted
Araecerus sp.	5
Araptus sp.	1
Arctiidae, species	22
Arocatus longiceps	2
Arocatus melanocephalus	24
Arocatus roeselii	1
Asemum sp.	6
Aspidiella hartii	1
Aspidomorpha sp.	1
Atta sp.	1
Auchenorrhyncha, species	1
Aulacaspis tubercularis	2
Aulacophora sp.	1
Autographa gamma	1
Bactrocera dorsalis	1
Bactrocera sp.	2
Baris sp.	1
Batocera rufomaculata	1
Batocera sp.	8
Belionota prasina	3
Belionota sp.	2
Beosus maritimus	11
Beosus quadripunctatus	3
Beosus sp.	2
Blapstinus sp.	36
Blissus sp.	1
Bostrichidae, species	94
Brachmia sp.	1
Brochymena sp.	5
Bruchidius sp.	1
Bruchinae, species	1
Bryothopha sp.	1
Bucrates capitatus	1
Buprestidae, species	103
Buprestis dalmatina	6
Buprestis haemorrhoidalis	1
Buprestis sp.	58
Cacopsylla sp.	1
Callidiellum sp.	5
Callidiellum villosulum	8
Callidium sp.	20
Calligrapha sp.	1
Callosobruchus sp.	1
Camptopus lateralis	26
Camptorhinus sp.	1

Taxon	Number of times intercepted
Carphoborus minimus	11
Carphoborus pini	5
Carphoborus rossicus	1
Carphoborus sp.	10
Carpocoris pudicus	1
Caryedon sp.	2
Cassidinae, species	1
Catocalinae, species	1
Catolethrus sp.	1
Catorhintha sp.	1
Caulotops sp.	1
Cecidomyiidae, species	10
Cecidomyiinae, species	3
Centrocoris variegatus	1
Cerambycidae, species	247
Cerambycinae, species	291
Cerambyx sp.	2
Ceratagallia sp.	1
Ceratitini, species	1
Ceratitis capitata	2
Cercopidae, species	2
Ceresium sp.	132
Ceutorhynchus sp.	4
Chaetocnema concinna	1
Chaetocnema conducta	36
Chaetocnema sp.	28
Chaetocnema tibialis	232
Chalcidoidea, species	2
Chalcoises plutus	1
Chalcophora sp.	7
Chilo sp.	2
Chilo suppressalis	10
Chlorida festiva	1
Chlorophanus sp.	1
Chlorophorus annularis	7
Chlorophorus diadema	1
Chlorophorus sp.	3
Chramesus sp.	3
Chrysauginae, species	1
Chrysobothrini, species	1
Chrysobothris chrysostigma	1
Chrysobothris sp.	74
Chrysodeixis chalcites	1
Chrysolina bankii	1
Chrysolina polita	1

Taxon	Number of times intercepted
Chrysolina rossia	2
Chrysolina sp.	1
Chrysomela sp.	1
Chrysomelidae, species	9
Cicadella viridis	1
Cicadellidae, species	32
Cinara sp.	1
Cixiidae, species	2
Cleonis sp.	1
Cleonus sp.	1
Clytini, species	3
Clytus sp.	1
Cnaphalocrocis medinalis	3
Cnemonyx sp.	1
Cneorhinus sp.	1
Coccotrypes sp.	22
Coccus viridis	2
Colaspis sp.	4
Coleophoridae, species	1
Coleoptera, species	50
Conarthrus sp.	1
Conchaspis newsteadi	1
Conistra rubiginea	1
Conocephalus sp.	2
Conoderus sp.	2
Conotrachelus sp.	10
Copitarsia sp.	1
Coptocycla sordida	1
Coptops sp.	5
Coptotermes crassus	2
Coptotermes sp.	11
Coreidae, species	1
Corizus hyoscyami	3
Cossidae, species	13
Cossoninae, species	26
Cossonus sp.	5
Cossus cossus	1
Crambidae, species	3
Crambinae, species	1
Crematogaster sp.	37
Cryphalus abietis	2
Cryphalus piceae	4
Cryphalus sp.	47
Cryptoblabes sp.	2
Cryptocarenus sp.	1

Taxon	Number of times intercepted
Cryptophlebia leucotreta	1
Cryptophlebia sp.	1
Cryptorhynchinae, species	6
Cryptorhynchus sp.	1
Cryptotermes sp.	60
Crypturgus cinereus	12
Crypturgus mediterraneus	19
Crypturgus numidicus	5
Crypturgus sp.	26
Ctenuchinae, species	1
Curculio sp.	1
Curculionidae, species	193
Curculionoidea, species	60
Cyclocephala sp.	5
Cyclorrhapha, species	7
Cydia sp.	2
Cylindrocopturus sp.	1
Cynipidae, species	1
Cyphostethus tristriatus	1
Cyrtogenius luteus	8
Cyrtogenius sp.	5
Dactynotus sp.	1
Delphacidae, species	1
Deltocephalinae, species	1
Demonax sp.	1
Dendrocoris sp.	2
Dendroctonus mexicanus	26
Dendroctonus sp.	19
Dere thoracica	1
Diabrotica sp.	1
Diabrotica undecimpunctata	1
Diaspididae, species	1
Dicerca sp.	1
Dieuches armatipes	2
Dihammus sp.	1
Diorthus sp.	1
Diplotaxis sp.	7
Diptera, species	14
Disonycha sp.	4
Dolycoris baccarum	17
Dorytomus sp.	3
Draeculacephala clypeata	1
Drasterius bimaculatus	2
Drasterius sp.	2
Drymus sylvaticus	1

Taxon	Number of times intercepted
Dryocoetes autographus	17
Dryocoetes hectographus	1
Dryocoetes sp.	119
Dryocoetes villosus	20
Dysdercus sp.	1
Dysmicoccus neobrevipes	1
Edessa sp.	2
Elachistidae, species	1
Elaphidion sp.	4
Elaphria sp.	1
Elateridae, species	17
Elaterinae, species	1
Eleodes sp.	1
Emblethis denticollis	3
Entiminae, species	5
Epicauta sp.	1
Epitragus sp.	9
Epitrix sp.	1
Eremocoris fenestratus	1
Eremocoris sp.	2
Eriococcidae, species	1
Erthesina fullo	5
Eubulus sp.	2
Euconocephalus sp.	2
Euetheola bidentata	2
Euetheola sp.	1
Euphoria sp.	2
Eurydema oleraceum	5
Eurydema ornatum	8
Eurydema ventrale	2
Euryscelis suturalis	1
Eurythyrea sp.	1
Euschistus cornutus	1
Exora sp.	1
Eyprepocnemis plorans	1
Eysarcoris ventralis	17
Formicidae, species	4
Frankliniella sp.	1
Galeruca sp.	3
Galerucella sp.	1
Galleriinae, species	1
Gastrodes abietum	1
Gastrodes grossipes	1
Gelechiidae, species	16
Gelechioidea, species	2

Taxon	Number of times intercepted
Geometridae, species	8
Geotomus punctulatus	1
Gerstaeckeria sp.	1
Giraudiella inclusa	2
Glenea sp.	1
Glyptotermes fuscus	1
Glyptotermes sp.	2
Gnathamitermes sp.	1
Gnathotrichus sp.	108
Gonioctena sp.	2
Gonocephalum sp.	10
Gonocerus acuteangulatus	1
Gonocerus sp.	1
Gonocerus venator	2
Grammophorus sp.	1
Graphosoma sp.	1
Gryllidae, species	9
Gryllinae, species	1
Gryllodes sp.	1
Gryllus bimaculatus	1
Gryllus campestris	1
Gryllus sp.	43
Gymnandrosoma sp.	1
Gypona sp.	1
Hadeninae, species	1
Halyomorpha picus	2
Heilipus sp.	2
Helicoverpa sp.	1
Helophorus sp.	1
Hemiptera, species	1
Hepialidae, species	1
Heraeus sp.	1
Herpetogramma sp.	1
Hesperiidae, species	2
Hesperophanes campestris	1
Hesperophanes sp.	64
Heterobostrychus aequalis	43
Heterobostrychus brunneus	3
Heterobostrychus sp.	5
Heteroptera, species	4
Heterotermes sp.	12
Hippopsis sp.	1
Holcostethus sphacelatus	16
Holcostethus vernalis	1
Homalodisca sp.	1

Taxon	Number of times intercepted
Homoeocerus marginellus	1
Hoplandrothrips sp.	2
Horvathiolus superbus	3
Hyalochilus ovatulus	1
Hylastes angustatus	4
Hylastes ater	54
Hylastes attenuatus	18
Hylastes cunicularius	6
Hylastes linearis	6
Hylastes sp.	20
Hylesininae, species	2
Hylesinus crenatus	1
Hylesinus sp.	5
Hylesinus varius	11
Hylobius abietis	8
Hylobius sp.	185
Hylurgops glabrotus	2
Hylurgops palliatus	295
Hylurgops sp.	39
Hylurgus ligniperda	245
Hylurgus sp.	47
Hymenoptera, species	26
Hypena gonospilalis	1
Hypena lividalis	1
Hypena sp.	2
Hypera constans	1
Hypera sp.	10
Hypocassida subferrugines	1
Hypocryphalus mangiferae	3
Hypocryphalus sp.	111
Hypothenemus sp.	180
Idiocerus sp.	7
Incisitermes modestus	2
Incisitermes sp.	23
Insecta, species	4
Ips acuminatus	23
Ips amitinus	2
Ips cembrae	11
Ips erosus	474
Ips mannsfeldi	5
Ips sexdentatus	179
Ips sp.	99
Ips typographus	268
Irbisia sp.	1
Ischnodemus sp.	2

Taxon	Number of times intercepted
Isoptera, species	5
Kalotermes flavicollis	5
Kalotermes sp.	3
Kalotermitidae, species	14
Lacon sp.	2
Lamia sp.	6
Lamia textor	4
Lamiinae, species	128
Largus sp.	1
Larinus cynarae	1
Larinus latus	1
Larinus sp.	4
Larinus turbinatus	1
Lepidoptera, species	21
Leptoglossus sp.	1
Leptostylus sp.	2
Leucania sp.	1
Ligyrocoris sp.	1
Ligyrus sp.	1
Liogenys macropelma	2
Liriomyza huidobrensis	1
Listronotus sp.	3
Lixus sp.	5
Lobometopon metallicum	1
Longitarsus sp.	3
Lycaenidae, species	1
Lyctidae, species	71
Lyctus simplex	3
Lyctus sp.	11
Lygaeidae, species	6
Lygaeoidea, species	8
Lygaeosoma sardeum	62
Lygaeus equestris	4
Lygaeus pandurus	1
Lygus gemellatus	1
Lygus sp.	5
Lymantriidae, species	2
Macrocopturus cribricollis	1
Macroglossum stellatarum	2
Macroscytus sp.	1
Marshallius sp.	2
Mecaspis alternans	1
Mecinus circulatus	1
Mecinus sp.	4
Mecopus sp.	2

Taxon	Number of times intercepted
Megacyllene sp.	2
Megalonotus chiragrus	95
Melalgus sp.	4
Melanaspis sp.	1
Melanocoryphus albomaculatus	24
Melanophila cuspidata	18
Melanophila sp.	43
Melanoplus sp.	1
Membracidae, species	2
Metamasius hemipterus	1
Metoponium sp.	1
Metopoplax origani	4
Metopoplax sp.	1
Micrapate brasiliensis	1
Micrapate scabrata	4
Micrapate sp.	7
Microplax interruptus	1
Microplax sp.	1
Microtheca sp.	1
Minthea rugicollis	12
Minthea sp.	3
Miridae, species	8
Mocis frugalis	2
Mocis undata	1
Mogoplistidae, species	5
Molorchus sp.	4
Molytinae, species	1
Monarthrum sp.	4
Monochamus alternatus	15
Monochamus galloprovincialis	2
Monochamus sartor	3
Monochamus sp.	452
Monochamus sutor	5
Monochamus teserula	1
Monosteira unicostata	1
Mordellidae, species	2
Mormidea sp.	1
Myochrous sp.	2
Myrmicinae, species	3
Nasutitermes costalis	4
Nasutitermes ephratae	2
Nasutitermes nigriceps	1
Nasutitermes sp.	6

Taxon	Number of times intercepted
Nemapogon sp.	3
Nematocera, species	3
Neoclytus olivaceus	1
Neoclytus sp.	4
Neoconocephalus guttatus	1
Neoconocephalus punctipes	2
Neoconocephalus sp.	4
Neotermes connezus	1
Neotermes modestus	2
Neotermes sp.	10
Neottiglossa sp.	1
Niphades sp.	1
Niphades variegatus	1
Noctuidae, species	37
Noctuinae, species	1
Nymphalidae, species	2
Nysius ericae	1
Nysius graminicola	1
Nysius senecionis	1
Nysius sp.	81
Nysius stalianus	1
Nysius thymi	1
Odontocera sp.	1
Oecophoridae, species	9
Olethreutinae, species	2
Omalus sp.	1
Opatrinae, species	3
Opogona sacchari	2
Opogona sp.	2
Orthostethus sp.	1
Orthotomicus erosus	4
Orthotomicus laricis	30
Orthotomicus proximus	2
Orthotomicus sp.	36
Orthotomicus suturalis	3
Oryctes rhinoceros	2
Osbornellus sp.	1
Ostrinia furnacalis	1
Otiorhynchus sp.	6
Oulema sp.	7
Ovalisia sp.	2
Oxycarenus pallens	1
Oxycarenus sp.	1
Oxypleurus nodieri	3
Ozophora sp.	1

Taxon	Number of times intercepted
Pachybrachius sp.	1
Pagiocerus sp.	1
Palaeocallidium sp.	1
Palomena prasina	1
Pangaeus rugiceps	4
Paraparomius lateralis	1
Pareuchaetes insulata	1
Parlatoria blanchardi	1
Paromius gracilis	1
Pectinophora gossypiella	3
Peltophorus sp.	1
Pentatomidae, species	10
Perissus delerei	1
Peritrechus gracilicornis	253
Phaedon cochleariae	1
Phaedon sp.	1
Phaenops sp.	1
Pheidole megacephala	1
Pheidole sp.	13
Phlaeothripidae, species	4
Phloeosinus rudis	24
Phloeosinus sp.	47
Phloeotribus scarabaeoides	3
Phloeotribus sp.	4
Phlogophora meticulosa	1
Phoracantha recurva	2
Phoracantha sp.	3
Phratora sp.	1
Phycitinae, species	6
Phylinae, species	1
Phyllobius sp.	2
Phyllophaga sp.	6
Phyllotreta sp.	9
Phymatodes sp.	60
Physonota sp.	1
Pieridae, species	1
Pieris brassicae	2
Pissodes castaneus	12
Pissodes harcyniae	1
Pissodes notatus	1
Pissodes pini	10
Pissodes sp.	288
Pityogenes bidentatus	26
Pityogenes bistridentatus	35
Pityogenes calcaratus	4

Taxon	Number of times intercepted
Pityogenes chalcographus	531
Pityogenes quadridens	7
Pityogenes sp.	20
Pityogenes trepanatus	1
Pityokteines curvidens	2
Pityokteines sp.	2
Pityokteines spinidens	12
Pityophthorus mexicanus	6
Pityophthorus pityographus	14
Pityophthorus sp.	713
Placosternus sp.	1
Plagionotus christophi	3
Plagionotus sp.	2
Planococcus halli	1
Platycleis sp.	1
Platynota sp.	1
Platyplax salviae	3
Platypodidae, species	54
Platypus sp.	12
Platysenta sp.	2
Plusiinae, species	1
Podagrica malvae	1
Podagrica sp.	1
Polycesta sp.	4
Polydrusus sp.	1
Polygraphus poligraphus	45
Polygraphus proximus	1
Polygraphus sp.	18
Polygraphus subopacus	2
Prosoplus sp.	1
Prostephanus sp.	2
Protaetia orientalis	1
Pseudococcidae, species	1
Pseudohylesinus variegatus	3
Pseudopamera sp.	2
Pseudopityophthorus sp.	63
Pseudothysanoes sp.	1
Psychidae, species	7
Psyllidae, species	1
Psylliodes sp.	3
Pteleobius vittatus	1
Pycnarmon cribrata	1
Pyralidae, species	8
Pyraustinae, species	5
Pyrgocorypha sp.	1

Taxon	Number of times intercepted
Pyrrhalta sp.	2
Pyrrhidium sanguineum	6
Pyrrhidium sp.	2
Pyrrhocoris apterus	8
Raglius alboacuminatus	98
Reticulitermes chinensis	1
Reticulitermes lucifugus	7
Reticulitermes sp.	5
Reuteroscopus sp.	1
Rhagium mordax	2
Rhagium sp.	13
Rhaphidophoridae, species	1
Rhaphigaster nebulosa	60
Rhinotermitidae, species	3
Rhopalidae, species	1
Rhopalus parumpunctatus	1
Rhopalus sp.	2
Rhopalus subrufus	1
Rhynchaenus sp.	1
Rhynchites bacchus	1
Rhynchitidae, species	1
Rhynchophorus palmarum	1
Rhyncolus elongatus	2
Rhyncolus sp.	6
Rhyparida sp.	2
Rhyparochromidae, species	4
Rhyparochromus confusus	4
Rhyparochromus pini	3
Rhyparochromus quadratus	1
Rhyparochromus sp.	3
Rhyparochromus vulgaris	45
Rhyssomatus sp.	2
Rhytidoderes plicatus	1
Ricania fumosa	1
Riodinidae, species	1
Ropica sp.	1
Rugitermes sp.	10
Sambus sp.	1
Saperda carcharias	5
Saperda scalaris	1
Saperda sp.	18
Scantius aegyptius	2
Scarabaeidae, species	7
Sciocoris maculatus	14
Sciocoris sp.	3

Taxon	Number of times intercepted
Scolopostethus affinis	1
Scolopostethus decoratus	1
Scolytidae, species	2504
Scolytinae, species	12
Scolytodes sp.	2
Scolytoplatypus sp.	2
Scolytus intricatus	13
Scolytus ratzeburgi	2
Scolytus scolytus	1
Scolytus sp.	76
Scotinophara sp.	1
Scyphophorus sp.	1
Scythridinae, species	1
Sehirus bicolor	1
Selepa sp.	1
Semanotus sp.	2
Semiothisa sp.	1
Sesiidae, species	2
Shirahoshizo sp.	14
Sinoxylon anale	115
Sinoxylon conigerum	76
Sinoxylon indicum	1
Sinoxylon sp.	21
Sipalinus gigas	3
Sipalinus sp.	2
Sirex noctilio	8
Sirex sp.	3
Siricidae, species	108
Sitona crinita	2
Sitona discoideus	1
Sitona humeralis	5
Sitona sp.	147
Smicronyx sp.	1
Sminthuridae, species	1
Solenopsis invicta	1
Solenopsis sp.	4
Spermophagus sericeus	1
Sphacophilus sp.	1
Sphenophorus sp.	2
Sphenoptera sp.	1
Sphingidae, species	1
Sphingonotus sp.	1
Spilosoma lubricipeda	1
Spilosoma sp.	2
Spodoptera litura	4

Taxon	Number of times intercepted
Spodoptera sp.	2
Stagonomus pusillus	1
Stenocarus fuliginosus	2
Stenoscelis sp.	1
Stephanopachys quadricollis	37
Stephanopachys sp.	72
Sternochetus mangiferae	1
Sternochetus sp.	1
Stictopleurus crassicornis	5
Stictopleurus sp.	1
Stizocera sp.	1
Stromatium barbatum	2
Stromatium longicorne	1
Synanthedon sp.	1
Syphrea sp.	1
Systena sp.	1
Taphropeltus contractus	7
Taphrorychus bicolor	21
Taphrorychus sp.	27
Taphrorychus villifrons	17
Targionia vitis	1
Teleogryllus commodus	1
Teleogryllus mitratus	1
Teleogryllus sp.	2
Tenebrionidae, species	10
Tentyria sp.	1
Tephritidae, species	1
Tephritis sp.	2
Termes panamaensis	2
Termitidae, species	1
Tessaratomidae, species	1
Tesserocerus sp.	1
Tetramorium sp.	1
Tetrigidae, species	1
Tetropium castaneum	83
Tetropium fuscum	6
Tetropium sp.	134
Tettigoniidae, species	1
Thripidae, species	4
Thrips meridionalis	1
Thrips palmi	3
Thyreocoris scarabaeoides	1
Thysanoptera, species	1
Tineidae, species	26
Tingidae, species	1

Taxon	Number of times intercepted
Tipula marmorata	1
Tipula sp.	1
Tipulidae, species	1
Tolype sp.	1
Tomarus sp.	1
Tomaspis inca	1
Tomicus minor	2
Tomicus piniperda	149
Tomicus sp.	32
Tortricidae, species	8
Torymus sp.	6
Trachyderes sp.	16
Tremex fusicornis	1
Trichoferus sp.	3
Trigonorhinus sp.	1
Trimerotropis pallidipennis	2
Trirhabda sp.	1
Trogoderma granarium	12
Trogoderma sp.	2
Trogoxylon praeustum	1
Trogoxylon sp.	3
Tropicanus sp.	1
Tropidothorax leucopterus	3
Tropistethus sp.	1
Trypodendron domesticum	7
Trypodendron signatum	6
Tychius sp.	3
Typhlocybinae, species	1
Typophorus sp.	3
Ulus sp.	2
Urgleptes sp.	1
Uroleucon sp.	1
Xanthochilus saturnius	32

Taxon	Number of times intercepted
Xestocephalus sp.	1
Xyleborinus sp.	4
Xyleborus apicalis	1
Xyleborus eurygraphus	25
Xyleborus sp.	38
Xylechinus pilosus	3
Xylechinus sp.	10
Xylobiops sp.	11
Xylocopa sp.	1
Xylodiplosis sp.	1
Xylopsocus capucinus	10
Xyloryctes fureata	1
Xylosandrus morigerus	1
Xylosandrus sp.	1
Xylothrips flavipes	4
Xylotrechus grayi	1
Xylotrechus magnicollis	3
Xylotrechus rusticus	14
Xylotrechus sp.	119
Xystrocera sp.	4
Yponomeutidae, species	1
Zascelis sp.	3
Zootermopsis sp.	1
Zygogramma sp.	1
Zygopinae, species	1
Zygops sp.	1
Mites	
Acari, species	1
Ixodes hexagonus	1
Tetranychus sp.	2

1

2

Note: Not AQIM data collection.

Taxon	Number of Times Intercepted
Molluscs	
Achatina fulica	1
Achatina sp.	1
Acusta despecta	5
Acusta tourannensis	1
Arianta arbustorum	1
Arion sp.	3
Bradybaena seiboldtiana	1
Bradybaena sp.	2
Bradybaenidae, species	9
Candidula gigaxii	1
Candidula intersecta	2
Candidula sp.	6
Candidula unifasciata	1
Cathaica fasciola	6
Cathaica sp.	1
Cepaea sp.	1
Cernuella (xerocincta)	10
Cernuella cf.	1
Cernuella cisalpina	56
Cernuella sp.	23
Cernuella virgata	26
Chilostoma cingulata	1
Cochlicella acuta	6
Cochlicella conoidea	1
Cochlicella sp.	1
Cornu aspersum	98
Cryptozona siamensis	1
Deroceras panormitanum	1
Deroceras sp.	4
Eobania constantinae	1
Eobania vermiculata	13
Euhadra sp.	1
Fruticicola fruticum	1
Helicarion sp.	7
Helicarionidae, species	2
Helicella itala	6
Helicella maritima	5
Helicella neglecta	1
Helicella sp.	4
Helicella variabilis	2
Helicella virgata	11
Helicellidae, species	1
Helicellinae, species	19
Helicidae, species	11

Taxon	Number of Times Intercepted
Helix cincta	1
Helix lucorum	6
Helix sp.	5
Hygromia cinctella	4
Hygromiidae, species	5
Karaftahelix blakeana	3
Limacidae, species	3
Limacus maculatus	1
Limax cinereoniger	1
Limax sp.	1
Massylaea punica	1
Microxeromagna armillata	5
Mollusca, species	4
Monacha bincinctae	1
Monacha cantiana	6
Monacha cartusiana	31
Monacha cf.	4
Monacha sp.	12
Monachoides glabella	1
Monachoides incarnatus	2
Otala punctata	2
Otala sp.	6
Oxychilus sp.	2
Phenacolimax major	1
Pomacea canaliculata	1
Prietocella barbara	16
Stylommatophora, species	1
Subulina sp.	1
Succinea costaricana	1
Succinea horticola	1
Succinea sp.	2
Theba pisana	62
Trochoidea cretica	7
Trochoidea elegans	3
Trochoidea pyramidata	2
Trochoidea sp.	1
Trochoidea trochoides	2
Vitrinidae, species	1
Xerolenta obvia	3
Xeropicta derbentina	1
Xeropicta protea	3
Xeropicta sp.	1
Xerosecta cespitum	5
Xerotricha conspurcata	399
Zonitidae, species	1

Taxon	Number of Times Intercepted
Weeds	
Asteraceae, species	2
Avena ludoviciana	1
Avena sterilis	1
Azolla pinnata	1
Imperata cylindrica	9
Ipomoea aquatica	1
Oryza sp.	2
Pennisetum polystachion	1
Poaceae, species	2
Saccharum sp.	1
Saccharum spontaneum	5
Setaria sp.	3
Solanum sp.	1
Tridax procumbens	1

Note: Not AQIM data collection.

Table A19-9: Types of Reportable Pests Intercepted on or in Wood Materials during Regular Phytosanitary Inspections of Maritime Cargo Nationwide between January 1985 and May 2007

Pest type	Number of interceptions
Diseases	27
Insects	14,262
Mites	4
Molluscs	978
Weeds	31
Grand Total	**15,301**

Note: Not AQIM data collection.

Many pests belonging to taxa that have been intercepted on WPM are already established and invasive in Hawai'i (Nishida 2002), including the following scolytid beetles (CABI 2006). The tropical nut borer, *Hypothenemus obscurus* (F.), occurs mainly in South and Central America, and attacks eucalyptus, macadamia, coffee and other hosts. The Asian ambrosia beetle, *Xylosandrus crassiusculus* (Motschulsky), is native to Asia, and feeds on coffee, sugarcane, litchi, and a large number of other species. The shot-hole borer, *Xylosandrus compactus* (Eichhoff), is native to Asia, and attacks coffee, cinnamon, and mango, among other plants. The tea shot-hole borer, *Euwallacea fornicatus* (Eichhoff), is also native to Asia; it attacks macadamia, avocado, pomegranate, guava, tea, and many other plants. The island pinhole borer, *Xyleborus perforans* (Wollaston), is native to Asia and Australia, has an immense host range (Gray and Wylie 1974), and has been intercepted by Japan and other countries from imported timber of many species and families (Ohno 1990). The brown twig beetle, *Xylosandrus morigerus* (Blandford), is native to Asia, and invasive in large parts of the world; it is highly polyphagous, feeding on coffee, cocoa, avocado, and teak. Likewise, the bamboo tiger longhorn beetle, *Chlorophorus annularis* (F.) (Cerambycidae), has been introduced and is widespread in Hawai'i (Nishida 2002; CABI 2006).

In a recent pest risk assessment (Stanaway et al. 2001), Australian researchers surveyed the wood floors of empty sea cargo containers for dead and live pests. They found pests in 1,174 out of 3,001 containers, collecting over 7,400 insects belonging to 18 orders and at least 114 families. Most of the time, a container harbored only one or two different pest species. Also found were spiders, isopods, mites, millipedes, centipedes, scorpions, and ticks. Among the insect pests collected were Chinese rose beetle, *Adoretus sinicus* Burmeister, introduced and invasive in Hawai'i, as well as unidentified species of the genera *Hypothenemus*, *Solenopsis*, and *Vespula*. The study concluded that even though the relative frequency of sea cargo containers with wood floors infested with exotic pests is very low, this pathway represents a significant risk due to the immense volume of containers entering ports.

A large number of pests potentially associated with WPM have, not surprisingly, already been introduced into Hawai'i and have established populations there. However, there is still a long list of species from all over the world that are not yet known to occur in Hawai'i, but have the potential to be introduced on or in WPM (Table A19-10). This evaluation concludes that, unless more effective safeguarding measures are introduced, many of these pests may be expected to appear and cause economic, as well as ecological, damage in Hawai'i over the coming years.

Table A19-10: Examples of Insects with Potential to be Introduced into Hawai'i in WPM

Order: Family	Species	Distribution[a]	References
Coleoptera: Bostrichidae	*Heterobostrychus brunneus* (Murray)	sub-Saharan Africa, United States (CA)	Pasek 2000; Haack 2006; Schabel 2006
	Sinoxylon anale Lesne	Australia, Brazil, China, India, Indonesia, New Zealand, Philippines, Saudi Arabia, Southeast Asia, Sri Lanka, United States (CA, FL, MI, NY, OH, PA), Venezuela	Pasek 2000; Teixeira et al. 2002
	Sinoxylon crassum Lesne	East Africa, India, Pakistan, Southeast Asia	Singh and Bhandari 1987; Singh Rathore 1995; Gul and Bajwa 1997; Pasek 2000; Walker 2006
	Xylothrips flavipes (Illiger)	Greece, Madagascar, North Africa, Southeast Asia	Lesne 1900; Pasek 2000; Nardi 2004
Coleoptera: Buprestidae	*Buprestis haemorrhoidalis* Herbst	Canary Islands, Europe, Kazakhstan	Pasek 2000; Löbl and Smetana 2006
	Melanophila cuspidata (Klug)	North Africa, southern Europe	Pasek 2000; Kubán 2004
Coleoptera: Cerambycidae	*Callidiellum rufipenne* (Motschulsky)	China, Italy, Japan, Korea, Russia, Spain, Taiwan, United States (CT, NC, WA)	Hoebeke 1999; Pasek 2000
	Euryscelis suturalis (Olivier)	Caribbean, United States (FL)	Cazier and Lacey 1952; Pasek 2000
	Monochamus alternatus (Hope)	China, Japan, Korea, Laos, Taiwan, Vietnam	Pasek 2000; Kawai et al. 2006
	Plagionotus christophi Kraatz	Japan, Korea, northeastern China, southeastern Central Asia	Cherepanov 1988; Pasek 2000; KFS 2004

Order: Family	Species	Distribution[a]	References
	Pyrrhidium sanguineum (L.)	Europe, North Africa, West Asia	Pasek 2000; Hoskovec and Rejzek 2006
	Stromatium barbatum (F.)	Bangladesh, Burma, East Africa, India, Pakistan	CAB 1985; Pasek 2000
	Xylotrechus grayi (White)	China, Japan, Korea, Taiwan	Pasek 2000; Hua 2002
	Xylotrechus magnicollis (Fairmaire)	Burma, China, India, Laos, Russia, Taiwan	Pasek 2000; Hua 2002
Coleoptera: Curculionidae	*Pissodes pini* (L.)	Russia, western Europe	Kulinich and Orlinskii 1998; Pasek 2000
Coleoptera: Scolytidae	*Carphoborus minimus* (F.)	Italy, Spain, Turkey	Haack 2001
	Carphoborus pini Eichhoff	Italy, Spain	Haack 2001
	Carphoborus rossicus Semenov	Germany	Haack 2001
	Cryphalus asperatus (Gyllenhal)	Germany, Italy	Haack 2001
	Cryphalus piceae (Ratzeburg)	France, Italy	Haack 2001
	Crypturgus cinereus (Herbst)	Australia, Belgium, Germany, Russia, Spain	Haack 2001
	Crypturgus mediterraneus Eichhoff	France, Italy, Netherlands, Portugal, Spain	Haack 2001
	Crypturgus numidicus Ferrari	Estonia, Greece, Latvia, Spain	Haack 2001
	Dryocoetes autographus (Ratzeburg)	Belgium, Brazil, Germany, Italy, Russia	Haack 2001
	Dryocoetes villosus (F.)	Belgium, France, Germany, Italy, United Kingdom	Haack 2001
	Euwallacea validus (Eichhoff) (= *Xyleborus validus* Eichhoff)	Burma, China, Costa Rica, Japan, Korea, Malaysia, Philippines, United States (LA, MD, NY, PA), Vietnam	Pasek 2000; Haack 2001; Cognato 2004a
	Gnathotrichus materiarius (Fitch)	Dominican Republic, United States (OR, SD), western Europe	Mudge et al. 2001
	Hylastes angustatus (Herbst)	Belgium, France	Haack 2001
	Hylastes ater (Paykull)	Chile, France, Germany, Italy, Spain	Haack 2001
	Hylastes attenuatus Erichson	France, Italy, Portugal, South Africa, Spain	Haack 2001
	Hylastes cunicularius Erichson	Belgium, Germany, Italy, Spain	Haack 2001
	Hylastes linearis Erichson	Italy, Portugal, Spain	Haack 2001

Order: Family	Species	Distribution[a]	References
Coleoptera: Scolytidae	*Hylastes opacus* Erichson	Brazil, Canada, Russia, United States (ME, NH, NY, OR, WV)	Mudge et al. 2001; Haack 2001; 2006
	Hylesinus varius (F.)	Belgium, Italy, United Kingdom	Haack 2001
	Hylurgops glabratus (Zetterstedt)	Italy	Haack 2001
	Hylurgops palliatus (Gyllenhal)	Belgium, Germany, Italy, Spain, United Kingdom, United States (PA)	Haack 2001; 2006
	Hylurgus ligniperda (F.)	Chile, France, Italy, Portugal, Spain, United States (NY)	Haack 2001; 2006
	Ips acuminatus (Gyllenhal)	China, France, Italy, Russia, Spain	Haack 2001
	Ips amitinus (Eichhoff)	Finland, Italy	Haack 2001
	Ips cembrae (Heer)	Belgium, China, Germany, Italy	Haack 2001
	Ips mannsfeldi (Wachtl)	Spain, Turkey	Haack 2001
	Ips sexdentatus (Börner)	Belgium, France, Italy, Portugal, Spain	Haack 2001
	Ips typographus (L.)	Belgium, France, Germany, Italy, Russia	Haack 2001
	Orthotomicus erosus (Wollaston)	China, Mediterranean Region, United States (CA), West and Central Asia	Lee et al. 2005
	Orthotomicus laricis (F.)	France, Germany, Italy, Russia, Spain	Haack 2001
	Orthotomicus proximus (Eichhoff)	Finland, Italy	Haack 2001
	Orthotomicus suturalis (Gyllenhal)	Estonia, France, Germany, United Kingdom	Haack 2001
	Phloeosinus rudis Blandford	Belgium, Japan	Haack 2001
	Phloeotribus scarabaeoides (Bernard)	Asia, Mediterranean Region, southern Europe	Pasek 2000; Rodríguez et al. 2003
	Pityogenes bidentatus (Herbst)	France, Germany, Italy, Portugal, Spain, United States (NY)	Haack 2001; 2006
	Pityogenes bistridentatus (Eichhoff)	France, Italy, Spain, Turkey, United Kingdom	Haack 2001
Coleoptera: Scolytidae	*Pityogenes calcaratus* (Eichhoff)	France, Italy, Spain	Haack 2001
	Pityogenes chalcographus (L.)	Belgium, Germany, Italy, Russia, Spain	Haack 2001
	Pityogenes quadridens	Finland, Lithuania,	Haack 2001

Order: Family	Species	Distribution[a]	References
	(Hartig)	Portugal, Spain, Turkey	
	Pityogenes trepanatus (Nordlinger)	Lithuania	Haack 2001
	Pityokteines curvidens (Germar)	France, Greece, Italy	Haack 2001
	Pityokteines spinidens (Reitter)	Austria, France, Germany, Italy, Russia	Haack 2001
	Pityophthorus pityographus (Ratzeburg)	France, Germany, Italy, Netherlands	Haack 2001
	Polygraphus poligraphus (L.)	Belgium, Germany, Italy, Russia, United Kingdom	Haack 2001
	Polygraphus subopacus Thomson	Azerbaijan, Italy	Haack 2001
	Pteleobius vittatus (F.)	Italy	Haack 2001
	Scolytus intricatus (Ratzeburg)	Belgium, France, Germany, Italy	Haack 2001
	Scolytus ratzeburgi Janson	Finland, Russia, Ukraine	Haack 2001
	Scolytus scolytus (F.)	United Kingdom	Haack 2001
	Taphrorychus bicolor (Herbst)	Belgium, Finland, France, Germany, Netherlands	Haack 2001
	Taphrorychus villifrons (Dufour)	Belgium, France, Germany, Latvia, Turkey	Haack 2001
	Tomicus minor (Hartig)	Brazil, Italy, New Zealand, Turkey	Haack 2001
	Tomicus piniperda (L.)	Belgium, France, Italy, Spain, United Kingdom, United States (OH)	Haack 2001; 2006
	Trypodendron domesticum (L.)	Italy, Turkey	Haack 2001
	Trypodendron signatum (F.)	Belgium, France, Germany, Netherlands	Haack 2001
Coleoptera: Scolytidae	*Xyleborinus alni* (Niisima)	Austria, former Czechoslovakia, Germany, Japan, Poland, Russia, United States (OR, WA)	Mudge et al. 2001
	Xyleborus californicus Wood	Canada, Russia, United States (AR, CA, DE, MD, OR, SC)	Mudge et al. 2001
	Xyleborus eurygraphus (Ratzeburg)	North Africa, southern and western Europe, Turkey	Haack 2001; Cognato 2004b
	Xyleborus pfeili (Ratzeburg)	Africa, Asia, Europe, New Zealand, United States (MD, OR)	Mudge et al. 2001
	Xyleborus similis Ferrari	Africa, Asia, Australia, Micronesia, United States (TX)	Wood 1960; Rabaglia et al. 2006

Order: Family	Species	Distribution[a]	References
	Xyleborus xylographus (Say)	Canada, Caribbean, United States (CA, OR)	Mudge et al. 2001
	Xylechinus pilosus (Ratzeburg)	Europe	Haack 2001; Alonso-Zarazaga 2004
	Xyloterinus politus (Say)	Canada, United States (WA)	Mudge et al. 2001
Hymenoptera: Siricidae	*Sirex noctilio* F.	Australia, Italy, New Zealand, South Africa, Spain, United States (NY)	Hoebeke et al. 2005
Hymenoptera: Xiphydriidae	*Xiphydria prolongata* (Geoffroy)	Russia, United States (MI, NJ, OR), western Europe	Mudge et al. 2001
Isoptera: Rhinotermitidae	*Coptotermes crassus* Snyder	Mexico, Central America	Constantino 1998; Pasek 2000

[a] U.S. state abbreviations: AR = Arkansas, CA = California, CT = Connecticut, DE = Delaware, FL = Florida, LA = Louisiana, MD = Maryland, ME = Maine, MI = Michigan, NC = North Carolina, NH = New Hampshire, NJ = New Jersey, NY = New York, OH = Ohio, OR = Oregon, PA = Pennsylvania, SC = South Carolina, SD = South Dakota, TX = Texas, WA = Washington, WV = West Virginia

A19.1 SUMMARY

- Hawai'i receives cargo with WPM from numerous countries all over the world.
- WPM is routinely reused and reconditioned, so that its origin usually cannot be determined.
- The effectiveness of the International Standard, ISPM #15, has not been demonstrated.
- An unfortunate lack of suitable data makes it impossible precisely to quantify the likelihood of introducing exotic pests into Hawai'i on or in WPM. However, it is likely that considerable numbers of pests have been entering Hawai'i in WPM.
- Inspectors at ports-of-entry in Hawai'i intercept only a small fraction of these pests.
- Many exotic species that have been intercepted on WPM have already established populations in Hawai'i, where they attack many economically or ecologically important hosts.
- A significant number of insects worldwide are imminent pests for Hawai'i with a potential for introduction via the WPM pathway.

A20 THE MILITARY

A20.1 MILITARY PRESENCE IN HAWAI'I

Because of its Central Pacific location, Hawai'i has been of strategic importance for more than half a century, hence the large military presence (Kelly 1998b). Almost 100,000 military personnel and their dependents made up 8% of Hawai'i's population in 1994 (Kelly 1998b), the highest proportion of any state in the country. Military expenditures of $3.2 billion in 1994 accounted for 9% of the gross state product (Kelly 1998b). In 2004, defense spending was $4.8 billion (HDBEDT 2007). The military employed 17,000 civilians, almost 3% of Hawai'i's workforce, with an annual payroll of $670 million in 1994. All five services were represented: Army personnel made up 44%, Navy 25%, Marine Corps 16%, Air Force 12%, and Coast Guard 3% of the total. The Hawai'i National Guard accounted for almost 5,000 residents. The military reduced active duty personnel in Hawai'i by 28%, from 61,019 in 1980 to 44,193 in 1994. Most military personnel in Hawai'i are stationed on the island of Oahu, with fewer than 200 active duty personnel assigned to other islands. There are about 100 military installations in the islands. Seventy-eight percent (78%) of personnel are stationed at four: Schofield Barracks, Pearl Harbor, Marine Corps Base Hawai'i (MCBH), and Hickam Air Force Base (AFB), all on Oahu. Seventy-seven percent (77%) of civilian personnel work at Pearl Harbor, Hickam AFB, Tripler Army Hospital, and Fort Shafter Army Base (Kelly 1998b). Approximately 12,000 military members and their families move to and from Hawai'i each year (USPACOM, 1998).

In 1998, the United States Pacific Command (USPACOM) reported 57,987 military and 22,984 civilian personnel in Hawai'i (excluding Air Guard) (USPACOM 1998). The 2000 United States Census recorded 39,036 military personnel in Hawai'i (Clark and Weismantle 2003). Despite declines in personnel, the military budget in Hawai'i increased from $862 million in 1977 to $3.2 billion in 1994 (Kelly 1998b).

A20.1.1 United States Pacific Command

The headquarters for the USPACOM Army, Navy, Air Force, and Marine Corps are located on Oahu. USPACOM's area of responsibility (AOR) extends from the west coast of the continental United States to the eastern shores of Africa, and covers over 700 million km^2, about half of the Earth's surface. There are 43 countries with over 60% of the world's population in this area. It contains countries with the world's six largest armed forces: People's Republic of China, Russia, United States, India, North Korea, and South Korea. Five of seven U.S. mutual defense treaties are with nations in the AOR. In 1998, the command had about 300,000 military personnel deployed, about one-fifth of the total U.S. active duty military force (USPACOM 1998). Most of the military traffic from the Pacific Region to Hawai'i is from Guam, Japan, and Korea (Simon 2006b).

In addition, four sub-unified commands report to USPACOM: U.S. Forces Korea, U.S. Forces Japan, Special Operations Command Pacific at Camp Smith, and the Alaskan Command. USPACOM deploys about 100,000 forward forces in the western Pacific, Japan, Korea, and Guam. A second tier of forward forces is based in Hawai'i and Alaska (USPACOM 1998).

The U.S. Navy Pacific Fleet, headquartered at Makalapa Crater near Pearl Harbor, is the world's largest naval command, with nearly half of the Navy's total strength. It is active in the Arctic, Indian, and Pacific oceans, and conducts more than 200 peacetime exercises per year. In 1998, the fleet had 190 ships, 1,400 Navy and Marine Corps aircraft, 222,000 Navy and Marine Corps personnel, and 38 shore installations. It employed 519 military and 230 civilian personnel in Hawai'i, on a payroll of $30 million and $10 million, respectively. The total annual budget in Hawai'i was $405 million (USPACOM 1998).

The U.S. Army Pacific Command (USARPAC) is headquartered at Fort Shafter. It has command and control of U.S. Army forces in the Pacific, except those in Korea. Terrain in the AOR varies from arid deserts and tropical rain forests to arctic tundra. Soldiers are based on the U.S. mainland (including Alaska), Hawai'i, Guam, American Samoa, the CNMI, and Japan (USPACOM 1998).

Marine Forces Pacific (MARFORPAC) is the largest field command in the U.S. Marine Corps, deployed both ashore and afloat. It is led by the Marine Force Commander. Combat and support forces were more than 80,000 strong in 1998. There are two major subordinate commands: First Marine Expeditionary Force, headquartered in California, and the Third Marine Expeditionary Force, headquartered in Japan. An air-ground-logistics team, which numbered 6,800 marines and sailors in 1998, is also located at MCBH, Kaneohe Bay (USPACOM 1998).

Air Force Pacific (PACAF), the air component of USPACOM, is headquartered at Hickam AFB. It is responsible for most Air Force units, bases, and facilities in the Pacific and Alaska. The command employs military and civilian personnel in nine major locations and numerous smaller ones, primarily in Hawai'i, Alaska, Japan, Guam, and South Korea. In 1998, about 300 fighter and attack aircraft were assigned to the command. There were 45,930 personnel, with 32,682 on active duty, 5,051 reserve components, and 8,197 civilians. Flying hours were 10,195 per month (USPACOM,1998). PACAF has about 100 bases in the Pacific (Spears 2007).

A20.1.2 Military Establishments in Hawai'i

The United States Department of Defense (DoD) listed 63 military installations in Hawai'i in 2004, covering 9,783 hectares and broken down as follows: Army: 20 installations totaling 3,327 hectares; Air Force: 6 installations totaling 1,331 hectares; Marine Corps: 6 installations totaling 1,290 hectares; and Navy: 31 installations totaling 3,835 hectares (DoD 2004). This account contradicts the Hawai'i Military Installation Area Handbook (USPACOM 1998), which listed land controlled by the military in Hawai'i in 1998 as 21,230 hectares on Oahu, 34,333 hectares on the island of Hawai'i, 779 hectares on Kauai, 44 hectares on Kaula (an islet about 32 km southwest of Niihau), 5 hectares on Molokai, and 2 hectares on Maui, totaling 56,393 hectares and comprising 3.4% of the total land area of the state. The reason for the discrepancy is unknown.

A20.2 REGULATIONS

DoD 4500.9-R, Defense Transportation Regulation Part V, Department of Defense Customs and Border Clearance Policies and Procedures, maintains the integrity of the defense transportation system. It prescribes procedures, defines responsibilities, and identifies agricultural requirements for entry into, and exit from, selected countries of the world in support of U.S. forces (DoD and APHIS, 2006). Chapter 505 covers agricultural cleaning and inspection requirements. Chapter 506 includes the DoD pre-clearance program, and Chapter 507 includes the military customs inspector program (USTC 2006a; b; c). The inter-service publication, *Quarantine Regulations of the Armed Forces* (Howard et al. 1992), defines DoD quarantine policies and procedures related to agriculture. In addition, the following combatant commands issue directives outlining customs and border clearance guidance: United States European Command (Directive 30-3); United States Central Command (Regulation 600-10); and USPACOM (Instruction 5840.3, Military Customs Inspection within the USPACOM). These publications establish policy, procedures, and responsibilities for compliance with U.S. and host nation customs laws. The DoD must assist and cooperate with other federal agencies when enforcing U.S. laws, regulations, and agricultural customs requirements without unnecessarily delaying the movement of DoD personnel and material. CBP and APHIS-PPQ are required to report promptly all detections of plant pests, diseases, and soil to DoD's executive agent, the United States Transportation Command (USTRANSCOM), for resolution (DoD and APHIS 2006).

The quarantine regulations of the armed forces require the forces to cooperate fully with other agencies and comply with the regulations above. APHIS-PPQ and CBP inspectors are authorized to board ships, aircraft, and other conveyances, and to inspect ports and other facilities. Commanders are required to provide full support for inspections. Cooperation with foreign officials, following applicable host country agreements, is also required. All examinations are subject to necessary restrictions to preserve the security of classified material (Howard et al. 1992).

The armed forces must comply with applicable regulations published by other federal agencies governing the movement of pathogens, other pests, wildlife, and arthropod vectors. Commanders of all echelons are responsible within their jurisdictions. They must be cognizant of, and comply with, provisions of the DoD directive 5030.49-R, Customs Inspection, and requirements of the Military Customs Inspection Program. Coordination at the department level is provided by the Armed Forces Pest Management Board (Howard et al. 1992).

A20.3 COOPERATION BETWEEN APHIS-PPQ AND THE DEPARTMENT OF DEFENSE

APHIS-PPQ and DoD have cooperated for over 30 years to safeguard U.S. agriculture and natural resources from plant pests and diseases, invasive species, and noxious weeds that might be harbored aboard returning aircraft and other vessels, both military and civilian (DoD and APHIS 2006). APHIS program duties include facilitating pathway analyses (DoD and APHIS 2006). Appropriate armed forces commanders are required to liaise with local representatives of PPQ (Howard et al. 1992).

The two agencies have a MOU, the current version of which was signed on May 5, 2006, and is to continue for 5 years from the date of signing. Concerns include troops, mail, and material, such as rolling stock, aircraft, assault vessels, household goods, ordnance, weapons, containerized cargo, and vehicles in support of contingency or wartime emergencies, the Joint Chiefs of Staff, special operations, and other military-sponsored exercises. More recently, WPM has been targeted for inspection (DoD and APHIS 2006).

APHIS-PPQ fulfills the objectives of the military agricultural pre-clearance inspection program in cooperation with DoD. PPQ works with DoD to establish permanent pre-clearance positions for combatant commands and, when appropriate, to provide local coordination and services to the military's agricultural pre-clearance inspection program. The MOU requires PPQ and DoD to make military agricultural pre-clearance inspection equivalent at all locations (DoD and APHIS 2006). Permanent PPQ pre-clearance positions are established at two combatant commands: the Central Command and the European Command (DoD and APHIS 2006). Despite having the largest military presence of any of the theaters, the Pacific Command does not have a permanent PPQ pre-clearance position.

A20.4 TRAINING

APHIS-PPQ cooperates with DoD to train military personnel in agricultural inspection procedures and requirements within the United States prior to their deployment overseas. This activity is coordinated with the DoD USTRANSCOM and occurs at the APHIS training facility in Frederick, Maryland, or at other locations as determined mutually by the two agencies (DoD and APHIS, 2006). Manuals and guidelines providing training for military cooperators (USDA 2002; 2003a) and options for soil treatment (USDA 2004) have been published.

A20.5 RESEARCH AND DEVELOPMENT

The MOU between DoD and APHIS-PPQ requires cooperation in research and methods development. Efforts include identifying data gaps that hinder effective pest risk and pathway analyses, and perfecting laboratory analysis of soil to detect pests, such as noxious weed seeds, nematodes, pathogens, snails, and insects (DoD and APHIS, 2006).

A20.6 RESPONSIBILITIES OF THE AGENCIES

APHIS-PPQ has general phytosanitary requirements regarding all ships and aircraft, including their cargo, stores, garbage, and baggage arriving in the continental United States from any outside location, including Hawai'i. All are subject to inspection by PPQ. When inspection discloses items prohibited or restricted by quarantine regulations, reveals a plant or animal pest, or when there is reason to presume such a pest is present, an inspector may take one of several actions, such as re-export or destruction of the items (Howard et al. 1992).

Air installation commanders or commanding officers of ships must ensure that all actions are taken to comply with PPQ requirements and regulations governing the handling or disposition of baggage, cargo, stores, and garbage. Garbage must be placed in leak-proof, covered containers and disposed of following port procedures authorized by, or under surveillance of, PPQ. Disposal facilities to incinerate or sterilize regulated garbage or other food materials of foreign origin are required (Howard et al. 1992).

CBP inspects non-propagative materials arriving from foreign countries, whereas PPQ inspects foreign propagative material. The HDOA PQ inspects foreign trade goods only if referred to them by CBP. HDOA has no authority to inspect mail or foreign goods not referred to it by CBP (Spears 2007). CBP is responsible for clearing aircraft arriving at Hickam AFB and Barber's Point Naval Air Station. CBP inspects all foreign (including military) traffic, using the Manual for Agricultural Clearance (USDA 2006c).

CBP has no jurisdiction in Guam. There is no general pre-clearance for military shipments or personnel leaving Guam. APHIS-WS performs pre-clearance inspections for BTS. All agricultural inspection is done at the first port of arrival in the U.S. mainland or in Hawai'i (Spears 2007).

HDOA PQ involvement in military inspection primarily entails the use of dog teams to detect BTS on aircraft arriving from Guam, Saipan, and northern Australia. For other inspections, PQ becomes involved only if requested, usually when prohibited items, such as exotic pets, or pests are detected in military cargo or personal effects.

DoD official control of pests in Hawai'i is facilitated through the cooperation of island invasive species committees, which have been formed on Kauai, Oahu, Molokai, Maui, and the Big Island (HEAR 2007). The Coordinating Group for Alien Pest Species governs the invasive species committees. The Hawai'i Invasive Species Council is a government body, at the governor's cabinet level, established by the Legislature of the State of Hawai'i with authority to provide funding and establish state policy for invasive species.

A20.7 MILITARY PATHWAYS FOR POTENTIAL INVASIVE SPECIES INTRODUCTION

A20.7.1 Aircraft

All Navy and Marine aircraft in Hawai'i are based at MCBH on Oahu (Simon 2006b). Table A20-1 summarizes aircraft arrivals at MCBH in 2006. The majority of aircraft arriving at MCBH (48%) originated on the U.S. mainland. Thirty-four percent (34%) came from locations within Hawai'i, and fewer than 1% from U.S. ships at sea. Only 18% arrived from foreign areas, including U.S. territories. Most of these aircraft came from Guam, Japan, Wake Island, and the Marshall Islands.

Table A20-1: Origin of Aircraft Arrivals at MCBH during Calendar Year 2006

Origin	Number
Continental United States	255
Hawai'i (other locations)	182
Guam	24
Japan	24
Wake Island	21
Marshall Islands	15
U.S. ships	4
Canada	3
Korea	3
Christmas Island	2
American Samoa	2
Iceland	1
Total	536

Source: Dinic 2007

A total of 536 aircraft carried 7,658 crew members, 10,210 other active duty passengers, and 2,076 non-duty or retired military members for a total of 19,944 passengers arriving in Hawai'i during 2006. In total, 298,469 kg of baggage and 1,188,222 kg of cargo were carried by these flights (Dinic 2007).

CBP inspects cargo on all military aircraft arriving from foreign areas, including Guam, at MCBH and Hickam AFB (Simon 2006b). The agency is given as little as 2 hours advance notice of foreign aircraft arrivals. Of primary concern to the military is the potential for introduction of BTS in flights from Guam; West Nile virus and coqui frog are also concerns. BTS often is found in the vicinity of military installations and equipment in Guam. For example, in February 2007, APHIS-WS personnel trapped 272 snakes around the perimeter of the Guam airfield (Salas 2007). All cargo and aircraft destined for Hawai'i are inspected with the help of specially trained detector dogs. There are 13 dog teams, 10 of which are at Anderson AFB and 3 at the naval station. Transiting aircraft remaining in Guam longer than 3 hours are inspected (Spears 2007). Further, HDOA inspects every flight arriving in Hawai'i from Guam for BTS (Simon 2006b; Spears 2007).

Personnel arriving from overseas are required to remain aboard aircraft until they are inspected by CBP, HDOA, and APHIS. Inspection of air crews sometimes is waived by CBP. Passengers arriving from the U.S. mainland are not inspected, but are required to complete a declaration form (Spears 2007).

Table A20-2 presents insect interceptions in military air cargo entering Hawai'i. All are classified as hitchhikers, since they were found on non-food items.

Table A20-2: Insect Interceptions in Military Air Cargo Entering Hawai'i

Family	Species	Where Intercepted	Date	Stage	Origin	Known to Occur in Hawai'i
Psychidae	*Apterona helix* (Siebold)	Private vehicle	03-Jan-99	Larva	California	No
Otitidae	*Ceroxys latiusculus* (Loew)	Pallet	16-Oct-98	Adult	California	Yes
Carabidae	*Gnathaphanus picipes* (Macleay)	Crates	03-Apr-97	Adult	Midway Island	Yes
Staphylinidae	*Philonthus turbidus* Erichson	Crates	03-Apr-97	Adult	Midway Island	Yes
Scarabaeidae	*Popillia japonica* Newman	Cargo deck	20-Jul-04	Adult	Kadena, Japan	No
Curculionidae	Unknown sp.	Private vehicle	03-Jan-99	Adult	California	No

Source: HDOA 2007c

Army air traffic arrives at Wheeler Army Airfield and Schofield Barracks. All arrivals at Wheeler are domestic, and are primarily transiting to Afghanistan and Iraq. CBP inspects the aircraft arriving from the U.S. mainland, whereas APHIS-PPQ inspects flights outbound to the mainland. Foreign flights land and are inspected at Hickam AFB (Spears 2007).

CBP inspects Navy and Coast Guard aircraft landing at Barber's Point Naval Air Station (now closed and returned to the State of Hawai'i). A major concern is the potential for aircraft from carriers arriving from foreign locations to introduce pests (Spears 2007).

No foreign vessels or flights are permitted to arrive at the Pacific Missile Range Facility at Barking Sands on Kauai. They arrive on Oahu first to be inspected and cleared. Flights that are precleared on the U.S. mainland may proceed directly to the Pacific Missile Range Facility (Burger 2007).

On Guam, military passengers arrive on contract flights at Anderson AFB. Inbound Navy aircraft may not give advance notification to the Guam Customs and Quarantine Agency, in which case, passengers disembark without being cleared. There also have been reports of Marine and Navy cargo aircraft opening holds before being cleared (Spears 2007). This is of significance to Hawai'i because any pests that become established on Guam are an imminent threat to Hawai'i.

A20.7.2 Ships

Large vessels periodically arrive at Pearl Harbor Naval Base (Simon 2006b). Upon arrival, Form 288, the ship arrival form, is completed (Spears 2007). Between the beginning of 2003 and May 20, 2007, 122 ships arrived at the base from 14 foreign countries (Table A20-3). The largest proportion of arrivals (38%) originated in Japan, followed by 16% from Canada, 10% from Australia, 8% from Mexico, and 7% from South Korea. Ships arriving from other countries comprised 21% (Sloane 2007).

Table A20-3: Origin of Foreign Ship Arrivals at Pearl Harbor Naval Base from January 1, 2003 to May 20, 2007

Year	2003	2004	2005	2006	2007	Total
Country	Number					
Japan	5	18	12	11		46
Canada	3	7	3	5	2	20
Australia	2	8		2		12
Mexico	1	0	7	2		10
South Korea		9				9
Chile		2		3		5
Russia	2					5
North Korea				4		4
France	1	1		1		3
Netherlands				2		2
Peru		1	1			2
Taiwan				2		2
Indonesia					1	1
Sweden			1			1
Total	14	46	24	32	3	122

Source: Sloane 2007

Commanders of fully active foreign military vessels arriving in Hawai'i may be reluctant to permit CBP inspectors onboard, with the result that these vessels may not always be fully inspected. Ships arriving from the U.S. mainland are not required to disclose any foreign ports-of-call visited earlier. The origin of stores procured for U.S. ships is not always known (Spears 2007).

A20.7.3 Material

Military cargo is difficult to track because of its complex nature, consisting of many types of goods and other materials. Although most items arriving in Hawai'i have been free of foreign contaminants, such as soil (Simon 2006a; b), there remains the potential for contaminated cargo or equipment to enter the state as has occurred elsewhere. For example, there were 984 instances of violations of Air Force quarantine regulations involving cargo shipments arriving at Dover AFB in Delaware and McGuire AFB in New Jersey between 2003 and 2006. Most of the cases involved rolling stock, pallets, and aircraft contaminated with soil. Military transports may carry cargo that is classified as not inspected, also a violation of quarantine regulations (Spears 2007).

Vehicles may enter Hawai'i from any of the 43 countries in the Pacific command as well as from the Middle East (Spears 2007). Marine material and vehicles come through Hickam AFB or Pearl Harbor (Bookless 2007).

Military cargo arriving in Guam, some of which may be classified, is not subject to inspection. Most rolling stock arrives on naval ships. It occasionally has been contaminated with soil, thus posing a risk of introducing pest organisms. Facilities in Guam for cleaning rolling stock are inadequate. Aircraft arriving in Guam are inspected only if they are carrying food items (Spears 2007).

A20.7.4 Stores and Garbage

The MOU directs APHIS and CBP to prepare and implement compliance agreements with DoD to regulate in-flight meals on air cargo flights (DoD and APHIS 2006). Crew members aboard naval vessels are instructed to consume prohibited products before arrival. Foreign military commanders are informed about the stores and garbage that can be removed from their vessels. Garbage composed of discarded fruit and vegetable material (wet garbage) is considered a high risk (Spears 2007).

DoD is responsible for the proper handling of USDA-regulated garbage aboard military conveyances arriving in the United States. Regulated garbage is restricted to prevent the introduction of plant pests and pathogens, and includes plant material that has been aboard any conveyance outside of the United States, except Canada (DoD and APHIS 2006). Special dumpsters are used for the disposal of trash from ships arriving from overseas. Honolulu Disposal, a civilian contractor, handles refuse from Navy ships, and incinerates it at its facility. After use, dumpsters are treated with bleach to sanitize them (Spears 2007).

Barber's Point Coast Guard Air Station, Hickam AFB, and MCBH have approved facilities for handling garbage arriving on aircraft from foreign points (USDA 2006c). Honolulu Biowaste, a civilian contractor, handles refuse for the Air Force. Garbage from foreign aircraft is double-bagged and steamed-sterilized (Spears 2007).

Regulated garbage arriving in Guam on military flights from Japan, Taiwan, and the Philippines is collected and deposited in special bins. Food from aircraft is inspected by Guam Customs and Quarantine (Spears 2007).

A20.7.5 Produce and Propagative Materials

Most of the produce destined for military commissaries comes through California; some may originate from foreign sources. HDOA regards this as a deficiency in agricultural safeguarding in Hawai'i, as produce coming through the U.S. mainland from foreign sources may harbor exotic pests. All produce, including that of foreign origin, must be precleared on the mainland (Spears 2007).

All produce for military commissaries on Guam originates in the mainland United States. Inspectors in Guam occasionally have detected small insects, such thrips and aphids, in produce shipped from the mainland. Produce of foreign origin found to be harboring pests is destroyed or re-exported (Spears 2007).

Military transports and cargo transiting Hawai'i en route to other Pacific islands, including Guam, are not inspected or precleared by APHIS-PPQ in Hawai'i (Spears 2007). Military exchanges on Guam import plants for propagation and freshly cut Christmas trees from the U.S. mainland. These practices allow for the potential introduction and establishment of alien species in Guam, which subsequently could enter Hawai'i via the military traffic between the two areas.

A20.7.6 Household Goods

The military customs inspection program for household goods was discontinued in the mid-1990s. Responsibility for inspection of household good was shifted to the owner (Spears 2007). The effectiveness of such self-inspections is unknown (Egan 2007). Household goods of military members are shipped through a commercial port-of-entry, where they are inspected. In Hawai'i, household goods are cleared at Sand Island, Honolulu (Bookless 2007; Spears 2007). The greatest risks associated with household goods, such as those shipped in van-packs, are the potential presence of hitchhiking pests and soil contamination.

A20.8 REDEPLOYMENT AND MILITARY EXERCISES

The frequent redeployment of troops and equipment into the United States from foreign regions potentially creates a major pathway for introduction of alien species. The MOU requires that any aircraft or ocean vessel presented for loading precleared cargo will be clean and substantially free from pests (DoD and APHIS 2006). Military quarantine regulations outline measures, such as surveillance and disinfection, to be used to reduce the risks of pest introduction (Howard et al. 1992).

A21 A SAMPLING OF IMMINENT PEST THREATS TO HAWAI'I

A21.1 ARTHROPODS

An average of about 20 exotic, terrestrial arthropods becomes established in Hawai'i every year (Beardsley 1979), a rate of introduction matching or exceeding that for the entire continental United States (Beardsley 1962). The latest period reported, July 1, 2005 to June 30, 2006, was typical, and saw the detection of 18 arthropods new to the state (HDOA 2006). Only a small proportion of these immigrants attains pest status in Hawai'i, causing economic harm and necessitating the implementation of control measures. There remain, however, numerous, as-yet unintroduced arthropod species that constitute major threats to the state's economy and natural environment. Some of those regarded as most significant, in terms of potential economic or ecological impact, are discussed below.

A21.1.1 Aleurodicus pulvinatus (Maskell) (Homoptera: Aleyrodidae)

This whitefly is known only from the New World tropics (Martin and Watson 1998). Distributional records include Belize, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Guyana, Honduras, Mexico, Nicaragua, Panama, Peru, Nevis, St. Kitts, Surinam, Trinidad, and Venezuela. The host range of *A. pulvinatus* is quite broad. Hosts include *Cocos nucifera* (Arecaceae), *Psidium guajav*a (Myrtaceae), *Coffea canephora* (Rubiaceae), *Coccoloba* spp. (Polygonaceae), *Persea americana* (Lauraceae), *Piper nigrum* (Piperaceae), *Hura crepitans* (Euphorbiaceae), *Lacistema* sp. (Lacistemataceae), *Vismia* sp. (Clusiaceae) (Martin and Watson 1998); *Echinodorus* sp. (Alismataceae), *Montrichardia arborescens* (Araceae), *Chrysobalanus icaco* (Chrysobalanaceae), *Terminalia catappa* (Combretaceae), *Ficus* sp. (Moraceae), *Musa* sp. (Musaceae), *Theobroma* sp. (Sterculiaceae), and *Petrea* sp. (Verbenaceae) (Kairo et al. 2001).

As an indication of the species' invasiveness, recent surveys suggest that it is expanding its geographical range in the Caribbean, the most likely mode of spread being the movement of nursery plants (Kairo et al. 2001). The whitefly (as *A. iridescens* Cockerell) has been intercepted at U.S. ports on 17 occasions since 1985 on various commodities, including ornamentals, from several countries (PIN 309a). It is a major pest of coconut palm in the West Indies (Martin and Watson 1998). Damage caused by *A. pulvinatus* is typical of that caused by whiteflies in general (Mound and Halsey 1978). Feeding by nymphs reduces plant vigor, and the sooty molds that grow in excreted honeydew coating leaf surfaces interfere with photosynthesis, further reducing plant fitness; aesthetic concerns also are raised by the unsightly appearance of infestations on valuable ornamental plants (Kairo et al. 2001). Although no studies have been carried out to quantify losses, the economic impact of this pest is thought potentially to be high. Apart from the loss of plants and costs of their replacement, there have been the high costs of control measures, and potentially adverse effects on the environment and on tourism (Kairo et al. 2001). The whitefly also is regarded as a minor pest of guava (Gould and Raga 2002). Given its history as a pest of coconut in the West Indies, and the importance of this palm, as an ornamental plant (Neal 1965), to economies dependent on tourism, such as Hawai'i, it poses a significant risk to the state. Introduction of the whitefly could result in the initiation of biological control programs, similar to what has occurred in response to introductions of other whitefly species (e.g., Clausen 1978a). Such programs would have the potential to perturb Hawai'i's native ecosystems by affecting non-target species (e.g. Howarth, 1991).

A21.1.2 Anastrepha bahiensis Lima (Diptera: Tephritidae)

The geographic distribution of *A. bahiensis* comprises tropical America. It has been reported from Brazil, Colombia, Panama, Trinidad (White and Elson-Harris 1992); Peru (Korytkowski and Ojeda 1968); and Mexico (Hernández-Ortiz and Pérez-Alonso 1993). Hosts include *Juglans neotropica* and *J. regia* (Juglandaceae), *Coffea arabica* (Rubiaceae) (White and Elson-Harris 1992); *Brosimum alicastrum*, *Pseudolmedia oxyphyllaria*, *Pouroma cecropiaefolia* (Moraceae) (Hernández-Ortiz and Pérez-Alonso 1993; Zucchi et al. 1996); *Spondias mombin* (Anacardiaceae), *Psidium guajava* (Myrtaceae) (Sommeijer 1975); and *Eugenia variabilis* (Myrtaceae) (Norrbom and Kim 1988).

Guava is considered almost a universal host for fruit-infesting Tephritidae (Gould and Raga 2002). The tree is widespread in Hawai'i (Wagner et al. 1999), and could facilitate the spread of this pest throughout the state. Information on the reproductive biology of *A. bahiensis* is unavailable. Fecundity of other species of *Anastrepha* ranges from 200 to about 1,500 eggs per female, and several generations per year are typical (White and Elson-Harris 1992). Adults of *Anastrepha* species may fly as far as 135 km (84 miles); flight thus can be an important means of spread (CABI 2006). The major means of dispersal to previously uninfested areas is the transport, in international trade, of fruit containing larvae. Puparia also may be disseminated, concealed in packing materials accompanying produce. Since 1984, specimens of *Anastrepha* spp. have been intercepted at U.S. ports on well over 38,000 occasions (PIN 309a). If the biology of *A. bahiensis* is similar to that of related species, its reproductive and dispersal potentials could be high. The fly represents a potential threat to crops in Hawai'i, such as coffee and guava, and, because it attacks a related species, to the endemic plant, *Eugenia koolauensis* (nioi), listed as Endangered in 50 CFR § 17.12). Introduction of the pest into Hawai'i also could result in the initiation of chemical or biological control programs, with potential ecological consequences. Insecticides for the control of fruit flies, such as *Anastrepha* spp., are used almost everywhere that guavas are grown commercially (Gould and Raga 2002). *Anastrepha* spp. also have been the targets for biological control programs, with some measure of success (Clausen 1978b).

A21.1.3 Anastrepha fraterculus Wiedemann (Diptera: Tephritidae)

The name *A. fraterculus* apparently represents a species complex that is as yet little studied (CABI 2006). This group ranges from temporary populations in the south of Texas to Argentina (Foote et al. 1993). *Anastrepha fraterculus* is extremely polyphagous. Preferred hosts are Myrtaceae, including *Eugenia* and *Syzygium* spp. (CABI 2006). A few of the species' many other hosts are *Terminalia catappa* (Combretaceae), *Malus pumila* and *Prunus* spp. (Rosaceae), *Annona* spp. (Annonaceae), *Citrus* spp. (Rutaceae), *Coffea* spp. (Rubiaceae), *Ficus carica* (Moraceae), *Juglans* spp. (Juglandaceae), *Diospyros kaki* (Ebenaceae), *Manilkara zapota* (Sapotaceae), *Persea americana* (Lauraceae), *Solanum quitoense* (Solanaceae), *Theobroma cacao* (Sterculiaceae), *Olea europaea* (Oleaceae), and *Vitis vinifera* (Vitaceae).

Guava is listed by Aluja et al. (1987) among natural hosts of the fly. Fecundity ranges from 200 to 400 eggs per female (White and Elson-Harris 1992). The species is multivoltine, there being several generations per year (Fletcher 1989a). Long-distance dispersal has not been reported for adults of *A. fraterculus*. The major means for introducing the species to previously uninfested areas is the transport, in international trade, of fruit containing larvae; for most regions, the most important fruits likely to be infested by this species are mango and guava (CABI 2006). *Anastrepha fraterculus* is the most economically important species of *Anastrepha* in Brazil and other South American countries because of its broad host range (Foote et al. 1993). In Brazil, where it causes severe yield losses in apple, the pest is of major concern to growers, and represents a significant constraint to fresh fruit export into countries with quarantine barriers (Sugayama et al. 1996). The insect also is an important pest of guava and mango, and to some extent of *Citrus* and *Prunus* spp. (CABI 2006). Even if eggs are not deposited in guava fruit, or do not hatch, the oviposition punctures (stings) may render fruit unmarketable (Gould and Raga 2002). *Anastrepha fraterculus* is a quarantine pest for Chile, Argentina, New Zealand, Turkey, China, and eastern and southern Africa (EPPO 2005a); thus, its introduction could result in a loss of domestic or foreign markets for Hawai'ian-grown commodities, such as citrus, mango, and avocado. In Peru, hot water is used as a quarantine treatment for mango exported to the United States (Sharp and Picho 1990), which increases production costs. *Anastrepha fraterculus* is a potential threat to native plants in Hawai'i listed as threatened or endangered (50 CFR § 17.12), such as *Eugenia koolauensis*, *Solanum incompletum* (popolo ku mai), and *S. sandwicense* (aiakeakua, popo lo). Its introduction into the state likely would lead to the employment of biological or chemical controls, as has occurred elsewhere (Clausen 1978b; Gould and Raga 2002).

A21.1.4 Anastrepha ludens (Loew) (Diptera: Tephritidae)

Originally native to Mexico, *A. ludens* presently occurs from southern Texas (temporary populations) to Costa Rica (Foote et al. 1993). This is the only important *Anastrepha* species that ranges more into subtropical regions, occupying the more northern portion of the range of the genus and extending southward only at higher elevations; the fly is said to be able to withstand freezing weather well (Weems 1963). Primary hosts are *Citrus* spp. (Rutaceae), *Mangifera indica* (Anacardiaceae), and *Prunus persica* (Rosaceae) (CABI 2006). Other hosts include *Annona* spp. (Annonaceae), *Coffea arabica* (Rubiaceae), *Passiflora edulis* (Passifloraceae), *Carica papaya* (Caricaceae), *Mammea americana* (Clusiaceae), *Musa* sp. (Musaceae), *Opuntia* sp. (Cactaceae), *Persea americana* (Lauraceae), *Pouteria sapota* (Sapotaceae), *Psidium guajava* (Myrtaceae), *Cucurbita* sp. (Cucurbitaceae), and *Inga* spp. (Fabaceae) (Norrbom and Kim 1988), several of which are economically or otherwise important in Hawai'i.

Fecundity is reported to range between 40 and 1,600 eggs per female (Liedo and Carey 1996). There are four to eight generations per year (Aluja 1993). A flight range of at least 36 km (22 miles) has been reported, and the regular appearance of adults in Texas at least 135 km (84 miles) from known breeding sites in Mexico suggests that the migratory powers of the species are considerably greater (Fletcher 1989b). Similar to other *Anastrepha* species, the major means of dispersal to previously uninfested areas is the transport of fruit, such as citrus and mango, and to a lesser extent peaches and guava, containing larvae (CABI 2006). Because of its broad host range, including fruits of considerable economic importance, such as grapefruit and orange, *A. ludens* is considered to be the most economically important *Anastrepha* species threatening the United States (Foote et al. 1993). In an early study, potential production losses caused by this and three other fruit fly species were conservatively estimated to be 26.7 million boxes of citrus at a value of $70.1 million (1975 farm-level prices) (Andrew et al. 1977); losses at current price levels would be significantly higher. The fly is considered to be a key pest of guava (Gould and Raga 2002). Quarantine treatments, such as hot water (Sharp et al. 1989a) and irradiation (Hallman and Martinez 2001), have been developed to disinfest fruit, potentially increasing production costs. *Anastrepha ludens* is a quarantine pest for Argentina, Brazil, Chile, Paraguay, Uruguay, Turkey, China, and eastern and southern Africa (EPPO 2005a). Its introduction into Hawai'i, therefore, could result in a loss of domestic or foreign markets for various commodities, such as citrus, mango, papaya, and avocado, and could lead to the initiation of biological control programs, as has occurred in response to the introduction of other *Anastrepha* species (Clausen 1978b).

A21.1.5 Anastrepha obliqua **(Macquart) (Diptera: Tephritidae)**

One of the most widespread of *Anastrepha* species (Foote et al. 1993), *A. obliqua*, ranges from Mexico to Argentina and across the Caribbean (CABI 2006). This fruit fly has been recorded on more than 60 plant species in 24 families (Foote et al. 1993). The main wild hosts are *Spondias* spp. (Anacardiaceae); *Mangifera indica* (Anacardiaceae) is the major commercial host (CABI 2006). Other hosts include citrus (Rutaceae), *Annona* spp. (Annonaceae), *Carica papaya* (Caricaceae), *Coffea arabica* (Rubiaceae), *Phaseolus* sp. (Fabaceae), *Prunus* spp. (Rosaceae), *Brosimum alicastrum* (Moraceae), *Eugenia* spp. (Myrtaceae), *Diospyros* spp. (Ebenaceae), *Vitis vinifera* (Vitaceae), and *Pouteria* spp. (Sapotaceae) (Norrbom and Kim 1988). Guava is among the natural hosts of the fly (Aluja et al. 1987), which suggests that the plant also is a primary host.

Fecundity may exceed 1,300 eggs per female in the laboratory (Liedo and Carey 1996), but 500 to 700 is the normal range under field conditions (Toledo and Lara 1996). There are four to eight generations per year (Aluja, 1993).Similar to other *Anastrepha* species, the major means of dispersal to previously uninfested areas is the transport of fruit, such as mango and, to a lesser extent, citrus and guava, containing larvae. The species has been intercepted in France on mangoes from Mexico (CABI 2006). *Anastrepha obliqua* is one of the most important fruit fly pests of mango (Foote et al. 1993). In Brazil, infestations ranging from 7 to 88% in commercial crops of *Malpighia punicifolia* (Malpighiaceae) were observed, leading to a downgrading of fruit quality (Ohashi et al. 1997). The fly is a major pest of *Eugenia stipitata* in Peru, causing reductions in yield and fruit quality (Couturier et al. 1996), and a major pest of guava (Gould and Raga 2002). Establishment of this pest in Hawai'i could cause a loss of domestic or foreign markets. The species is a quarantine pest for Argentina, Uruguay, China, Taiwan, Indonesia, Korea, New Zealand, Namibia, South Africa, Turkey, eastern and southern Africa, and the European Union (EPPO 2005a; PRF 2007). It also represents a potential threat to native plants in Hawai'i, such as *Eugenia koolauensis*. Its introduction likely would stimulate the initiation of control programs. For example, biological control is employed in Brazil to suppress populations of this species in mango orchards (e.g., Montoya et al. 2000).

A21.1.6 Anastrepha serpentina **(Wiedemann) (Diptera: Tephritidae)**

This fruit fly occurs in most countries of Central America and in South America south to Brazil and Argentina (Foote et al. 1993; CABI 2006). At least 40 species in 13 plant families have been recorded as hosts of *A. serpentina* (Foote et al. 1993). Species of Sapotaceae appear to be the favored hosts. Other hosts include *Citrus* spp. (Rutaceae), *Mammea americana* (Clusiaceae), *Spondias* spp. (Anacardiaceae), *Malus domestica* and *Prunus persica* (Rosaceae), *Solanum lycopersicum* (Solanaceae), *Persea americana* (Lauraceae), *Annona glabra* (Annonaceae), *Ficus* sp. (Moraceae), *Byrsonima crassifolia* (Malpighiaceae), and *Eugenia uniflora* and *Psidium guajava* (Myrtaceae) (Eskafi and Cunningham 1987; Norrbom and Kim 1988).

Average fecundity ranges from about 80 to 100 eggs per female (CABI 2006), although a maximum of almost 900 eggs per female has been recorded (Liedo and Carey 1996). There are four to eight generations per year (Aluja 1993). Long-distance dispersal is accomplished by the transport of immature stages in fruit or packaging (CABI 2006). *Anastrepha serpentina* is an important pest of sapote (*Calocarpum* spp.), sapodilla (*Manilkara zapota*), *Lucuma salicifolia*, and other fruits in Mexico; infestations in tree-ripened fruit are said frequently to be so high that growers are forced to harvest early and ripen fruit artificially, which lowers its quality (Weems 1969). It also is considered a key pest of guava (Gould and Raga 2002). Hot-water quarantine treatments have been developed for mango infested with this pest (Sharp et al. 1989b), which increase production costs. Establishment of the fly in Hawai'i could lead to the loss of domestic or foreign markets for commodities, such as citrus and avocado. The fly is a quarantine pest for Argentina, Uruguay, New Zealand, Indonesia, and Taiwan (EPPO 2005a; PRF 2007). *Anastrepha serpentina* is a potential threat to native plants in Hawai'i listed as threatened or endangered (50 CFR § 17.12), such as *Eugenia koolauensis*, *Solanum incompletum*, and *S. sandwicense*. Its introduction into Hawai'i also could stimulate the initiation of biological control programs, as has occurred in response to the introduction of other fruit fly pests (e.g., Clausen 1978b).

A21.1.7 Anastrepha striata Schiner (Diptera: Tephritidae)

This species is found throughout Central America, in South America south to Bolivia and Brazil, and in the Netherlands Antilles (CABI 2006). *Psidium guajava* is the primary host (Aluja et al. 1987; CABI 2006). Secondary hosts include *Citrus sinensis* (Rutaceae), *Annona muricata* (Annonaceae), *Chrysophyllum cainito* (Sapotaceae), *Prunus persica* (Rosaceae), *Mangifera indica* (Anacardiaceae), *Persea americana* (Lauraceae), *Terminalia catappa* (Combretaceae) (CABI 2006); *Manihot esculenta* (Euphorbiaceae) (White and Elson-Harris 1992); *Solanum macranthum* (Solanaceae), *Eugenia uniflora* (Myrtaceae), and *Passiflora edulis* (Passifloraceae) (Norrbom and Kim 1988).

Fecundity ranges from 100 to 800 eggs per female; there are four to eight generations per year (Aluja 1993). As in other *Anastrepha* species, long-distance dispersal is accomplished by the movement of immature stages present in consignments of infested fruit (CABI 2006). Little detailed information is available concerning the economic impact of *A. striata*. Although Weems (1982) stated that the species is not considered to be of primary economic importance, it is reported to be an important pest of guava in Venezuela (Marín 1973). It is listed in Gould and Raga (2002) as a key pest of guava. Norrbom (2003) also considered the species to be an important pest of guava and other myrtaceous fruits. Because it is a quarantine pest for New Zealand (EPPO 2005a), establishment of *A. striata* could result in a loss of that market, as well as domestic markets, for Hawai'ian-grown commodities, such as citrus, mango, and avocado. *Anastrepha striata* has the potential to attack federally listed (50 CFR § 17.12) native plants in

Hawai'i (e.g., *Eugenia koolauensis*, *Solanum incompletum*, and *S. sandwicense*). Because it represents a potential threat to citrus and other cultivated fruit crops, biological control programs could be initiated against the species, as has occurred in response to the introduction of other fruit fly pests (e.g., Clausen 1978b).

A21.1.8 Bactrocera depressa (Shiraki) (Diptera: Tephritidae)

The geographic distribution of *B. depressa* is within temperate to tropical East Asia. It ranges from Hokkaido, south through the remaining islands of Japan and the Ryukyu Archipelago, to mainland China (Sichuan) and Taiwan (White and Elson-Harris 1992; Carrol et al. 2002). The species is widely distributed in Korea (Han et al. 1994). Hosts are predominantly Cucurbitaceae. The fly has been recorded on *Cucurbita moschata* and *C. maxima*, *Cucumis metuliferus* and *C. sativus*, *Citrullus lanatus*, *Lagenaria siceraria*, and *Trichosanthes kirilowii* (White and Elson-Harris 1992; Mun et al. 2003). Larvae of *B. depressa* are reported to infest fruit of tomato (*Solanum lycopersicum* [Solanaceae]) in Korea (Han et al. 1994) and Japan (Okadome 1962). Because *B. depressa* has been found in areas (e.g., mountainous regions of the Ryukyu Islands), from which cucurbits are absent, White and Elson-Harris (1992) suggested that the species probably had additional, non-cucurbit hosts.

No information is available on reproduction in *B. depressa*. If its biology is similar to that of other *Bactrocera* species (Fletcher 1989a; CABI 2006), a high fecundity (e.g., greater than 1,000 eggs per female) may be indicated, as is typical of the polyphagous dacine Tephritidae (Fletcher 1987). Migratory movements are exhibited by several species of *Bactrocera*, in which flights up to 94 km (58 miles) (*B. tryoni* [Froggatt]) have been reported (Fletcher 1989b). However, investigations into the population structure of *B. depressa* by Mun et al. (2003) indicated that the frequency of long-distance dispersal in this species is extremely low. Long-distance dissemination could occur via movement in infested fruit, and the species potentially could be introduced into Hawai'i in commodities, such as cucurbits or tomato. *Bactrocera depressa* is said to be a significant pest of *Cucurbita moschata* (pumpkin or winter squash) and *C. maxima* (Hubbard squash) in Korea and Japan (Mun et al. 2003). In their survey, Han et al. (1994) reported severe damage to *C. moschata* (≥ 31% of fruits); lesser damage (10 to 30%) to *Citrullus lanatus* (watermelon), *Lagenaria siceraria* (bottle gourd), and ornamental pumpkin (*Cucurbita* spp.); and "mild" damage (≤ 10%) in tomato and melon. Damage is caused by larvae tunneling through and macerating fruit tissue (Fletcher 1987). As *Bactrocera* spp. are quarantine pests for numerous countries, including French Polynesia, New Caledonia, Turkey, Madagascar, Argentina, Brazil, New Zealand, Syria, Uruguay, and Chile (PRF 2007), introduction of *B. depressa* into Hawai'i could result in a loss of foreign, as well as domestic, markets for commodities, such as tomato and cucurbits. As a pest of tomato, the fly represents a potential threat to the endemic *Solanum incompletum* and *S. sandwicense*. Further, its introduction likely would result in the initiation of chemical or biological control programs similar to those targeting other tephritid pests (Roessler 1989; Sivinski 1996).

A21.1.9 Bactrocera passiflorae (Froggatt) (Diptera: Tephritidae)

This tephritid is restricted to the tropical South Pacific (Fiji, Niue, Tonga, Wallis and Futuna) (CABI 2006). It has been recorded on at least 55 plant species in 42 genera (SPC 2002a). Hosts include *Artocarpus altilis* (Moraceae), *Mangifera indica* (Anacardiaceae), *Passiflora* spp. (Passifloraceae), *Carica papaya*

(Caricaceae), *Citrus* spp. (Rutaceae), *Persea americana* (Lauraceae), *Theobroma cacao* (Sterculiaceae), *Ochrosia oppositifolia* (Apocynaceae) (SPC 2002a; CABI 2006); *Eugenia malaccensis*, *Psidium guajava*, and *P. cattleianum* (Myrtaceae), *Coffea liberica* (Rubiaceae), *Pometia pinnata* (Sapindaceae), *Santalum yasi* (Santalaceae), *Gossypium barbadense* (Malvaceae), *Inocarpus edulis* (Fabaceae) (Simmonds 1936); and *Chrysobalanus icaco* (Chrysobalanaceae) (Clausen et al. 1965).

No information is available on the reproductive or dispersal potentials of *B. passiflorae*. If its biology is similar to that of other *Bactrocera* species (Fletcher 1989a; b), it may exhibit a high degree of fecundity and mobility. The transport of infested fruit would be a major pathway for the pest to be introduced into new regions (CABI 2006). The fly's association with plants, such as common guava and strawberry guava, which are widespread in Hawai'i (Wagner et al. 1999), likely would facilitate its rapid spread throughout the islands. What little information is available concerning the economic impact of this species indicates that its potential impact may be significant. White and Elson-Harris (1992, p. 221) referred to it as a "potential pest," probably because of its restricted distribution. In Fiji, infestation levels have been reported to be as high as 60% in *Fortunella japonica* (kumquat), 40 to 90% in guava, 62% in *Syzygium malaccense*, and 20 to 25% in mango (SPC 2002a). Control measures include the bagging of fruit, field sanitation, and trapping (SPC 2002a), which tend to increase production costs. The species is regarded as a serious plant quarantine threat to other Pacific islands (it is a quarantine pest for French Polynesia and New Caledonia [PRF 2007]), and to countries in Australasia and the Asian mainland (CABI 2006). Thus, its introduction into Hawai'i could result in further losses of foreign, as well as domestic, markets for such fruit fly host fruits as mango, citrus, avocado, and papaya. As it attacks closely related host species, its introduction into Hawai'i also could put at risk native plants, such as *Eugenia koolauensis*, *Ochrosia kilaueaensis* (holei), *Santalum freycinetianum* var. lanaiense (iliahi), and *Solanum incompletum* and *S. sandwicense*, all listed as endangered in 50 CFR § 17.12. Its introduction also could spur the initiation of biological control programs, as has occurred elsewhere (e.g., Wharton 1989).

A21.1.10 Bactrocera tau (Walker) (Diptera: Tephritidae)

The geographic distribution of *B. tau* is restricted to temperate to tropical countries of the Oriental Region. The fly occurs in Bangladesh, Bhutan, Brunei, Burma, Cambodia, China, India, Indonesia, Laos, Malaysia, Nepal, the Philippines, Sri Lanka, Taiwan, Thailand, and Vietnam (Narayanan and Batra 1960; White and Elson-Harris 1992; Waterhouse 1993b; Huque 2006). Although preferred hosts appear to be species of *Cucurbitaceae*, such as *Cucumis sativus*, *Luffa acutangula*, *Cucurbita maxima*, *Trichosanthes anguina*, *Benincasa hispida*, and *Momordica charantia*, the fly has been recorded on hosts in several other families (Narayanan and Batra 1960; Batra 1968; Syed 1970; White and Elson-Harris 1992; Allwood et al. 1999). These include *Mangifera foetida* and *M. indica* (Anacardiaceae), *Muntingia calabura* (Elaeocarpaceae), *Citrus maxima* (Rutaceae), *Solanum lycopersicum* (Solanaceae), *Borassus flabellifer* (Arecaceae), *Phaseolus vulgaris* (Fabaceae), *Strychnos* spp. (Loganiaceae), *Ficus racemosa* (Moraceae), *Psidium guajava* and *Syzygium samarangense* (Myrtaceae), *Myxopyrum smilacifolium* (Oleaceae), *Manilkara zapota* (Sapotaceae), and *Tetrastigma lanceolarium* (Vitaceae).

The fly thus poses a potential threat to several important crops in Hawai'i. Depending on cucurbit host, mean fecundity ranged from 666 to 911 eggs per female (Liu and Lin 2001). The fly is said to exhibit several overlapping generations throughout summer in India; there is no diapause (Batra 1968). Two generations per year in Taiwan are indicated (Chen 2001). The species is reported to make migratory flights (Fletcher 1989b). It has been intercepted in Japan in fresh fruits from Southeast Asia (Takeishi 1992), indicating that it is readily transported long distances by human agency. *Bactrocera tau* is an important pest of various fruit crops, such as pumpkin, watermelon, mango, sapodilla, citrus, and tomato, in India (Kapoor 1989) and China (Zhou et al. 1993), presumably causing significant yield losses. In China, insecticides, such as BHC, diazinon, and trichlorfon, are applied to control the pest (Zhou et al. 1993; Yang et al. 1994), a practice that increases production costs. As the fly is a quarantine pest for Korea (PRF 2007), its introduction could result in a loss of that market for various Hawai'i fruit crops. *Bactrocera tau* represents a potential threat to native plants in Hawai'i listed as endangered in 50 CFR § 17.12, such as *Solanum incompletum* and *S. sandwicense*. As it is a pest of economically important crops (e.g., cucurbits, citrus, mango, guava, tomato), introduction of the fly into Hawai'i likely would result in the initiation of chemical or biological control programs, which have proven to be effective against it and other species of fruit fly elsewhere (Clausen 1978b; Zhou et al. 1993).

A21.1.11 Bactrocera tryoni (Froggatt) (Diptera: Tephritidae)

This fruit fly is found throughout the eastern half of Queensland, eastern New South Wales, and the extreme east of Victoria in Australia (CABI 2006). There also have been short-lived outbreaks in South Australia. Adventive populations occur in the Austral and Society Islands and New Caledonia. The fly has been recorded on plants in numerous families (CABI 2006). Hosts include *Mangifera indica* (Anacardiaceae), *Annona* spp. (Annonaceae), *Carica papaya* (Caricaceae), *Terminalia aridicola* (Combretaceae), *Artocarpus odoratissima* (Moraceae), *Coffea arabica* (Rubiaceae), *Eugenia uniflora*, *Psidium guajava*, and *P. cattleianum* (Myrtaceae), *Olea europaea* (Oleaceae), *Nerium oleande*r (Apocynaceae), *Averrhoa carambola* (Oxalidaceae), *Passiflora* spp. (Passifloraceae), *Prunus persica* (Rosaceae), *Diospyros kaki* (Ebenaceae), *Dimocarpus longan* and *Litchi chinensis* (Sapindaceae), *Momordica charantia* (Cucurbitaceae), *Musa x paradisiaca* (Musaceae), *Citrus* spp. (Rutaceae), *Persea americana* (Lauraceae), *Manilkara zapota* (Sapotaceae), *Solanum* spp. (Solanaceae), and *Vitis* spp. (Vitaceae).

An average fecundity of 415 eggs per female has been reported under laboratory conditions; populations under such conditions increased at more than 90% per week (Fitt 1990), indicating a considerable biotic potential. There are four to five generations per year (Hely et al. 1982). The adults are strong fliers. Adult flight and the transport of infested fruit are the major means of long-distance dispersal (CABI 2006). The fly's association with plants, such as common guava, strawberry guava, and bitter melon, which are widespread in Hawai'i (Wagner et al. 1999), likely would facilitate its rapid spread throughout the islands. *Bactrocera tryoni* is the most serious insect pest of fruit and vegetable crops in Australia, infesting all commercial fruit crops other than pineapple and strawberry (CABI 2006). Larvae damage fruit directly by their feeding and indirectly by facilitating entry by organisms of decay. In certain fruits, such as citrus, yield losses are overshadowed by the negative economic impact of lost markets due to quarantine barriers (Hely et al. 1982). In Australia, potential losses to fruit flies in the absence of control measures have been estimated at A$100 million per year, and most of this is attributable to *B. tryoni* (CABI 2006). As it is known to attack closely related hosts, *B. tryoni* is a potential threat to endangered or threatened native plants in Hawai'i, such as *Eugenia koolauensis*, *Solanum incompletum*, and *S. sandwicense*. Because of its status as a pest of a wide variety of crops economically or otherwise important to Hawai'i, including papaya, coffee, eggplant, tomato, mango, lychee, avocado, and citrus (CABI 2006), introduction of *B. tryoni* likely would trigger the initiation of control programs. Biological control has proved to be at least partially effective is suppressing population densities of other dacine fruit flies (Clausen 1978b).

A21.1.12 Ceratitis rosa Karsch (Diptera: Tephritidae)

The geographic distribution of *C. rosa* is restricted to subtropical and tropical Africa, the species apparently being less tolerant of cold temperatures than is *Ceratitis capitata* (CABI/EPPO 1997c). It has been reported from Angola, Ethiopia, Kenya, Malawi, Mali, Mauritius, Mozambique, Nigeria, Réunion, Rwanda, South Africa, Swaziland, Tanzania, Uganda, Zaire, Zambia, and Zimbabwe. Hosts include *Prunus* spp. (Rosaceae), *Persea americana* (Lauraceae), *Citrus* spp. (Rutaceae), *Ficus carica* (Moraceae), *Vitis vinifera* (Vitaceae), *Litchi chinensis* (Sapindaceae), *Mangifera indica* (Anacardiaceae), *Carica papaya* (Caricaceae) (CABI/EPPO 1997c); *Averrhoa carambola* (Oxalidaceae), *Coffea arabica* (Rubiaceae), *Annona reticulata* (Annonaceae), *Passiflora* sp. (Passifloraceae), *Manilkara zapota* (Sapotaceae), *Eugenia uniflora* and *Psidium* spp. (Myrtaceae) (Grové 2001); *Strychnos spinosa* (Loganiaceae) (Weems 1966); *Carissa macrocarpa* (Apocynaceae), *Ziziphus zizyphus* (Rhamnaceae), *Theobroma cacao* (Sterculiaceae), *Garcinia mangostana* (Clusiaceae), *Musa* sp. (Musaceae), *Diospyros virginiana* (Ebenaceae), *Opuntia* spp. (Cactaceae), *Dovyalis caffra* (Flacourtiaceae), *Solanum lycopersicum* and *S. auriculatum* (Solanaceae), Cecropiaceae, Euphorbiaceae, and Podocarpaceae (White and Elson-Harris 1992).

In the laboratory, fecundity averaged 520 eggs per female (Monty 1973). Depending on climatic conditions, there may be as many as 12 generations per year (Hill 1983). Adult flight and the transport of infested fruit are the primary means of long-distance dispersal and spread to previously uninfested areas (CABI/EPPO 1997c). *Ceratitis rosa* is a major pest of mango (Joubert et al. 2000) and avocado in South Africa, resulting in a cull rate in the latter of 1.9% (Dennill and Erasmus 1992). Lychee fruit, although a poor host, is damaged by organisms of decay introduced by ovipositing females (de Villiers 1990). In South Africa, infestation rates of 50 to 100% have been reported in plum (Weems 1966). After its introduction into Mauritius, *C. rosa* displaced *C. capitata* from many of their shared hosts (Fitt 1989), and a similar phenomenon may have occurred in Zimbabwe (Anonymous 1963), suggesting the potential for *C. rosa* to become as serious a pest as *C. capitata*. Control routinely is achieved by the application of insecticides (de Villiers 1978), which increases production costs. Like *C. capitata*, *C. rosa* is an international quarantine pest with the potential to restrict international trade in fruit (Barnes et al. 2000). For example, the fly is an A1 quarantine pest for Europe, and considered by the European and Mediterranean Plant Protection Organization (EPPO) the most important of all *Ceratitis* species (CABI/EPPO 1997c). Its establishment in Hawai'i thus could result in a further loss of domestic or foreign markets for various commodities. *Ceratitis rosa* is a potential threat to plants in Hawai'i listed as threatened or endangered, such as *Eugenia koolauensis*, *Solanum incompletum*, and *S. sandwicense*. Its introduction into Hawai'i likely would result in the initiation of chemical or biological control programs, as has occurred in response to the entry elsewhere of other tephritid species (Roessler 1989; Wharton 1989).

A21.1.13 Ceroplastes japonicus Green (Homoptera: Coccidae)

This soft scale insect is native to the Old World. It has been reported from Armenia, Azerbaijan, China, Georgia, Japan, Korea, and Nepal in Asia, and, in Europe, England, France, Italy, Russia, Slovakia, and Slovenia (CABI 2003; Ben-Dov et al. 2006). In China, it ranges from the temperate zone to the tropics (Hua 2000). The species has been recorded on plants in at least 26 families (Ben-Dov et al. 2006). Hosts include *Diospyros kaki* (Ebenaceae), *Acer* spp. (Aceraceae), *Nerium oleander* (Apocynaceae), *Ilex* spp. (Aquifoliaceae), *Berberis* sp. (Berberidaceae), *Buxus sempervirens* (Buxaceae), *Cycas revoluta* (Cycadaceae), *Magnolia grandiflora* (Magnoliaceae), *Ficus carica* (Moraceae), *Ziziphus* sp. (Rhamnaceae), *Prunus* spp. (Rosaceae), *Citrus* spp. (Rutaceae), and P*unica granatum* (Punicaceae). Several of these plants are, or are related to economically or aesthetically valuable, or endemic species in Hawai'i, such as *D. kaki* (Japanese persimmon), *N. oleander* (oleander), *Cycas* spp. (cycads, sago-palms), and *Buxus* and *Ziziphus* spp. (Imada et al. 2005; NASS 2006b), and thus are potentially threatened by the introduction of *C. japonicus*.

An average fecundity as high as 1,540 eggs per female has been reported for the scale (Jiang and Gu 1988). There is one generation per year (CABI 2006). Natural dispersal is accomplished by first-instar nymphs (crawlers), which may be carried on wind or other animals; all stages may be transported long distances in consignments of plant material and produce (CABI 2006). *Ceroplastes japonicus* is reported to be an important pest of several crops, including citrus, mulberry, jujube, pomegranate, tea, apple, and persimmon (Dzhashi 1971; Konstantinova 1976; Luo et al. 1994; Swirski et al. 1997; CABI 2006; Ma and Bai 2004). Konstantinova and Gura (1986) found the scale to infest deciduous fruits, although Pfeiffer (1997) considered it to be only a minor pest in such crops. No information is available specifically on the magnitude of damage (e.g., yield losses) attributed to the pest. Infestation results in reduced vigor and general debility of the host, premature leaf drop and dieback of stems, and the secreted honeydew may serve as a medium for the growth of sooty molds, which interfere with photosynthesis and may lower the market value of fruit (CABI 2006). The species is a quarantine pest for Belarus, Ukraine, New Zealand, and Peru (EPPO 2005a; PRF 2007), suggesting that its introduction could result in a loss of domestic or foreign markets for Hawai'i-grown commodities. Its introduction into Hawai'i could result in the initiation of chemical or biological control programs, as has occurred elsewhere (e.g., Xia et al, 1985; Swirski et al. 1997; Zhou et al. 2003), thus potentially impacting native ecosystems.

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A21.1.14 Conogethes punctiferalis (Guenée) (Lepidoptera: Pyralidae)

The geographic distribution of *C. punctiferalis* extends from temperate to tropical Asia and into Australasia (Australia, Papua New Guinea) (CABI 2006). This polyphagous species has been recorded on plants in at least 20 families (CABI 2006). Hosts include *Carica papaya* (Caricaceae), *Gossypium herbaceum* (Malvaceae), *Helianthus annuus* (Asteraceae), *Prunus persica* (Rosaceae), *Zea mays* (Poaceae), *Citrus nobilis* (Rutaceae), *Punica granatum* (Punicaceae), *Vitis vinifera* (Vitaceae), *Zingiber officinale* (Zingiberaceae), *Ricinus communis* (Euphorbiaceae), *Morus alba* (Moraceae), *Psidium guajava* (Myrtaceae), *Macadamia integrifolia* (Proteaceae) (CABI 2006); *Diospyros kaki* (Ebenaceae) (Umeya and Okada 2003); *Quercus* spp. (Fagaceae) (Park et al. 1998b); *Mangifera indica* (Anacardiaceae) (Nair 1975); *Dimocarpus longan* (Sapindaceae) (Huang et al. 2000); *Pinus massoniana* (Pinaceae) (Hua 2005); and *Durio zibethinus* (Bombacaceae) (Brown 1997). Several of these (e.g., papaya, guava, macadamia, mango, and Japanese persimmon) are economically important crops in Hawai'i (NASS 2006b).

Female *C. punctiferalis* lay an average of 20 to 30 eggs on the surface of fruits or on the ear silk and tassels of corn (CABI 2006). Five generations per year have been reported (Wang and Cai 1997). Demographic studies indicated that, under ideal conditions, populations may increase by a factor of almost 21 times per generation (Bilapate 1977). Long distance dispersal may be effected via the transport of commercial consignments of fruit. For example, pear fruits from Korea were found to be infested with larvae of *C. punctiferalis* at a Canadian port-of-entry (Lee et al, 2000). Since 1984, the moth has been intercepted at U.S. ports on at least 79 occasions (PIN 309a). *Conogethes punctiferalis* is one of the most destructive pests of peach in China and of cotton and grain sorghum in Australia, in which latter country infestations of 27% of bolls and 100% of seed heads, respectively, have been reported (Anonymous 1957). In grains, stems bored by the moth are easily broken down by the wind and farming practices, resulting in decreased yields (CABI 2006). Yield losses were as high as 42% in castor bean (Kapadia 1996), 49% in plum (Wang and Cai 1997), and 50% in grape (Ram et al, 1997). In persimmon, the pest may be present as eggs and larvae on or in fruit at harvest (Tomomatsu et al. 1995). Losses in persimmon crops of almost 2% have been reported, and may continue until harvest (Kim et al. 1997). Annual losses in chestnut crops in parts of Zhejiang Province, China, have been estimated at 120 tonnes at a value of almost $121,000 (Xu et al. 2001). In fruit crops, injury generally occurs when fruit is nearly ripe (Hely et al. 1982). Larval tunneling and attack by secondary organisms of decay may render fruit valueless (Clausen 1931). As the species is a quarantine pest for countries, such as Canada, Chile, New Zealand, and Peru (EPPO 2005a; PRF 2007), its introduction could result in a loss of domestic or foreign markets for various agricultural commodities grown in Hawai'i. Introduction of the pest into the state likely would result in the initiation of chemical or biological control programs similar to those carried out in other countries (e.g., Choo et al. 1995; Wang et al. 2002), again potentially putting native Hawai'ian ecosystems further at risk.

A21.1.15 Copitarsia decolora (Guenée) (Lepidoptera: Noctuidae)

This moth is reported to occur in Mexico, Guatemala, Costa Rica, Venezuela, Uruguay, Peru, Colombia, Ecuador, Chile, Argentina, and Bolivia (Liberman 1986; Angulo and Olivares 2003). It has been recorded on *Medicago sativa* (Fabaceae), *Capsicum frutescens* and *Solanum tuberosum* (Solanaceae), *Cynara* *scolymus* and *Helianthus* sp. (Asteraceae), *Allium* spp. (Liliaceae), *Fragaria ananassa*, *Malus pumila*, and *Rubus* sp. (Rosaceae), *Simmondsia chinensis* (Simmondsiaceae), *Zea mays* and *Triticum* sp. (Poaceae), *Pistacia vera* (Anacardiaceae), *Beta vulgaris* (Chenopodiaceae), *Brassica oleracea* (Brassicaceae), *Dianthus caryophyllus* (Caryophyllaceae), *Feijoa sellowiana* (Myrtaceae), *Actinidia deliciosa* (Actinidiaceae), *Vitis vinifera* (Vitaceae) (Angulo and Olivares 2003); and *Amaranthus cruentus* (Amaranthaceae) (Guerrero et al. 2000).

Copitarsia decolora exhibited an average fecundity of 1,038 eggs per female under laboratory conditions (Larraín 1996). At least four generations per year have been reported (Urra and Apablaza 2005). Long-distance spread of the moth is accomplished via the movement of infested plant materials in commerce. *Copitarsia* spp. frequently are intercepted on produce and cut flowers at U.S. ports (Venette and Gould 2006). *Copitarsia decolora* has been intercepted at U.S. ports on grape and apple from Chile (Santacroce 1993). In Peru, *C. decolora* is a major pest of potato (Alcala 1978), and is one of a complex of pests (including *Spodoptera eridania* Stoll and agromyzid leafminers) of broad bean (*Vicia faba*), which reduces yield by 50 to 60% (Gomez 1972). Defoliation on the order of 60% has been reported in rape (*Brassica napus* var. napus), although with no appreciable effect on yield (Larraín 1996). The noctuid may also constitute a significant pest of quinoa (*Chenopodium quinoa*) in Chile (Lamborot et al. 1999). Gonzalez (1983) identified the moth (as *C. consueta* [Walker]) as an occasional pest in vineyards. It occasionally is found on fruit trees, and the larvae may bore into immature fruits (Santacroce 1993). *Copitarsia decolora* poses a potential threat to listed (50 CFR § 17.12) native plant species in Hawai'i, such as *Solanum incompletum* and *S. sandwicense*. As it is known to attack cultivated crops that are valuable in Hawai'i, such as brassicas and grape, its introduction could result in the initiation of chemical control programs, as have targeted the pest elsewhere (e.g., Gonzalez 1983).

A21.1.16 Cryptophlebia leucotreta (Meyrick) (Lepidoptera: Tortricidae)

The distribution of *C. leucotreta* is restricted to subtropical and tropical Africa, where it is widespread (CABI 2006). This pest attacks host plants in numerous families, including *Ananas comosus* (Bromeliaceae), *Camellia sinensis* (Theaceae), *Citrus* spp. (Rutaceae), *Annona muricata* (Annonaceae), *Averrhoa carambola* (Oxalidaceae), *Ceiba pentandra* (Bombacaceae), *Coffea arabica* (Rubiaceae), *Litchi chinensis* (Sapindaceae), *Mangifera indica* (Anacardiaceae), *Olea europaea* (Oleaceae), *Persea americana* (Lauraceae), *Punica granatum* (Punicaceae), *Ricinus communis* (Euphorbiaceae), *Zea mays* (Poaceae) (CABI 2006); *Prunus* spp. (Rosaceae), *Quercus* sp. (Fagaceae), *Juglans* sp. (Juglandaceae), *Macadamia integrifolia* (Proteaceae), *Vitis vinifera* (Vitaceae) (Annecke and Moran 1982); *Bequaertiodendron magalismontanum* (Sapotaceae), *Calotropis procera* (Asclepiadaceae), *Capparis tomentosa* (Capparaceae), *Catha edulis* (Celastraceae), *Cola nitida* (Sterculiaceae), *Combretum* spp. (Combretaceae), *Diospyros* spp. (Ebenaceae), *Eugenia uniflora* and *Psidium guajava* (Myrtaceae), *Ficus capensis* (Moraceae), *Garcinia mangostana* (Clusiaceae), *Abutilon* spp. and *Hibiscus* spp. (Malvaceae), *Musa x paradisiaca* (Musaceae), *Phaseolus* spp. (Fabaceae), *Podocarpus falcatus* (Podocarpaceae), *Schotia afra* (Caesalpiniaceae), *Triumfetta* spp. (Tiliaceae), *Ximenia caffra* (Olacaceae), and *Ziziphus* spp. (Rhamnaceae) (Whittle 1984). Many of these are economically or otherwise important in Hawai'i.

Depending on temperature, average fecundity was reported to range from 87 to 456 eggs per female (Daiber 1980). There may be as many as five generations per year (van den Berg 2001). The capacity for long-distance flight by adults is indicated by records of migrants found in Sweden, thousands of kilometers beyond the natural range of the species (Svensson 2002). Dispersal over long distances also may be facilitated by the transport of fruit infested with larvae (CABI 2006). The species has been intercepted at U.S. ports in various fruits on more than 166 occasions (Whittle 1984; PIN 309a). In South Africa, *C. leucotreta* is a major pest of citrus, guava, lychee, and avocado, in which crop losses may reach 80% (van den Berg 2001). The moth occasionally is an important pest of cotton (Whittle 1984), causing yield losses as high as 90% (CABI 2006). Losses of up to 28% in peach crops also have been reported (CABI 2006). Primary damage is caused by larvae boring into fruits (Hill, 1983). Opportunistic secondary fungal and bacterial rots may cause further damage to fruits or bolls (van der Geest et al. 1991). Larvae attacking the young, green fruits of guava, although unable to penetrate the skin, produce blemishes (van den Berg 2001), which likely lowers market price. The moth is a quarantine pest for Korea, Paraguay, Uruguay, Argentina, Brazil, Chile, New Zealand, and Indonesia (PRF 2007), suggesting that its introduction could result in a loss of domestic or foreign markets for various Hawai'ian-grown commodities, such as citrus, pineapple, mango, mangosteen, macadamia, lychee, and avocado. Introduction of this pest into Hawai'i also poses a potential threat to native plants listed as threatened or endangered, such as *Eugenia koolauensis*, *Abutilon eremitopetalum*, *A. menziesii* (kooloaula), and *A. sandwicense*, and *Hibiscus arnottianus* ssp. *immaculatus* (kokio keokeo), *H. brackenridgei* (mao hau hele), *H. clayi*, and *H. waimeae* ssp. *hannerae* (kokio keokeo).

A21.1.17 Eotetranychus cendanai Rimando (Acari: Tetranychidae)

Except for an adventive population in Guam (Nafus and Schreiner 1999), *E. cendanai* is restricted to East and Southeast Asia. It occurs in Cambodia, the Philippines, Taiwan, and Thailand (Bolland et al. 1998). In addition to various *Citrus* species, the mite has been recorded on *Sesbania grandiflora* (Fabaceae) and *Zoysia japonica* (Poaceae) (Bolland et al. 1998).

Thongtab et al. (2002) studied the reproductive biology of the mite in the laboratory. Fecundity on *C. maxima* averaged 26 eggs per female; population densities tended to increase rapidly. The calculated intrinsic rate of natural increase was 0.156, indicating that the average population was growing at almost 16% per day. Several generations per year are indicated (Barrion and Corpuz-Raros 1975; Thongtab et al. 2002). Tetranychid mites may disperse over considerable distances naturally by "ballooning" on air currents (Jeppson et al. 1975). The disjunct distribution of *E. cendanai*, with a population established in Guam far from the presumed Asian center of origin of the species, suggests that it has significant spread potential. The mite is listed in Waterhouse (1993b) as a widespread and important pest in Thailand; although, because of its limited distribution, Gerson (2003) considered its overall, global pest status to be minor. On citrus, feeding injury results in leaf and fruit drop, and fruit russetting, resulting in a downgrading of its quality (Thongtab et al, 2002). The mite thus is a potential threat to *Citrus* spp. in Hawai'i, which not only are commercially important (NASS 2006a), but are popular as ornamental and fruit trees in residential plantings (Neal 1965). *Eotetranychus cendanai* poses a potential threat to *Sesbania tomentosa,* listed in 50 CFR § 17.12 as endangered in Hawai'i. Its introduction into the islands could spur the initiation of biological control programs of the kind presently being considered elsewhere (e.g., Thongtab et al. 2001).

A21.1.18 Gymnandrosoma aurantianum Lima (Lepidoptera: Tortricidae)

This tortricid is known from the American tropics. It has been reported from Argentina, Brazil, Peru, Ecuador, Venezuela, Colombia, French Guiana, and Surinam in South America, throughout Central America, Mexico, and from Cuba, Dominica, Puerto Rico, and Trinidad and Tobago in the Caribbean (White 1999; Adamski and Brown 2001). Hosts include *Cupania vernalis* and *Litchi chinensis* (Sapindaceae), *Cojoba arborea* (Fabaceae), *Theobroma cacao* (Sterculiaceae), *Citrus* spp. (Rutaceae), *Macadamia integrifolia* (Proteaceae), *Prunus persica* (Rosaceae), *Punica* sp. (Punicaceae), *Psidium guajava* (Myrtaceae) (Adamski and Brown 2001); *Simarouba amara* (Simaroubaceae) (White and Tuck 1993); *Cocos nucifera* (Arecaceae), *Musa acuminata* (Musaceae), and *Annona* spp. (Annonaceae) (Bento et al. 2001).

Fecundity ranges from about 150 to 200 eggs per female (Bento et al. 2001); eggs apparently are deposited on mature fruit (White and Tuck 1993). The life cycle may be completed within 36 days (Blanco et al. 1993). Field data indicate at least three generations per year (White 1999). Rapid, long-distance dispersal probably is accomplished by larvae within fruit transported in commerce, as is suggested by the record of species of *Gymnandrosoma* or *Ecdytolopha* (a closely related genus) intercepted at U.S. and foreign ports in cargo or baggage (Adamski and Brown 2001; PIN 309a). *Gymnandrosoma aurantianum* is an important pest of citrus in Brazil (Bento et al. 2001). Yield losses have been estimated to be as high as 50% in infested areas, and total losses to the industry may reach $50 million per year. The moth also is considered to be a major pest of macadamia in Costa Rica, causing reductions in yield and nut quality (Coto 1999). Damage is caused by caterpillars boring through fruits and consuming seeds (Adamski and Brown 2001). Control measures typically consist of insecticidal treatments (e.g., Scarpellini and dos Santos 1997), which increase costs of production. Because this pest reportedly is difficult to control (Faria et al. 1998; Bento et al. 2001), its introduction could cause a loss of domestic or foreign markets for Hawai'ian-produced citrus, macadamia, or lychee. *Gymnandrosoma* spp. are quarantine pests for New Zealand and Venezuela (PRF 2007). *Gymnandrosoma aurantianum* also has the potential to attack plants in Hawai'i of considerable aesthetic value, such as coconut (Neal 1965). As it represents a potential threat to citrus and macadamia production, its introduction could stimulate the initiation of control programs. The pest is a candidate for biological control in Brazil (Molina et al. 2005).

A21.1.19 Helicoverpa assulta (Guenée) (Lepidoptera: Noctuidae)

This moth is distributed from the temperate zone to the tropics of the Old World (CABI 2006). It occurs in sub-Saharan Africa, throughout South, Southeast, and East Asia, and ranges south through Oceania to Australasia. *Helicoverpa assulta* appears mainly to attack members of the Solanaceae, including *Nicotiana* spp., *Datura stramonium*, *Solanum lycopersicum*, *S. melongena*, *Capsicum annuum*, and *Physalis* spp.; other hosts are *Cucurbita moschata* (Cucurbitaceae), *Zea mays* (Poaceae), *Crocosmia* sp. (Iridaceae), *Perilla* sp. (Labiatae), *Vigna unguiculata* and *Pisum sativum* (Fabaceae), and *Piper* sp. (Piperaceae) (Zhang 1994; Robinson et al. 2001; CABI 2006).

Fecundity ranging from 423 to 505 eggs per female has been reported, and may be influenced by host plant (Nandihalli and Lee 1995a). Up to three generations per year have been reported in Japan (CABI 2006). *Helicoverpa* spp. (e.g., *H. zea*) are strong fliers, and may disperse long distances (Metcalf and Metcalf 1993). Larvae of *H. assulta* may be moved internationally in infested commodities. The pest has been intercepted at U.S. ports on at least 21 occasions, most commonly on cut flowers (PIN 309a). Damage is caused by larvae boring into the fruits of hosts, which not only causes direct damage, but also may facilitate the entry of bacteria causing soft rots (Park et al. 1998a). In Korea, the moth is the most serious insect pest of *Capsicum annuum* (Kim et al. 2002). Yields of *C. frutescens* were reduced 10 to 15% in the absence of control measures (Wei 1987). Rates of damage in unprotected tobacco crops exceeded 23% (Nandihalli and Lee 1995b). The species also is reported to be a major pest of corn in Indonesia (Chu 1979). Insecticidal applications are a prevalent control tactic (Yang et al. 2004), which raises production costs and may impact non-target arthropods. The insect represents a potential threat to crops in Hawai'i, such as cucurbits, eggplant, tomato, peppers, and corn. It is a quarantine pest for New Zealand (PRF 2007), suggesting that its introduction could result in the loss of that market, as well as domestic markets, for Hawai'ian agricultural products. Outbreaks on crops in Hawai'i could trigger biological or chemical control programs, similar to those that have been initiated against the pest elsewhere (e.g., Hirai et al. 1996; Yang et al. 2004). *Helicoverpa assulta* also represents a potential threat to the endangered, native Hawai'ian plants, *Vigna o-wahuensis*, *Solanum incompletum*, and *S. sandwicense*.

A21.1.20 Hemiberlesia diffinis (Newstead) (Homoptera: Diaspididae)

This is a tropical species, known from Central and South America, and the Caribbean (Miller and Davidson 1998). Plants in at least 20 families have been recorded as hosts of *H. diffinis*, including *Psidium guajava* (Myrtaceae), *Persea* sp. (Lauraceae), *Prunus domestica* (Rosaceae), *Cocos* sp. (Arecaceae), *Hibiscus* sp. (Malvaceae), *Maniho*t sp. (Euphorbiaceae), *Theobroma* sp. (Sterculiaceae), *Nerium oleander* (Apocynaceae), *Ficu*s sp. (Moraceae), and *Punica* sp. (Punicaceae) (Miller and Davidson 1998; Ben-Dov et al. 2006). At least some hosts recorded in the United States (e.g., Nakahara 1982) apparently should be considered those of a closely related species, *H. neodiffinis* Miller and Davidson, which is strictly temperate in distribution and with which *H. diffinis* has long been confused (Miller and Davidson 1998).

No information is available concerning the biology or ecology of *H. diffinis*. The reproductive potentials of related species, such as *H. rapax* (Comstock), H. lataniae (Signoret), and *H. pitysophila* Takagi, vary, with fecundities ranging between 6 and 30 to 50 eggs per female with generations numbering from 2 to 6 or more per year, depending on latitude (Kosztarab 1996; CABI 2006). If the reproductive biology of *H. diffinis* is similar, a high reproductive potential for this species may be indicated. Long-distance dispersal may be accomplished on plant materials transported in trade, as evidenced by several interceptions of *Hemiberlesia* spp., including *H. diffinis*, on various fruits in cargo (PIN 309a). *Hemiberlesia diffinis* is considered a minor pest of guava (Gould and Raga 2002). The scale is a potential threat to avocado and guava production in Hawai'i, and has the potential to attack plants of aesthetic value, such as coconut and oleander (Neal 1965), as well as the endemics, *Hibiscus arnottianus* ssp. immaculatus, *H. brackenridgei*, H. clayi, and *H. waimeae* ssp. hannerae, listed as endangered in 50 CFR § 17.12. Its introduction also could stimulate the initiation of biological control programs, similar to what has occurred in response to the introduction of numerous other invasive diaspidid scales (e.g., Rosen and DeBach 1978).

A21.1.21 Icerya aegyptiaca (Douglas) (Homoptera: Margarodidae)

The geographic distribution of *I. aegyptiaca* is tropical to subtropical. Its range extends from Africa (Egypt, Kenya, Zanzibar), eastward through the Middle East (Israel, Yemen), South, Southeast, and East Asia (China, Japan, Taiwan), and south through the Pacific to Australia (Ben-Dov et al. 2006). This species is highly polyphagous. Hosts include *Artocarpus* spp. and *Ficus* spp. (Moraceae), *Annona* spp. (Annonaceae), *Citrus* spp. (Rutaceae), *Cocos nucifera* and *Phoenix dactylifera* (Arecaceae), *Pandanus odoratissimus* (Pandanaceae), *Mangifera indica* (Anacardiaceae), *Achras sapota* (Sapotaceae), *Eugenia* spp., *Psidium guajava*, and *P. cattleianum* (Myrtaceae), *Solanum* spp. (Solanaceae), *Acacia* spp. and *Vigna marina* (Fabaceae), *Euphorbia* sp. (Euphorbiaceae), *Hibiscus* sp. (Malvaceae), *Ochrosia* spp. (Apocynaceae), *Casuarina equisetifolia* (Casuarinaceae), *Carica papaya* (Caricaceae), *Punica granatum* (Punicaceae), *Zea mays* (Poaceae), *Musa* spp. (Musaceae), *Scaevola* spp. (Goodeniaceae), *Bidens pilosa* (Asteraceae), *Malus pumila* (Rosaceae), *Dodonaea viscosa* (Sapindaceae), *Plumbago capensis* (Plumbaginaceae), *Tectona grandis* (Verbenaceae), *Vitis vinifera* (Vitaceae) (Ben-Dov et al. 2006); *Piper nigrum* (Piperaceae), *Persea americana* (Lauraceae), *Coffea* spp. (Rubiaceae), *Colocasia esculenta* (Araceae) (CABI 2006); *Ipomoea tuba* (Convolvulaceae) (Williams and Watson 1990); and *Camellia sinensis* (Theaceae) (Gentry 1965).

Depending on temperature, mean fecundity has been reported to range from 70 to 143 (maximum: 247) eggs per female; there are at least two generations per year (Azab et al. 1968). Females are largely sedentary, moving only when disturbed; long distance dispersal is accomplished on infested fruit, cuttings, and leaves of hosts (CABI 2006). *Icerya aegyptiaca* has been reported to be a serious pest of citrus, fig, and shade trees in Egypt, although it is now largely controlled by natural enemies (CABI 2006). It also is a pest of breadfruit, avocado, banana, citrus, and ornamentals in the South Pacific; annona, jackfruit, sapote (*Pouteria sapota*), mulberry, and guava in India; and breadfruit in the Maldive Islands. Its status in relation to these hosts in Hawai'i likely would be the same. Damage to the plant is caused by sap depletion; shoots dry up and die, and defoliation occurs (Waterhouse 1993a). In addition, copious quantities of honeydew are produced by the scales, which may foster the growth of sooty molds over the surfaces of leaves, reducing photosynthesis. Heavy infestations of breadfruit on Pacific atolls have been reported to kill even mature trees, but, more often, trees are partially defoliated, reducing crop yields, sometimes by 50 to 100%. Introduction of *I. aegyptiaca* could result in a loss of foreign, as well as domestic, markets for Hawai'ian-grown agricultural commodities. The scale is a quarantine pest for several countries other than the United States, including Syria, French Polynesia, Chile, and Korea (PRF 2007). As it represents a potential threat to several plants that are culturally or economically important to Hawai'i, including *Pandanus tectorius* (hala), taro, citrus, mango, papaya, breadfruit, palms, koa, avocado, and banana, its introduction could result in the initiation of biological control programs, which have proved successful against it elsewhere (Waterhouse 1993a). The scale also poses a threat to listed (50 CFR § 17.12) endemic plants in Hawai'i, such as *Scaevola coriacea* (dwarf naupaka), *Eugenia koolauensis*, *Solanum incompletum* and *S. sandwicense*, *Vigna o-wahuensis*, *Euphorbia haeleeleana* (akoko), *Ochrosia kilaueaensis*, *Bidens micrantha* ssp. kalealaha (kookoolau) and *B. wiebkei* (kookoolau), and *Hibiscus arnottianus* ssp. immaculatus, *H. brackenridgei*, *H. clayi*, and *H. waimeae* ssp. hannerae.

A21.1.22 Lobesia aeolopa Meyrick (Lepidoptera: Tortricidae)

The geographic distribution of this widespread species extends across four biogeographic regions: the Ethiopian, Palearctic, Oriental (Razowski 2000), and Australasian (Robinson et al. 2007), from the cold temperate zone to the tropics. Countries where it is reported to occur include: in Africa–Kenya, Madagascar, Uganda, and Zimbabwe; in Asia–China, India, Indonesia, Japan, Korea, Malaysia, Sri Lanka, Taiwan, and Thailand; and in Australasia–New Guinea and Norfolk Island (Zhang 1994; Smithers 1998; Hua 2005; Robinson et al. 2007). *Lobesia aeolopa* has been recorded on a wide range of plants in several families, among which are some of economic and ecological importance to Hawai'i. Hosts include *Diospyros kaki* (Ebenaceae), *Hibiscus* sp. (Malvaceae), *Quercus acutissima* (Fagaceae), *Prunus yedoensis* (Rosaceae), *Solidago canadensis* and *Vernonia* sp. (Asteraceae), *Caesalpinia* sp. (Fabaceae), *Actinidia chinensis* (Actinidiaceae), *Citrus* sp. (Rutaceae), *Camellia sinensis* and *Ternstroemia gymnanthera* (Theaceae), *Coffea arabica* (Rubiaceae), *Ilex integerrima* (Aquifoliaceae), *Litchi chinensis* (Sapindaceae), *Mangifera indica* (Anacardiaceae), *Melochia* spp. (Sterculiaceae), L*antana camara* (Verbenaceae), *Ricinus communis* (Euphorbiaceae), *Lindera* sp. (Lauraceae), *Ulmus parvifolia* (Ulmaceae), *Vitis* spp. (Vitaceae), *Zea mays* (Poaceae) (Robinson et al. 2007); and *Eucalyptus* spp. (Myrtaceae) (Nasu et al. 2004).

No information is available on the reproductive biology of *L. aeolopa*. In the related species, *L. botrana* (Denis and Schiffermüller), fecundity may exceed 300 eggs per female; there may be four generations per year (Avidov and Harpaz 1969). If reproduction in *L. aeolopa* is similar, its biotic potential could be high. The occurrence of the species in remote areas, such as Norfolk Island (Smithers 1998), demonstrates its capacity to disperse over long distances. Little information is available on the economic impact of *L. aeolopa*. It is reported to be a pest of eucalyptus (Nasu et al. 2004) and tea (Sonan 1939) in Japan; although, in the latter case, damage was said to be slight. Plant reproductive organs, as well as leaves, are attacked. Larvae have been found in fruit of *Leucas cephalotes*, *Lantana camara*, and coffee (van der Geest et al. 1991; Robinson et al. 2001), which would lower yields. As the species is a quarantine pest for South Africa (DEAT 2005), its introduction could result in a loss of that market for Hawai'ian-grown commodities, such as lychee, mango, and corn. *Lobesia aeolopa* has the potential to attack endemic plants in Hawai'i listed as endangered or threatened (50 CFR § 17.12), and which are close relatives of its known hosts, such as *Hibiscus arnottianus* ssp. immaculatus, *H. brackenridgei*, *H. clayi*, and *H. waimeae* ssp. hannerae, and *Caesalpinia kavaiense* (uhiuhi). As a potential pest of corn, its introduction could result in the initiation of chemical control programs; insecticidal use is common in that crop throughout the United States (Wright and Van Duyn 1999). Other management options might include biological control programs, which have proven effective against other tortricid pests in the United States and elsewhere (Clausen 1978c).

A21.1.23 Lobesia botrana (Denis & Schiffermüller) (Lepidoptera: Tortricidae)

This moth is widespread in Europe (ranging as far north as Germany), occurs in Africa as far south as Kenya, and ranges through the Near East into central Asia; its distribution in East Asia is restricted to

Japan, where it occurs on all of the main islands (Whittle 1985). Disjunct populations have been reported from the south Pacific (Samoa and Tuvalu; Hopkins 1927). Although polyphagous, *L. botrana* prefers *Vitis* spp. (Vitaceae) (Whittle 1985; CABI 2006). Other hosts include *Berberis vulgaris* (Berberidaceae), *Clematis vitalba* (Ranunculaceae), *Galium mollugo* (Rubiaceae), *Olea europaea* (Oleaceae), *Prunus* and *Rubus* spp. (Rosaceae), *Rhus glabr*a (Anacardiaceae), *Ribes* spp. (Grossulariaceae), Silene vulgaris (Caryophyllaceae), *Solanum tuberosum* (Solanaceae), *Medicago sativa* and *Trifolium pratense* (Fabaceae), *Ziziphus jujuba* (Rhamnaceae) (Whittle 1985); *Actinidia chinensis* (Actinidiaceae), *Dianthus* sp. (Asteraceae), *Diospyros kaki* (Ebenaceae) (CABI 2006); *Hypericum calycinum* (Hypericaceae), and *Punica granatum* (Punicaceae) (Robinson et al. 2001).

Fecundity may exceed 300 eggs per female; a maximum of four generations per year has been recorded (Avidov and Harpaz 1969). Mobility of adults apparently is limited. Schmitz et al. (1996) found dispersal of virgin females within vineyards rarely to exceed 80 meters. However, larvae may be moved long distances within fruit in baggage or cargo; the moth has been intercepted at U.S. ports-of-entry more than 80 times since 1975 (Whittle 1985; PIN 309a). *Lobesia botrana* is an important pest of grape, in which losses of 80% have been reported (Whittle 1985). Apart from the direct impact of larval feeding or tunneling, a major contributor to yield loss is infection of damaged berries by opportunistic saprophytes or pathogens, particularly *Botrytis cinerea* (Roehrich and Boller 1991; CABI 2006). Further losses stem from the time and labor spent in cleaning grape bunches of the silk webbing and feces deposited by larvae, which may account for 30 to 40% of the harvesting effort (Avidov and Harpaz 1969). In viticulture, the damage caused, particularly fungal contamination, interferes with the wine-making process and may result in a product of low quality (Rousseau et al. 2005). *Lobesia botrana* thus represents a potential threat to Hawai'i's growing winemaking industry (e.g., Shimabukuro 2004). Damage to other fruit crops, such as persimmon and pome and stone fruit, may be significant (Ben-Yehuda et al. 1999), and may result from larvae feeding and developing within fruit (e.g., Maison and Pargade 1967). The species is a quarantine pest for South Africa, Brazil, China, Egypt, Jordan, Paraguay, Uruguay, Argentina, Canada, and Chile (EPPO 2005a; PRF 2007), suggesting that its introduction could result in a loss of domestic or foreign markets for Hawai'ian-grown fruits. Because it is known to feed on close relatives of plants listed as threatened or endangered in Hawai'i, *L. botrana* represents a potential threat to *Silene alexandri*, *S. hawaiiensis*, *S. lanceolata*, and *S. perlmanii*, and *Solanum incompletum* and *S. sandwicense*. As the moth is a pest of grape and other fruit crops, its introduction could result in the inauguration of biological control programs, which have proven effective against other tortricid pests in the United States and elsewhere (Clausen 1978c).

A21.1.24 Mamestra brassicae (L.) (Lepidoptera: Noctuidae)

This species occurs throughout Europe, ranging into temperate and subtropical Asia, and northern Africa (Carter 1984). *Mamestra brassicae* is highly polyphagous, attacking crops in several families, including Brassicaceae (particularly varieties of *Brassica oleracea*), Asteraceae (*Lactuca sativa*, *Chrysanthemum* sp.), Chenopodiaceae (*Beta vulgari*s), Fabaceae (*Pisum sativum*, *Phaseolus vulgaris*), Liliaceae (*Allium sativum*), Solanaceae (*Solanum lycopersicum*, *S. tuberosum*, *Nicotiana tabacum*), Rosaceae (*Prunus persica*), Caryophyllaceae (*Dianthus caryophyllus*), Poaceae (*Zea mays*), Vitaceae (*Vitis vinifera*), Fagaceae (*Quercus* sp.), and Polygonaceae (*Rheum* sp.) (Carter 1984; Zhang 1994; CABI 2006). Although brassicas are said to be the most preferred hosts (CABI 2006), Rojas et al. (2001) found no significant difference in the mean number of eggs deposited on cabbage and tomato by females in choice tests.

Fecundity averages 500 to 1,500 eggs per female; there may be three generations per year (CABI, 2006). Adults are said to be “sedentary” (Bues et al. 1988) and ”non-migratory” (Poitout and Bues 1976), indicating a low natural potential for long-distance dispersal. However, the pest has been intercepted at U.S. ports on more than 1,100 occasions on various commodities in cargo (PIN 309a), indicating its potential to move long distances rapidly by human agency. *Mamestra brassicae* is considered to be a serious pest of many crops, in which even small larval populations may be quite damaging (Hill 1987). Damage is caused by larvae defoliating and tunneling into the interiors of plants or plant organs, including fruits, such as apple and tomato (Carter 1984; CABI 2006). Feeding damage of 50% has been recorded in sugar beet (Onodera 1998). Cabbage crops may suffer losses of up to 80% (CABI 2006). Under certain cropping systems, damage may be too great to produce a commercially viable cabbage crop (Brandsaeter et al. 1998). Control typically involves the application of insecticides (Steene 1995; Beltrami et al. 2004), which increases costs of production. As the moth is a quarantine pest for New Zealand, the former states of Yugoslavia, and Southern Africa (EPPO 2005a; PRF 2007), its introduction could result in a loss of foreign, as well as domestic, markets for Hawai’i agricultural commodities, such as tomato, cabbage, and corn. Introduction into Hawai’i also could result in the initiation of biological control programs, as has occurred elsewhere (e.g., Rost 1997), and could put at risk endangered, native plants, such as *Solanum incompletum* and *S. sandwicense*.

A21.1.25 Parlatoria blanchardi (Targioni Tozzetti) (Homoptera: Diaspididae)

This scale is widespread in tropical and subtropical areas of Europe, Asia, and Africa (Watson 2005; Ben-Dov et al. 2006). It also occurs in South America (Argentina, Bolivia, Brazil), parts of the Caribbean, and Australia. Hosts are predominantly species of palms (Arecaceae), such as *Hyphaene thebiaca*, *Latania* sp., *Neowashingtonia* sp., *Phoenix* spp., *Pritchardia filifera*, and *Washingtonia filifera*, but the insect has been recorded on plants in other families, such as *Vinca major* (Apocynaceae), *Jasminum* spp. (Oleaceae), and *Ziziphus mauritiana* (Rhamnaceae) (Ben-Dov et al. 2006).

Fecundity averages about 10 eggs per female, with a maximum of 29 recorded (Howard 2001). There are three to five overlapping generations annually (Watson 2005). Dispersal of this species may occur locally via wind, birds, or insects, or long distances in the transport of infested plants. High scale densities towards the end of the season may result in infestation of fruit just prior to harvest (Howard 2001), also facilitating spread. The scale was introduced into the United States in 1890 on date palm offshoots from Algeria and Egypt, but later eradicated (Carpenter and Elmer 1978). Since 1984, it has been intercepted at U.S. ports on more than 1,300 occasions (PIN 309a). Howard (2001) and Watson (2005) summarized the damage caused by this pest. Heavy infestations weaken the tree by increasing transpiration, depleting nutrients and destroying chlorophyll, thus impairing photosynthesis and productivity. Feeding on fronds causes necrosis of tissues and dieback. Heavily infested offshoots become stunted; attacked fruit shrivels, resulting in downgrading or rejection. Yield losses as high as 70 to 80% have been reported. Palms 5 to 10 years of age may be killed outright. *Parlatoria blanchardi* is the most serious insect pest of date palm, *Phoenix dactylifera*, in Australia, and has been a factor in hindering the development of a significant date industry in that country (Knihinicki and Flechtmann 1999). The scale poses a threat to various ornamental palms in Hawai'i, which are important aesthetically and otherwise to the state (Neal 1965). It also represents a potential threat to Hawai'i's endangered (50 CFR § 17.12), native *Pritchardia palms* (loulu, wahane). Its introduction could spur the initiation of chemical or biological control programs, as has occurred elsewhere (Carpenter and Elmer 1978).

A21.1.26 Planococcus lilacinus (Cockerell) (Homoptera: Pseudococcidae)

This tropical species ranges from South Asia through Southeast and East Asia into Melanesia and some of the other island groups (Marianas, Carolines) of the Pacific. It occurs in East Africa, and has a limited distribution in the Americas (CABI 1995; Ben-Dov et al. 2006). It is reported from Fujian and Guangxi in China, and is established in Taiwan (Hua 2000). The host range of *P. lilacinus* includes species in at least 35 families, including *Mangifera indica* (Anacardiaceae), *Annona* spp. (Annonaceae), *Cordia myxa* (Boraginaceae), *Rhododendron* sp. (Ericaceae), *Euphorbia pyrifolia* (Euphorbiaceae), *Arachis hypogaea* and *Erythrina* spp. (Fabaceae), *Artocarpus* spp. (Moraceae), *Psidium guajava* and *Eugenia* spp. (Myrtaceae), *Citrus* spp. (Rutaceae), *Pandanus* sp. (Pandanaceae), *Cocos nucifera* (Arecaceae), *Gardenia jasminoides* (Rubiaceae), *Litchi* sp. (Sapindaceae), *Punica granatum* (Punicaceae), *Zizyphus jujuba* (Rhamnaceae), *Manilkara zapota* (Sapotaceae), *Solanum* spp. (Solanaceae), *Theobroma cacao* (Sterculiaceae), *Vitis vinifera* (Vitaceae) (Ben-Dov et al. 2006); and *Santalum album* (Santalaceae) (Rostaman 1997).

Fecundity has been reported to range from 55 to 152 eggs per female (Loganathan and Suresh 2001). Two or three generations per year have been suggested (Ooi et al. 2002). Similar to other species of Coccoidea (scale insects) (Gullan and Kosztarab 1997), local dispersal would be accomplished by newly emerged crawlers. Longer-distance movement would be effected via the transport of infested plant materials. The mealybug has been introduced accidentally into continental Africa within the past three decades (Williams et al. 2001). Since 1984, *P. lilacinus* has been intercepted on various commodities at U.S. ports on almost 1,700 occasions (PIN 309a). *Planococcus lilacinus* is a serious pest of various fruit and other crops in Asia, including guava, lemon, ber, pomegranate, lychee, coffee, and cocoa (Williams 2004). Infestations in citrus and coffee result in premature fruit drop and heavy losses in the latter crop. Feeding in coconut palm results in drying of the inflorescence and button shedding (Moore 2001). The mealybug also transmits a cocoa virus in Sri Lanka (Schmutterer 1977). It has been reported to infest fruit for sale in southern Asia (Williams et al. 2001). Infested fruit may be downgraded in quality or become unmarketable (Ooi et al. 2002). In India, insecticides are applied to control the mealybug in coffee (Williams 2004), a practice that increases production costs. Miller et al. (2002) considered the species to be a major threat to U.S. agriculture. As it is a quarantine pest for Paraguay, Uruguay, Argentina, Brazil, Korea, and southern Africa (EPPO 2005a; PRF 2007), its introduction could result in a loss of domestic or foreign markets for Hawai'i crops, such as mango, eggplant, *Annona* spp., and lychee. Other valued plants, such as hala, coconut, and *Erythrina sandwicensis* (wiliwili) (Neal 1965), potentially could be at risk. This pest poses a potential threat to listed native plants in Hawai'i, such as *Eugenia koolauensis*, *Euphorbia haeleeleana*, *Gardenia brighamii* (nau) and *G. mannii* (nanu), *Santalum freycinetianum* var. *lanaiense*, and *Solanum incompletum* and *S. sandwicense*. Its introduction could result in the initiation of biological control programs, similar to what has occurred elsewhere (e.g., India; Reddy et al. 1992).

A21.1.27 Planococcus minor (Maskell) (Homoptera: Pseudococcidae)

This mealybug ranges from South Asia, through parts of Southeast and East Asia (Taiwan), and into several island groups of the South Pacific to Australia (Ben-Dov et al. 2006). It also is widespread in South America (from southern Argentina to Guyana), southern North America (Costa Rica, Guatemala, Honduras, Mexico), and the Caribbean. The species is extremely polyphagous, having been recorded on plants in at least 69 families (Ben-Dov et al. 2006). Hosts include *Colocasia esculenta* (Araceae), *Abutilon* sp. and *Hibiscus* spp. (Malvaceae), *Solanum* spp. (Solanaceae), *Harrisia portoricensis* (Cactaceae), *Theobroma cacao* (Sterculiaceae), *Citrus* spp. (Rutaceae), *Coffea* spp. and *Gardenia jasminoides* (Rubiaceae), *Mangifera indica* (Anacardiaceae), *Musa* spp. (Musaceae), *Cyperus rotundus* (Cyperaceae), *Cordia alliodora* (Boraginaceae), *Eugenia* spp. and *Psidium guajava* (Myrtaceae), *Vitis vinifera* (Vitaceae), *Ziziphus* sp. (Rhamnaceae), *Amaranthus* sp. (Amaranthaceae), *Annona* spp. (Annonaceae), *Helianthus* sp. and *Bidens pilosa* (Asteraceae), *Euphorbia* spp. and *Manihot esculenta* (Euphorbiaceae), *Persea americana* (Lauraceae), *Ipomoea* spp. (Convolvulaceae), *Brassica* spp. (Brassicaceae), *Cucurbita* spp. (Cucurbitaceae), *Zea mays* (Poaceae), *Arachis hypogaea* and *Erythrina* sp. (Fabaceae), *Artocarpus* spp. (Moraceae), *Cocos nucifera* (Arecaceae), *Pandanus* spp. (Pandanaceae), *Pyrus pyrifolia* (Rosaceae), and *Asparagus plumosus* (Liliaceae).

Reported fecundity ranges from about 200 to over 500 eggs per female, depending on host plant; there may be as many as 10 generations per year (Maity et al. 1998; Martinez and Suris, 1998; Sahoo et al., 1999). As in other species of Coccoidea (Gullan and Kosztarab 1997), local dispersal would be accomplished by newly emerged crawlers. Longer-distance movement would be effected via the transport of infested plant materials. The mealybug has been intercepted in Japan in shipments of banana fruit from the Philippines (Sugimoto 1994). It has been intercepted at U.S. ports on more than 4,400 occasions on commodities from various countries (PIN 309a). *Planococcus minor* is an important pest of coffee in India (Reddy et al. 1997). It is a pest of durian (*Durio zibethinus*) in Thailand, causing loss of yield and reduction in market value (Anonymous 2003). Infestations in other fruits may result in a downgrading of quality or unmarketable fruit (Ooi et al. 2002). The mealybug is a vector of banana streak virus in Cuba (González et al. 2002). Insecticidal applications provide good control of the mealybug (e.g., Shukla and Tandon 1984), but increase crop production costs. Miller et al. (2002) considered the species to be a major threat to U.S. agriculture. As it is a quarantine pest for Korea (PRF 2007), introduction of *P. minor* into Hawai'i could result in the loss of that market for important crops, such as mango, avocado, banana, and cucurbits. Because it is known to feed on closely related hosts, the mealybug is a potential threat to listed native plants in Hawai'i, such as *Amaranthus brownii*, *Hibiscus arnottianus* ssp. immaculatus, *H. brackenridgei*, *H. clayi*, and *H. waimeae* ssp. hannerae, *Solanum incompletum* and *S. sandwicense*, *Bidens micrantha* ssp. kalealaha and *B. wiebkei*, Abutilon eremitopetalum, *A. menziesii*, and *A. sandwicense*, *Eugenia koolauensis*, *Euphorbia haeleeleana*, *Gardenia brighamii* and *G. mannii*, and *Cyperus trachysanthos* (puukaa). Because it represents a potentially serious threat to economically or aesthetically valuable crops (e.g., avocado, banana, citrus, coffee, mango, guava, hala, wiliwili, coconut, corn, brassicas, cucurbits), its introduction likely would spur the initiation of control programs. It has been the target of a biological control program in India (Reddy et al, 1997); other species of *Planococcus* have been targeted for biological control in the United States and elsewhere (Bartlett 1978).

A21.1.28 Pseudaonidia trilobitiformis (Green) (Hemiptera: Diaspididae)

This scale occurs primarily in subtropical and tropical regions of Australasia, the Orient, Africa, Central and South America, the Caribbean, and Florida in the United States, but also has been reported from more temperate areas, such as the Republic of Georgia and Japan (Ben-Dov et al. 2006). It is extremely polyphagous, having been recorded on plants in at least 47 families (Ben-Dov et al. 2006). Hosts include *Agave mexicana* (Agavaceae), *Mangifera indica* (Anacardiaceae), *Carica papaya* (Caricaceae), *Diospyros kaki* (Ebenaceae), *Quercus* sp. (Fagaceae), *Persea americana* (Lauraceae), *Hibiscus* sp. (Malvaceae), *Artocarpus* spp. (Moraceae), *Punica granatum* (Punicaceae), *Coffea* spp. (Rubiaceae), *Litchi sinensis* (Sapindaceae), *Psidium guajava* and *Eugenia* spp. (Myrtaceae), *Cocos nucifera* (Arecaceae), *Ziziphus spina-christi* (Rhamnaceae), *Citrus* spp. (Rutaceae), *Santalum austro-caledonicum* (Santalaceae), *Capsicum* spp. (Solanaceae), *Prunus domestica* (Rosaceae), and *Vitis vinifera* (Vitaceae).

No information is available on the biology of the scale. A related species, *P. duplex* (Cockerell), exhibits three generations per year in Louisiana; fecundity of *P. paeoniae* (Cockerell), also known from the southern United States, ranges from 30 to 50 eggs per female (Kosztarab 1996). If the biology of *P. trilobitiformis* is similar, its reproductive potential could be high. Long-distance dispersal of *P. trilobitiformis* likely is accomplished by transport on infested plant materials, as evidenced by numerous interceptions of the species at U.S. ports (PIN 309a). *Pseudaonidia trilobitiformis* is regarded as a minor pest of avocado, cacao, citrus, coconut, coffee, mango, and passion fruit (Hill 1983). The scale is a pest of cashew in Brazil, requiring treatment with insecticides for its control (Silva et al. 1977), which increases costs of production and may impact non-target species. It is a quarantine pest for Korea and New Zealand (PRF 2007), suggesting that its introduction into Hawai'i could result in a loss of domestic or foreign markets for commodities, such as mango, papaya, avocado, and lychee. *Pseudaonidia trilobitiformi* has the potential to attack plants listed as endangered or threatened in Hawai'i, such as *Hibiscus arnottianus* ssp. immaculatus, *H. brackenridgei*, *H. clayi*, and *H. waimeae* ssp. hannerae, and *Eugenia koolauensis*. Since it poses a potential threat to citrus and other economically important crops, its introduction into Hawai'i could stimulate the initiation of biological control programs, similar to those that have occurred in response to the introduction of other diaspidid scales (e.g., Rosen and DeBach 1978).

A21.1.29 Tetranychus lambi Pritchard & Baker (Acari: Tetranychidae)

With the exception of two disjunct populations reported from Asia (Iran and Taiwan), the geographic range of *T. lambi* is restricted to islands of the South Pacific, Australia, and New Zealand (Bolland et al. 1998). This polyphagous species has been recorded on plants in several families. Hosts include *Abutilon tubulosum* (Malvaceae), *Acaena* sp. and *Prunus persica* (Rosaceae), *Euphorbia* sp. and *Manihot esculenta* (Euphorbiaceae), *Arenga engleri* (Arecaceae), *Aspidistra* sp. (Liliaceae), *Calathea crocata* (Marantaceae), *Carica papaya* (Caricaceae), *Galactia tenuiflora* (Fabaceae), *Colocasia esculenta* (Araceae), *Cucurbita* spp. (Cucurbitaceae), *Goodenia ovata* (Goodeniaceae), *Homalocladium platycladum* (Polygonaceae), *Lobelia heterophylla* (Campanulaceae), *Morus alba* (Moraceae), *Musa* spp. (Musaceae), *Solanum melongena* (Solanaceae), *Oxalis* spp. (Oxalidaceae), *Panicum maximum* (Poaceae), *Poncirus trifoliata* (Rutaceae), *Quercus alba* (Fagaceae), and *Stephania japonica* (Menispermaceae) (Bolland et al. 1998).

Bonato and Gutierrez (1999) reported mean fecundity in a population reared on green bean, *Phaseolus vulgaris*, to be approximately 134 eggs per female. The calculated net replacement rate (the number of times a population increases in a generation) was 69.5, indicating considerable biotic potential. In Australia, there are said to be many overlapping generations annually (Pinese and Elder 2004). As in all spider mites (Tetranychidae), long-distance dispersal occurs by wind-borne individuals and in the movement of infested plant materials (Jeppson et al. 1975). Little information is available on the economic importance of *T. lambi*. It is considered a major pest of agriculture in much of the southern and western Pacific (Waterhouse 1997). It is one of three spider mites that are significant pests of cotton in Australia, causing bronzing and desiccation of leaves (OGTR 2002). In banana, attack is concentrated on leaves, although, in severe outbreaks, mites may move to the fruit (Gold et al. 2002). Feeding produces areas of discoloration on the fruit surface that may later dry out and crack. As indicated by its reported host range, *T. lambi* is a potential threat to economically or culturally important plants in Hawai'i, such as papaya, taro, cucurbits, banana, and eggplant. The mite also is a potential threat to endemic Hawai'ian plants, such as *Abutilon eremitopetalum*, *A. menziesii*, and *A. sandwicense*, *Acaena exigua* (liliwai), *Euphorbia haeleeleana*, *Lobelia gaudichaudii* ssp. koolauensis, *L. monostachya*, *L. niihauensis*, and *L. oahuensis*, *Panicum fauriei* var. carteri and *P. niihauense* (lauehu), and *Solanum incompletum* and *S. sandwicense*, all listed as endangered (50 CFR § 17.12). Its introduction into Hawai'i could result in the initiation of biological control programs. Natural enemies of the pest are known (e.g., Chazeau 1983), and could prove effective at regulating its numbers.

A21.1.30 Unaspis yanonensis (Kuwana) (Homoptera: Diaspididae)

This armored scale is widespread in East and Southeast Asia, from Pakistan to Japan and south to Indonesia (Ben-Dov et al. 2006). Adventive populations also occur in Armenia, Australia, Fiji, France, and Italy. Hosts are predominantly Rutaceae, in particular, species of Citrus (e.g., *C. aurantium*, *C. deliciosa*, *C. maxima*, *C. medica*, *C. natsudaidai*, *C. nobilis*), *Fortunella japonica*, and *Poncirus trifoliata*, but also include *Damnacanthus* sp. (Rubiaceae) (Ben-Dov et al, 2006).

Fecundity averages 177 to 196 eggs per female; there are as many as three generations per year (Blackburn and Miller 1984). Although *U. yanonensis* is said to have a low inherent dispersal potential (CABI/EPPO 1997j), it has spread over long distances in the international movement of plant materials (e.g., to southern France; Burger and Ulenberg 1990). The scale also has been intercepted at U.S. ports on more than 2,800 occasions since 1984, mainly on citrus fruit (PIN 309a). *Unaspis yanonensis* is said to do more damage to citrus crops in Japan than any other pest (Kukhtina 1970). Twigs, leaves, and fruits may be heavily attacked, and severe infestations often result in the death of trees (Rosen and DeBach 1978). An inordinate amount of damage seems to be caused relative to the numbers of scales feeding (Clausen, 1933). Feeding causes circular, yellowish blotches on leaves, eventually resulting in almost total necrosis, and severe distortion of fruit (Blackburn and Miller 1984). Affected fruits lose their commercial value (CABI/EPPO 1997j). *Unaspis yanonensis* is said to replace the closely related *U. citri* as an important citrus pest in China, Taiwan, and Japan (Smith and Peña 2002). It thus is a potential threat to *Citrus* spp. in Hawai'i, which not only are commercially important (NASS 2006a), but are valued as ornamental and fruit trees in residential plantings (Neal 1965). The scale is a quarantine pest for Turkey, Syria, Tunisia, Peru, Belarus, and East and southern Africa (EPPO 2005a; PRF 2007), suggesting that its introduction could result in the loss of domestic or foreign markets for Hawai'ian-grown citrus. As *U. yanonensis* represents a significant threat to citrus production, its introduction likely would result in the initiation of chemical or biological control programs, similar to those that have occurred elsewhere. For example, routine insecticidal applications have been required to control the pest in Japan and France (Blackburn and Miller 1984). The scale is under apparently successful biological control in Japan (Rosen 1990).

A21.2 PLANT PATHOGENS

As indicated by the recent detection of the fungus, *Puccinia psidii* Winter (Urediniomycetes: Uredinales), which produces a rust disease in the native myrtaceous plants, *Metrosideros polymorpha* (ohia lehua) and the federally listed (50 CFR § 17.12) *Eugenia koolauensis* (Uchida et al. 2006), Hawai'i is vulnerable to the introduction of potentially devastating invasive plant pathogens. The fungus causing ohia rust has been established in Florida for many years (Burnett and Schubert 1985), and possibly entered Hawai'i on plant material imported from that state. A sampling of pathogens that represent potential threats to Hawai'i's plant resources is discussed below.

A21.2.1"*Candidatus Liberobacter asiaticum*" Jagoueix et al. (Alphaproteobacteria: Rhizobiales)

This bacterium exhibits a primarily Asian distribution, ranging from Saudi Arabia and Yemen in the west to Taiwan and Japan (Ryukyu Islands) in the east (EPPO 2005d). It also occurs in Mauritius and Réunion in Africa. Recently, it has been introduced into Florida (EPPO 2005b) and New Guinea (Davis et al. 2005). Hosts are restricted to Rutaceae, and include *Citrus* spp. and *Fortunella* spp. (CABI/EPPO 1997d). Natural infection of plants in other rutaceous genera (e.g., *Severinia*, *Feronia*) is said to be possible (Timmer et al. 2000). *Liberobacter asiaticum* is spread from host to host by grafting or by an insect vector, the psyllid, *Diaphorina citri* Kuwayama (Timmer et al. 2000; CABI 2006), which now occurs in Hawai'i (HDOA 2006). However, both graft- and insect-transmission apparently are not highly efficient. Graft-transmission rates are variable because of the irregular distribution of the bacterium within hosts; most vector-aided spread occurs when psyllid population densities are high and succulent growth is present on both donor and receptor plants (Timmer et al. 2000). Moreover, some hosts may be more resistant to the bacterium than others. For example, Schwartz et al. (1973) found that, even in areas of high disease incidence, pummelo, lemon, and lime (*C. aurantiifolia*) crops maintained acceptable fruit yields despite infection. Pummelo and lime are said to show some of the weakest symptoms among *Citrus* spp. (CABI/EPPO 1997d). Rapid, long-distance dispersal would be facilitated most likely by the movement of infected plant propagative material (CABI/EPPO 1997d). Its introduction into Florida and New Guinea (where infected planting material was found; Davis et al. 2005) suggests that it is spread widely by human agency.

This bacterium causes the disease known as greening or Huanglongbing (Timmer et al. 2000), which is one of the most devastating diseases of citrus (Garnsey 1999). According to Garnsey, no other disease so completely limits citrus production or is so difficult to control. Yield losses of 30 to 100% have been reported, and the impact of the disease may be so severe that large areas of citrus cultivation must be abandoned (CABI/EPPO 1997d). Chronically infected trees show extensive defoliation and twig dieback; fruits tend to be undersized, misshapen, and poorly colored, often with a bitter taste (Timmer et al. 2000), and thus are likely to be of below-market quality. In South Africa, citrus trees routinely are treated with antibiotics (CABI/EPPO 1997d), which increases production costs. As the pathogen is a quarantine pest for countries, such as Argentina, Brazil, Chile, Jamaica, Korea, Paraguay, Uruguay, and the European Union (EPPO 2005a; PRF 2007), its introduction could result in a loss of foreign, as well as domestic, markets for Hawai'ian-grown citrus. Citrus also is valued in Hawai'i as an ornamental and fruit tree in residential plantings (Neal 1965). Spread of the bacterium from Florida or Asia to Hawai'i could have an indirect environmental impact, spurring the initiation of chemical or biological control programs targeting its vector, *D. citri*, similar to what has occurred elsewhere (CABI 2006). The survival of Hawai'i's endemic *Trioza psyllids* (Zimmerman 1948) could thereby be jeopardized.

A21.2.2 Xanthomonas axonopodis pv. citri (Hasse) Vauterin et al. (Gammaproteobacteria: Xanthomonadales)

This bacterium is widespread in tropical and subtropical Asia, ranging from Saudi Arabia in the west to Taiwan and Japan in the east, and south to Indonesia (EPPO 2005e). It also occurs in New Guinea and Australia, parts of Oceania, Africa, and South America, and in Florida, where it is under official control (7 CFR § 301.75-1). Natural hosts are species of Rutaceae, and include *Citrus* spp., *Poncirus trifoliata*, *Fortunella* spp., *Severinia buxifolia*, and *Swinglea glutinosa* (Bradbury 1986; CABI/EPPO 1997k).

Of the several forms of the bacterium, the Asian strain (A strain) is the most virulent and polyphagous (CABI/EPPO 1997k). Evidence suggests a high reproductive rate for the species. For example, following initial infection and multiplication, bacteria may emerge from leaf stomatal openings in as few as 5 days to provide inoculum for further disease development (Graham et al. 2004). In experimental citrus plots, Gottwald et al. (1988) found infection to increase as much as 0.9% per day, suggesting a rather high biotic potential. Natural spread of the pathogen is achieved locally through the transport of propagules in rain splash and on the wind; longer-distance dispersal may be effected by severe storms, such as tornadoes and hurricanes (Gottwald et al., 1997). The calculated maximal distance of natural spread ranged from 12 m (39 feet) to 3.5 km (2 miles) over a 4-month period (Gottwald et al. 2002b). Dissemination also may occur via the movement of infected propagative material and planting stock, such as budwood and rootstock seedlings (CABI/EPPO 1997k), and probably has been the predominant means of spread to other continents from the species' presumed center of origin in tropical Asia (Das 2003). The pathogen has been intercepted at U.S. ports on more than 60 occasions since 1988 (PIN 309a).

Citrus canker, the disease caused by this pathogen, is considered one of the most damaging to commercial citrus crops, affecting both the appearance and flavor of fruits (Anonymous 1982b). Infection causes necrotic lesions on leaves, stems, and fruit; trees may suffer defoliation, badly blemished fruit, secondary fruit rots, premature fruit drop, twig dieback, and general decline (CABI/EPPO 1997k; Schubert and Sun 2003). For example, 83 to 97% of diseased fruit in grapefruit crops has been reported; canker lesions may make fresh fruit unmarketable (Das 2003). In less severe cases, lesions on fruit may reduce its market value (Timmer et al. 2000; Wang et al. 2004). Control measures commonly include the application of copper-based bactericides (e.g., Graham et al., 2004), which may significantly increase production costs. For example, Gottwald et al. (2002a) predicted that, should the disease become endemic in Florida, the high costs of chemical and other controls might make impossible the profitable cultivation of some of the more susceptible citrus species, such as grapefruit. These authors also estimated that establishment of the pathogen would result in severe curtailment of interstate and international trade in fresh fruit, which currently represents approximately 20% of the state's $9-billion commercial citrus industry. As the bacterium is a quarantine pest for numerous countries, including Argentina, Ukraine, New Zealand, Peru, Chile, Turkey, Uruguay, Thailand, and the European Union (EPPO 2005a; PRF 2007), Hawai'i's citrus exports could be similarly affected. Given the importance of *Citrus* spp. as fruit and ornamental trees, the spread of *X. axonopodis* pv. *citri* to Hawai'i could result in initiation or expansion of chemical control programs employing the copper-based compounds typically used against crop-infecting bacteria (Timmer et al. 2000). Long-term use of these bactericides may result in accumulation of high levels of copper in soils, with potential phytotoxic and other environmental consequences (Graham et al. 2004). Although research is still in a preliminary stage, the efficacy of biological control of citrus canker, involving the release of strains of bacterial species antagonistic to *X. axonopodis* pv. *citri*, also has been considered (Das 2003).

A21.2.3 Guignardia citricarpa Kiely (Ascomycetes: Dothideales)

This fungus is thought to have originated in Southeast Asia, subsequently spreading to other tropical and subtropical regions, including Australia, Africa, and South America (CABI/EPPO 1997f). In East Asia, the fungus ranges from Zhejiang Province in China to Taiwan (EPPO 2005c). Potential global distribution apparently is limited by cold and dry conditions (Paul et al. 2005). Hosts are principally or exclusively species of Citrus (Rutaceae), including *C. maxima*, *C. sinensis*, *C. paradisi*, *C. limon*, *C. aurantiifolia*, and *C. reticulata*; records of the fungus on non-citrus plants are considered doubtful, and may involve other Guignardia species (CABI/EPPO 1997f; Farr et al. 2006). *Guignardia citricarpa* may be established in an area for many years before symptoms of disease appear, and a further 5 to 30 years may pass until the disease reaches epidemic proportions (Anonymous 1982a). Local spread within orchards occurs primarily through the dissemination of ascospores in water and on the wind, whereas long-distance dispersal is achieved by the movement of infected plant materials or nursery stock (CABI/EPPO 1997f). The broad distribution of the fungus, showing establishment on four continents (EPPO 2005c), suggests that it is readily dispersed via the international transport of citrus propagative material. It has been intercepted on more than 6,300 occasions at U.S. ports on various citrus organs, including living plants, from numerous countries (PIN 309a). Disease is caused by the anamorphic form of the fungus, *Phyllosticta citricarpa* (McAlpine) van der Aa, which invades the fruit rind without harming the pulp (Timmer et al. 2000). Characteristic symptoms involve the appearance of black spots on the fruit surface, which range from 1 to 25 mm in diameter and may number more than 1,000; spots may coalesce to affect most of the surface (Anonymous 1982a; Seymour and Burnett 1982). Severe infection often causes premature fruit drop (Timmer et al. 2000). Losses exceeding 80% have been reported

(Seymour and Burnett 1982; CABI/EPPO 1997f). Affected fruits that mature to harvest-stage are unmarketable as fresh fruit, and suitable only for lower value end uses, such as processing (Anonymous 1982a; Timmer et al. 2000). Ironically, although infection renders fruits unmarketable for cosmetic reasons, it may improve their eating quality by making them sweeter (Anonymous 1988). The pathogen is a quarantine pest for several countries, including Turkey, Peru, Uruguay, Chile, New Zealand, and the European Union (PRF 2007), suggesting that its introduction could result in a loss of foreign, as well as domestic, markets for Hawai'ian-grown citrus fruit.

A21.2.4 Helicobasidium mompa Tanaka (Urediniomycetes)

This fungus occurs in Asia (China, India, Indonesia, Japan, Korea, Malaysia, Taiwan) and Africa (Malawi, South Africa, Uganda) (CABI 2006; Farr et al, 2006). It is known to attack at least 104 plant species in 44 families (Uetake et al. 2001). Hosts include *Asparagus officinalis* (Liliaceae), *Beta vulgaris* (Chenopodiaceae), *Brassica oleracea* (Brassicaceae), *Citrus* sp. (Rutaceae), *Daucus carota* (Apiaceae), *Diospyros kaki* (Ebenaceae), *Ficus* spp. (Moraceae), *Ipomoea batatas* (Convolvulaceae), *Glycine max* (Fabaceae), *Pyrus* sp. (Rosaceae), *Sesamum orientale* (Pedaliaceae), *Solanum tuberosum* (Solanaceae), *Gossypium* sp. (Malvaceae), *Camellia sinensis* (Theaceae) (Farr et al. 2006); *Vitis* sp. (Vitaceae) (Clark and Moyer, 1988); and *Medicago sativa* (Fabaceae) (Sakuma et al. 1984).

This pathogen is dispersed in irrigation water and in infested manure, and, more commonly, by the movement of infested soil, such as that eroded by heavy rains or adhering to transplants from infested nurseries (Clark and Moyer 1988). Although it is primarily soilborne, infecting plants in the field, it also causes a rot that continues to develop on the roots in storage, and, thus, could be transported rapidly in the international root crop trade. The fungus is said to be highly virulent, exhibiting an infection rate in apple of greater than 33% within 6 months in experimental field tests (Uetake et al. 2001). This fungus, the causal agent of violet root rot, is known to cause serious losses in sweetpotato crops in Asia during years that favor disease development (Clark and Moyer 1988). Decay of the fibrous roots progresses from the tips, and may destroy the entire root system. Foliage of severely infected plants becomes chlorotic; older leaves may fall prematurely. In Korea, infection rates in apple were somewhat greater than 5% (Lee et al. 1995). Mortality of apple stocks in Japan was reported to be about 8% under experimental conditions (Uetake et al, 2001). Soil fumigation is one means employed for control (e.g., Sakuma et al. 1984), which increases production costs. Establishment of the pathogen in Hawai'i could cause a loss of foreign or domestic markets for root crops, such as sweetpotato. It is a quarantine pest for New Zealand (PRF 2007). *Helicobasidium mompa* also poses a potential threat to endemic Hawai'ian plants listed as threatened or endangered, such as *Solanum incompletum* and *S. sandwicense*.

A21.2.5 Scutellonema bradys (Steiner & Le Hew) Andrássy (Tylenchida: Hoplolaimidae)

This nematode is native to West Africa, but has spread to other regions of the world (CABI 2006). It has a scattered distribution in the New World between the southern United States (Arkansas, Florida, Louisiana) and Brazil, and in parts of the Caribbean (including Puerto Rico) (CABI 2006; Handoo 2007). In Asia, it occurs in India, Pakistan, and Korea; and possibly Taiwan (Tsay 1997). Primary hosts are species of *Dioscorea* (Dioscoreaceae); other hosts include *Hibiscus* spp. (Malvaceae), *Cucurbita melo* (Cucurbitaceae), *Sesamum indicum* (Pedaliaceae), *Sorghum bicolor* (Poaceae), *Manihot esculenta*

(Euphorbiaceae), *Cocos nucifera* (Arecaceae), *Corchorus olitorius* (Tiliaceae), *Solanum lycopersicum* (Solanaceae), *Synedrella nodiflora* (Asteraceae), *Pachyrhizus erosus* (yam bean; Fabaceae) (CABI 2006); *Citrus sinensis* (Rutaceae) (Mead 1987); and Convolvulaceae (Kermarrec et al. 1987). Jatala and Bridge (1990) listed *Scutellonema* spp. among nematode pests of sweetpotato.

Scutellonema bradys exhibits high reproductive and dispersal potentials. In stored tubers of *Dioscorea* spp. (yam), populations may increase as much as 14-fold in a 5 to 6-month period (Jatala and Bridge 1990). The nematode is a migratory endoparasite of roots and tubers, and may also be present in soils around host plants (CABI 2006). In Florida, *Scutellonema* spp. are widespread in field and greenhouse soils (O'Bannon and Duncan 1990). Imported nursery stock thus is a potential pathway for entry of *S. bradys* into Hawai'i. Infested tubers also are known to be a major means of long-range dispersal of the pest. It has moved among the islands of the Caribbean in recent decades (e.g., Degras and Kermarrec 1976; Kermarrec et al. 1987), and has been intercepted at U.S. ports (PIN 309[28]) in yam tubers. *Scutellonema bradys* causes a decay of yam known as "dry rot disease," resulting in blackening and cracking of the skin of the tuber (Jatala and Bridge 1990). This condition causes a significant reduction in the quality and marketable value of tubers. Preharvest damage to yams by *S. bradys* was as high as 40% in Nigeria; losses in storage may run 80 to 100%. The nematode is a quarantine pest for French Polynesia and Thailand (PRF 2007), and an A2 quarantine pest for the Caribbean Plant Protection Commission (EPPO 2005a). Its introduction into Hawai'i, therefore, could result in a loss of foreign, as well as domestic, markets for commodities, such as sweetpotato. As it represents a potential threat to plants, such as citrus, sweetpotato, cucurbits, tomato, and coconut, its introduction also could result in the increased use of nematicides, which are employed for the control of *Scutellonema* spp. elsewhere (e.g., Ogbuji 1983). Because it is known to attack related hosts, *S. bradys* represents a potential threat to native plants in Hawai'i, such as *Hibiscus arnottianus* ssp. immaculatus, *H. brackenridgei*, *H. clayi*, and *H. waimeae* ssp. hannerae, and *Solanum incompletum* and *S. sandwicense*, all listed as endangered in 50 CFR § 17.12.

[28] Records from the USDA-APHIS-PPQ Port Information Network (PIN 309). Last accessed February 2007.

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A25 SUPPORTING DATA TABLES

Table A25-1: Shipments of Fresh Agricultural Commodities of Foreign Origin Entered Hawai'i during the Period January 1, 2004 and December 31, 2006

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
American Samoa	Airport	CF	*Alyxia*	3	68	Stems	Baggage: *Ceroplastes rubens* (arthropod), *Orchamoplatus mammaeferus* (arthropod)
American Samoa	PIS	MC	Permit Pathogen	1	100	Each	
American Samoa	PIS	PM	*Anthurium* sp.	1	7	Plant unit	
American Samoa	PIS	PM	*Gardenia* sp.	1	8	Plant unit	
American Samoa	PIS	PM	*Metroxylon* sp.	1	1.5	kg	
American Samoa	PIS	PM	*Metroxylon* sp.	not given	25	Plant unit	
American Samoa	PIS	PM	*Zingiber* sp.	1	6	Plant unit	
Argentina	PIS	PM	*Zea mays*	1	2.5	kg	
Australia	Airport	CF	*Banksia*	1	1,200	Stems	
Australia	Airport	CF	*Protea*	3	6,641	Stems	
Australia	Airport	FV	Blueberry	1	60	kg	
Australia	Airport	FV	Cassava	1	1	kg	
Australia	Airport	FV	Mango	4	4,648	kg	
Australia	Airport	FV	Strawberry	1	770	kg	
Australia	Airport	PM	*Anigozanthos* sp.	2	1,144	Plant unit	
Australia	Airport	PM	*Anthurium* sp.	1	2,686	Plant unit	
Australia	Airport	PM	*Arachis* sp.	1	10	kg	
Australia	Airport	PM	*Gossypium* sp.	1	54	kg	
Australia	Airport	PM	*Linum usitatissimum*	1	410	kg	
Australia	Airport	PM	Orchidaceae (Unknown Genus)	1	33,200	Plant unit	
Australia	Airport	PM	Zygopetalum sp.	1	3,900	Plant unit	
Australia	Maritime	FV	Macadamia	15	221,941	kg	
Australia	Maritime	FV	Orange	2	44,800	kg	Baggage: species of Diaspididae (arthropod)
Australia	PIS	PM	*Adansonia* sp.	1	0.01	kg	
Australia	PIS	PM	*Alloxylon* sp.	1	3	Plant unit	
Australia	PIS	PM	*Alpinia* sp.	1	2	Plant unit	
Australia	PIS	PM	*Anigozanthos* sp.	2	1,248	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Australia	PIS	PM	*Arachis* sp.	1	10	kg	
Australia	PIS	PM	*Araucaria* sp.	1	8.5	kg	
Australia	PIS	PM	*Brachychiton* sp.	1	31	Plant unit	Permit cargo: *Alternaria* sp. (pathogen)
Australia	PIS	PM	*Bromelia* sp.	1	317	Plant unit	
Australia	PIS	PM	*Brownea* sp.	1	1	Plant unit	
Australia	PIS	PM	*Callistemon* sp.	2	32	Plant unit	
Australia	PIS	PM	*Calyptrocalyx* sp.	1	0.075	kg	
Australia	PIS	PM	*Carpoxylon macrospermum*	1	7	kg	
Australia	PIS	PM	*Carpoxylon macrospermum*	not given	7	Plant unit	
Australia	PIS	PM	*Clerodendrum* sp.	1	1	Plant unit	
Australia	PIS	PM	*Cordyline* sp.	1	1	Plant unit	
Australia	PIS	PM	*Corypha* sp.	1	1	kg	
Australia	PIS	PM	*Cymbidium* sp.	2	29	Flask	
Australia	PIS	PM	*Cynodon* sp.	1	100	kg	
Australia	PIS	PM	*Dendrobium* sp.	1	11	Flask	
Australia	PIS	PM	*Dendrobium* sp.	not given	8	Plant unit	
Australia	PIS	PM	*Drymophloeus* sp.	1	0.5	kg	
Australia	PIS	PM	*Dypsis* sp.	1	101	Plant unit	Permit cargo: *Palmicultor browni* (arthropod)
Australia	PIS	PM	*Eremophila* sp.	1	2	Plant unit	
Australia	PIS	PM	*Etlingera* sp.	1	23	Plant unit	
Australia	PIS	PM	*Eucalyptus* sp.	1	12	Plant unit	
Australia	PIS	PM	*Fagraea* sp.	1	1	Plant unit	
Australia	PIS	PM	*Ficus* sp.	1	1	Plant unit	
Australia	PIS	PM	*Gardenia* sp.	1	13	Plant unit	Permit cargo: species of Aleyrodidae (arthropod)
Australia	PIS	PM	*Geonoma* sp.	1	0.01	kg	
Australia	PIS	PM	*Grevillea* sp.	3	17	Plant unit	Permit cargo: *Phoma* sp. (pathogen)
Australia	PIS	PM	*Heliconia* sp.	1	24	Plant unit	
Australia	PIS	PM	*Heterospathe* sp.	1	0.5	kg	
Australia	PIS	PM	*Howea* sp.	41	789,000	Plant unit	
Australia	PIS	PM	*Hydriastele* sp.	1	15	Plant unit	
Australia	PIS	PM	*Kentia* - Use (=) *Gronophyllum*	7	108,000	Plant unit	
Australia	PIS	PM	*Leptospermum* sp.	1	1	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Australia	PIS	PM	*Leucaena* sp.	1	44	kg	
Australia	PIS	PM	*Licuala* sp.	1	0.025	kg	
Australia	PIS	PM	*Livistona* sp.	1	0.01	kg	
Australia	PIS	PM	*Lophanthera* sp.	1	2	Plant unit	
Australia	PIS	PM	*Maniltoa* sp.	1	1	Plant unit	
Australia	PIS	PM	*Melaleuca* sp.	1	1	Plant unit	
Australia	PIS	PM	*Michelia* sp.	1	50	Plant unit	
Australia	PIS	PM	*Murraya paniculata*	1	1	Plant unit	
Australia	PIS	PM	*Murraya* sp.	2	40	Plant unit	
Australia	PIS	PM	*Mussaenda* sp.	1	1	Plant unit	
Australia	PIS	PM	*Nepenthes* sp.	9	2,147	Plant unit	
Australia	PIS	PM	*Phalaenopsis* sp.	1	1	Flask	
Australia	PIS	PM	*Plumeria* sp.	1	2	Plant unit	
Australia	PIS	PM	*Polyalthia* sp.	1	1	Plant unit	
Australia	PIS	PM	*Psidium* sp.	1	7	Plant unit	
Australia	PIS	PM	*Pterocarpus* sp.	1	7	Plant unit	
Australia	PIS	PM	*Rhododendron* sp.	2	376	Plant unit	
Australia	PIS	PM	*Saraca* sp.	1	2	Plant unit	
Australia	PIS	PM	*Syzygium* sp.	2	16	Plant unit	
Australia	PIS	PM	*Toona* sp.	1	0.1	kg	
Australia	PIS	PM	*Urochloa* sp.	1	250	kg	
Australia	PIS	PM	*Vanilla* sp.	1	200	Plant unit	
Australia	PIS	PM	*Wodyetia bifurcata*	1	90	kg	
Australia	PIS	PM	*Xanthostemon* sp.	1	23	Plant unit	
Australia	PIS	PM	*Zingiber* sp.	1	2	Plant unit	
Australia	USPS	PM	*Araucaria* sp.	1	9	kg	
Brazil	PIS	MC	Permit Pathogen	1	29.092	kg	
Canada	Airport	FV	Blueberry	2	5,020	kg	
Canada	Airport	FV	Cherry	5	3,638	kg	
Canada	Airport	FV	Mushroom	17	1,291	kg	
Canada	Airport	FV	Pepper	2	30	kg	
Canada	Airport	FV	Tomato	9	3,462	kg	
Canada	Airport	PM	*Wasabia* sp.	1	7	Plant unit	
Canada	PIS	PM	*Acalypha* spp.	1	96	Plant unit	
Canada	PIS	PM	*Adiantum* sp.	2	255	Plant unit	
Canada	PIS	PM	*Aeschynanthus* sp.	3	600	Plant unit	
Canada	PIS	PM	*Agave* sp.	1	15	Plant unit	
Canada	PIS	PM	*Aphelandra* sp.	21	4,140	Plant unit	
Canada	PIS	PM	*Aralia* sp.	1	240	Plant unit	
Canada	PIS	PM	*Argyranthemum* sp.	1	336	Plant unit	
Canada	PIS	PM	Azalea - Use	6	1,161	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
			Rhododendron				
Canada	PIS	PM	*Begonia* sp.	233	66,238	Plant unit	
Canada	PIS	PM	*Bixa* sp.	2	345	Plant unit	
Canada	PIS	PM	*Blechnum* sp.	2	96	Plant unit	
Canada	PIS	PM	*Bolbitis* sp.	1	5	Plant unit	
Canada	PIS	PM	*Bracteantha* sp.	1	210	Plant unit	
Canada	PIS	PM	*Calathea* sp.	22	1,026	Plant unit	
Canada	PIS	PM	*Calceolaria* sp.	8	1,371	Plant unit	
Canada	PIS	PM	*Calluna* sp.	1	153	Plant unit	
Canada	PIS	PM	*Capsicum* sp.	13	3,750	Plant unit	
Canada	PIS	PM	*Chamaedorea* sp.	4	1,080	Plant unit	
Canada	PIS	PM	*Chlorophytum* sp.	3	750	Plant unit	
Canada	PIS	PM	*Chrysanthemum* sp.	170	30,849	Plant unit	
Canada	PIS	PM	*Cineraria* sp.	6	1,116	Plant unit	
Canada	PIS	PM	*Crassula* sp.	4	662	Plant unit	
Canada	PIS	PM	*Crinum* sp.	1	5	Plant unit	
Canada	PIS	PM	*Crocus* sp.	25	3,865	Plant unit	
Canada	PIS	PM	*Cryptocoryne* sp.	1	15	Plant unit	
Canada	PIS	PM	*Cupressus* sp.	8	2,568	Plant unit	
Canada	PIS	PM	*Cyclamen* sp.	96	18,471	Plant unit	
Canada	PIS	PM	*Cyperus* sp.	2	310	Plant unit	
Canada	PIS	PM	*Dahlia* sp.	1	210	Plant unit	
Canada	PIS	PM	*Dalea* sp.	2	312	Plant unit	
Canada	PIS	PM	*Dianthus* sp.	6	1,440	Plant unit	
Canada	PIS	PM	*Dieffenbachia* sp.	34	6,720	Plant unit	
Canada	PIS	PM	*Dizygotheca* sp.	1	96	Plant unit	
Canada	PIS	PM	*Dracaena* sp.	7	1,290	Plant unit	
Canada	PIS	PM	*Echeveria* sp.	2	106	Plant unit	
Canada	PIS	PM	*Echinodorus* sp.	1	5	Plant unit	
Canada	PIS	PM	*Euphorbia pulcherrima*	31	181,153	Plant unit	
Canada	PIS	PM	*Euphorbia* sp.	32	169,585	Plant unit	
Canada	PIS	PM	*Exacum* sp.	15	2,888	Plant unit	
Canada	PIS	PM	*Ficus* sp.	19	5,020	Plant unit	
Canada	PIS	PM	*Fittonia* sp.	3	440	Plant unit	
Canada	PIS	PM	*Gerbera* sp.	54	10,458	Plant unit	
Canada	PIS	PM	*Gloxinia* sp.	3	563	Plant unit	
Canada	PIS	PM	*Graptopetalum* sp.	1	15	Plant unit	
Canada	PIS	PM	*Gynura* sp.	11	1,743	Plant unit	
Canada	PIS	PM	*Hedera* sp.	21	1,765	Plant unit	
Canada	PIS	PM	*Hemigraphis* sp.	7	1,095	Plant unit	
Canada	PIS	PM	*Hoya* sp.	3	143	Plant unit	
Canada	PIS	PM	*Hyacinthus* sp.	25	3,746	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Canada	PIS	PM	*Hygrophila* sp.	1	15	Plant unit	
Canada	PIS	PM	*Hypericum* sp.	1	40	Plant unit	
Canada	PIS	PM	*Hypoestes* sp.	30	7,070	Plant unit	
Canada	PIS	PM	*Iris* sp.	16	2,500	Plant unit	
Canada	PIS	PM	*Juglans* sp.	1	5	Plant unit	
Canada	PIS	PM	*Kalanchoe* sp.	253	97,064	Plant unit	
Canada	PIS	PM	*Lilium* sp.	56	10,306	Plant unit	
Canada	PIS	PM	*Ludwigia* sp.	1	5	Plant unit	
Canada	PIS	PM	*Microlepia* sp.	1	255	Plant unit	
Canada	PIS	PM	*Microsorum* sp.	1	20	Plant unit	
Canada	PIS	PM	*Narcissus* sp.	28	3,862	Plant unit	
Canada	PIS	PM	*Nematanthus* sp.	1	40	Plant unit	
Canada	PIS	PM	*Oxalis* sp.	5	1,134	Plant unit	
Canada	PIS	PM	*Panax quinquefolius*	1	1.363	kg	
Canada	PIS	PM	*Pelargonium* sp.	1	35	Plant unit	
Canada	PIS	PM	*Pellaea* sp.	2	216	Plant unit	
Canada	PIS	PM	*Peperomia* sp.	28	6,355	Plant unit	
Canada	PIS	PM	*Philodendron* sp.	2	226	Plant unit	
Canada	PIS	PM	*Pilea* sp.	8	1,800	Plant unit	
Canada	PIS	PM	*Pinus* sp.	1	312	Plant unit	
Canada	PIS	PM	*Podocarpus* sp.	6	1,200	Plant unit	
Canada	PIS	PM	*Polianthes* sp.	1	168	Plant unit	
Canada	PIS	PM	*Polyanthus* = *Primula* X *Polyantha*	1	204	Plant unit	
Canada	PIS	PM	*Portulacaria* sp.	1	19	Plant unit	
Canada	PIS	PM	*Pothos* sp.	20	2,999	Plant unit	
Canada	PIS	PM	*Primula* sp.	17	3,342	Plant unit	
Canada	PIS	PM	*Pteris* sp.	7	1,740	Plant unit	
Canada	PIS	PM	*Radermachera* sp.	1	240	Plant unit	
Canada	PIS	PM	*Ranunculus* sp.	5	900	Plant unit	
Canada	PIS	PM	*Rhododendron* sp.	15	2,643	Plant unit	
Canada	PIS	PM	*Rosa* sp.	245	72,313	Plant unit	
Canada	PIS	PM	*Rosmarinus officinalis*	1	90	Plant unit	
Canada	PIS	PM	*Rosmarinus* sp.	1	120	Plant unit	
Canada	PIS	PM	*Rudbeckia* sp.	2	360	Plant unit	
Canada	PIS	PM	*Saintpaulia* sp.	141	31,043	Plant unit	
Canada	PIS	PM	*Sansevieria* sp.	12	2,496	Plant unit	
Canada	PIS	PM	*Schefflera* sp.	3	465	Plant unit	
Canada	PIS	PM	*Schlumbergera* sp.	21	7,326	Plant unit	
Canada	PIS	PM	*Scindapsus* sp.	11	2,994	Plant unit	
Canada	PIS	PM	*Sedum* sp.	2	49	Plant unit	
Canada	PIS	PM	*Selaginella* sp.	1	160	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Canada	PIS	PM	*Sempervivum* sp.	1	15	Plant unit	
Canada	PIS	PM	*Senecio* sp.	13	1,923	Plant unit	
Canada	PIS	PM	*Sinningia* sp.	10	1,714	Plant unit	
Canada	PIS	PM	*Stapelia* sp.	1	15	Plant unit	
Canada	PIS	PM	*Syngonium* sp.	2	450	Plant unit	
Canada	PIS	PM	*Tulipa* sp.	19	2,697	Plant unit	
Canada	PIS	PM	*Viola* sp.	8	2,091	Plant unit	
Canada	PIS	PM	*Zamioculcas* sp.	7	420	Plant unit	
Canada	PIS	PM	*Zamioculcas zamiifolia*	3	216	Plant unit	
Canada	PIS	PM	*Zygocactus* sp.	9	3,252	Plant unit	
Chile	Maritime	FV	Apple	11	229,494	kg	
Chile	PIS	PM	*Zea mays*	7	1,317.5	kg	
Chile	USPS	PM	*Allium* sp.	1	22	kg	
China	Airport	FV	Dasheen	1	2	kg	
China	Airport	FV	Mushroom	80	20,180	kg	
China	Airport	FV	Soybean	1	2	kg	
China	Maritime	FV	Arrowhead	4	5,877	kg	
China	Maritime	FV	Arrowroot	4	3,230	kg	
China	Maritime	FV	Burdock	2	720	kg	
China	Maritime	FV	Chestnut	2	1,130	kg	
China	Maritime	FV	Ginger, Root	4	84,660	kg	
China	Maritime	FV	Lily Bulb	1	300	kg	
China	Maritime	FV	Lotus Root	5	3,565	kg	
China	Maritime	FV	Onion	1	1,250	kg	
China	Maritime	FV	Shallot	5	4,114	kg	
China	Maritime	FV	Waterchestnut	5	3,092	kg	
China	Maritime	FV	Dasheen	3	5,535	kg	
China	Maritime	FV	Soybean	2	20,350	kg	
China	Maritime	PM	*Allium* sp.	1	30	kg	
China	Maritime	PM	*Amaranthus* sp.	1	50	kg	
China	Maritime	PM	*Brassica* sp.	1	137	kg	
China	Maritime	PM	*Chrysanthemum* sp.	1	13	kg	
China	Maritime	PM	*Coriandrum* sp.	1	13	kg	
China	Maritime	PM	*Cycas revoluta*	1	32,000	Plant unit	
China	Maritime	PM	*Narcissus* sp.	7	38,913	Plant unit	
China	Maritime	PM	*Phaseolus* sp.	3	61,661	kg	
China	Maritime	PM	*Raphanus* sp.	1	25	kg	
China	Maritime	PM	*Vigna* sp.	1	100	kg	
China	PIS	PM	*Adenium* sp.	6	550	Plant unit	Mail: *Planococcus minor* (arthropod)
China	PIS	PM	*Allium fistulosum*	1	4	kg	
China	PIS	PM	*Brassica* sp.	2	50	kg	
China	PIS	PM	*Camellia* sp.	2	260	kg	
China	PIS	PM	*Carmona* sp.	3	1,255	Plant unit	
China	PIS	PM	*Coriandrum* sp.	1	60	kg	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
China	PIS	PM	*Cycas revoluta*	1	32,000	Plant unit	
China	PIS	PM	*Cymbidium* sp.	1	5,000	Plant unit	
China	PIS	PM	*Dracaena* sp.	1	4,600	Plant unit	Permit cargo: *Colletotrichum* sp. (pathogen); *Polydrusus* sp. (arthropod)
China	PIS	PM	*Ficus* sp.	1	3	Plant unit	
China	PIS	PM	*Ilex* sp.	1	200	Plant unit	
China	PIS	PM	*Lactuca* sp.	1	50	kg	
China	PIS	PM	*Lagerstroemia* sp.	1	3	Plant unit	
China	PIS	PM	*Magnolia* sp.	1	1,980	Plant unit	
China	PIS	PM	*Oncidium* sp.	2	1,290	Flask	
China	PIS	PM	*Pachira aquatica*	1	8	Plant unit	
China	PIS	PM	*Pachira* sp.	1	150	kg	
China	PIS	PM	*Pachira* sp.	not given	3	Plant unit	
China	PIS	PM	*Pachira* sp.	2	13	Plant unit	
China	PIS	PM	*Paphiopedilum* sp.	1	594	Flask	
China	PIS	PM	*Phalaenopsis* sp.	1	6,000	Plant unit	
China	PIS	PM	*Phalaenopsis* sp.	3	1,867	Flask	
China	PIS	PM	*Rhapis* sp.	1	21	kg	
China	PIS	PM	*Rhapis* sp.	3	2,205	Plant unit	
China	PIS	PM	*Sabina* sp.	1	16	Plant unit	
China	PIS	PM	*Sansevieria* sp.	1	2	Plant unit	
China	PIS	PM	*Serissa* sp.	3	2,430	Plant unit	
China	PIS	PM	*Washingtonia* sp.	2	750	Plant unit	
China	PIS	PM	*Wodyetia bifurcata*	2	700	Plant unit	
China	PIS	PM	*Zelkova* sp.	1	490	Plant unit	
China	PIS	PM	*Zygopetalum* sp.	1	80	Not specified	
China	USPS	PM	*Allium* sp.	4	153	kg	
China	USPS	PM	*Brassica* sp.	25	573	kg	
China	USPS	PM	*Chrysanthemum* sp.	1	2	kg	
China	USPS	PM	*Lactuca* sp.	1	1	kg	
China	USPS	PM	*Raphanus* sp.	1	30	kg	
China	USPS	PM	*Spinacia* sp.	1	5	kg	
China	USPS	PM	*Vigna* sp.	1	44	kg	
Colombia	Airport	CF	*Rosa* sp.	1	720	Stems	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Cook Islands	Airport	CF	*Alyxia*	202	62,920	Stems	Permit cargo: *Phyllachora alyxiae* (pathogen), *Orchamoplatus mammaeferus* (arthropod), *Eremopeas tukeri* (mollusc); General cargo: *Ceroplastes rubens* (arthropod); Baggage: *Phyllachora alyxiae* (pathogen), *Ceroplastes rubens* (arthropod), *Orchamoplatus mammaeferus* (arthropod), *Sassetia* sp. (arthropod), Tettagoniidae species
Cook Islands	Airport	FV	Dasheen	2	2,316	kg	
Costa Rica	PIS	MC	Permit Pathogen	1	30	Each	
Costa Rica	PIS	PM	*Elaeis* sp.	1	3,060	Plant unit	
Denmark	USPS	PM	*Spinacia* sp.	1	1	kg	
Dominican Republic	PIS	PM	*Pseudophoenix* sp.	1	1	kg	
Ecuador	Airport	CF	*Rosa* sp.	1	1,115	Stems	
Egypt	PIS	MC	Permit Pathogen	1	2	Each	
Fiji	Airport	CF	Pandanus	1	750	Stems	
Fiji	Airport	FV	Cassava	1	60	kg	
Fiji	Airport	FV	Dasheen	56	105,869	kg	
Fiji	Airport	FV	Kava	13	2,793	kg	
Fiji	Maritime	FV	Breadfruit	2	5,495	kg	
Fiji	Maritime	FV	Ginger, Root	1	20,520	kg	
Fiji	Maritime	FV	Cassava	3	20,184	kg	
Fiji	Maritime	FV	Dasheen	73	768,870	kg	
Fiji	PIS	PM	*Carpodetus* sp.	1	6.1	kg	
Fiji	PIS	PM	*Carpoxylon macrospermum*	1	9	kg	
France	Airport	PM	*Zea mays*	2	621	kg	
France	PIS	PM	*Zea mays*	7	1,249	kg	
Germany	Airport	PM	*Dendrobium* sp.	1	2,500	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Germany	PIS	PM	*Agave* sp.	1	100	Plant unit	
Germany	PIS	PM	*Agave victoriae-reginae*	1	100	Plant unit	
Germany	PIS	PM	*Arenga* sp.	1	400	Plant unit	
Germany	PIS	PM	*Arisaema* sp.	1	0.004	kg	
Germany	PIS	PM	*Bismarckia* sp.	1	0.4	kg	
Germany	PIS	PM	*Borassus* sp.	1	1	kg	
Germany	PIS	PM	*Butia* sp.	1	0.01	kg	
Germany	PIS	PM	*Calyptrogyne* sp.	2	0.07	kg	
Germany	PIS	PM	*Carpoxylon macrospermum*	1	2.3	kg	
Germany	PIS	PM	*Caryota* sp.	1	1	kg	
Germany	PIS	PM	*Chamaerops* sp.	2	11.01	kg	
Germany	PIS	PM	*Clinostigma* sp.	1	0.01	kg	
Germany	PIS	PM	*Cyrtostachys* sp.	1	2,000	Plant unit	
Germany	PIS	PM	*Cyrtostachys* sp.	3	0.47	kg	
Germany	PIS	PM	*Dictyosperma* sp.	1	1,000	Plant unit	
Germany	PIS	PM	*Dictyosperma* sp.	2	0.77	kg	
Germany	PIS	PM	*Dypsis* sp.	2	2,000	Plant unit	
Germany	PIS	PM	*Dypsis* sp.	7	5.03	kg	
Germany	PIS	PM	*Elaeis* sp.	1	0.1	kg	
Germany	PIS	PM	*Ensete* sp.	1	100	Plant unit	
Germany	PIS	PM	*Euterpe* sp.	1	0.12	kg	
Germany	PIS	PM	*Gronophyllum* sp.	1	0.1	kg	
Germany	PIS	PM	*Heliconia* sp.	1	0.8	kg	
Germany	PIS	PM	*Heliconia* sp.	not given	300	Plant unit	
Germany	PIS	PM	*Heterospathe* sp.	1	0.1	kg	
Germany	PIS	PM	*Howea* sp.	2	0.4	kg	
Germany	PIS	PM	*Hydriastele* sp.	1	0.9	kg	
Germany	PIS	PM	*Hyophorbe* sp.	2	0.51	kg	
Germany	PIS	PM	*Jubaea* sp.	1	1	kg	
Germany	PIS	PM	*Latania* sp.	1	0.4	kg	
Germany	PIS	PM	*Licuala* sp.	4	1.76	kg	
Germany	PIS	PM	*Lilium* sp.	1	0.02	kg	
Germany	PIS	PM	*Lobelia* sp.	2	0.04	kg	
Germany	PIS	PM	*Marojejya* sp.	1	0.4	kg	
Germany	PIS	PM	*Musa* sp.	1	1,100	Plant unit	
Germany	PIS	PM	*Nannorrhops ricthiana*	1	0.1	kg	
Germany	PIS	PM	*Nolina* sp.	1	1,100	Plant unit	
Germany	PIS	PM	*Phoenix* sp.	1	1	kg	
Germany	PIS	PM	*Pholidostachys* sp.	1	0.3	kg	
Germany	PIS	PM	*Pseudophoenix* sp.	2	0.61	kg	
Germany	PIS	PM	*Ptychosperma*	2	3.52	kg	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
			sp.				
Germany	PIS	PM	*Ravenala* sp.	1	0.01	kg	
Germany	PIS	PM	*Ravenea* sp.	1	0.01	kg	
Germany	PIS	PM	*Rhapis* sp.	1	4,000	Plant unit	
Germany	PIS	PM	*Rhopalostylis* sp.	1	0.06	kg	
Germany	PIS	PM	*Roystonea* sp.	2	0.11	kg	
Germany	PIS	PM	*Strelitzia* sp.	2	0.06	kg	
Germany	PIS	PM	*Syagrus* sp.	1	0.01	kg	
Germany	PIS	PM	*Trachycarpus* sp.	3	1.07	kg	
Germany	PIS	PM	*Welwitschia mirabilis*	1	0.007	kg	
Germany	PIS	PM	*Wodyetia bifurcata*	1	0.01	kg	
Germany	USPS	PM	*Agave* sp.	1	1	kg	
Ghana	PIS	PM	*Argyreia* sp.	1	21	kg	
Guam	PIS	PM	*Bromelia* sp.	1	25	Plant unit	
Guam	PIS	PM	*Euphorbia* sp.	1	10	Plant unit	
Guam	PIS	PM	*Sorghum* sp.	1	120	Plant unit	
Guatemala	PIS	PM	*Pothos* sp.	2	12,000	Plant unit	
Honduras	PIS	PM	*Acrocarpus* sp.	1	100	Gram	
Honduras	PIS	PM	*Azadirachta* sp.	1	200	Gram	
Honduras	PIS	PM	*Cajanus* sp.	1	200	Gram	
Honduras	PIS	PM	*Dalbergia* sp.	2	550	Gram	
Honduras	PIS	PM	*Eucalyptus* sp.	1	0.025	kg	
Honduras	PIS	PM	*Gliricidia* sp.	1	0.05	kg	
Honduras	PIS	PM	*Ochroma* sp.	1	50	Gram	
Honduras	PIS	PM	*Pterocarpus* sp.	1	50	Gram	
Honduras	PIS	PM	*Swietenia humilis*	1	1	kg	
Honduras	PIS	PM	*Tectona* sp.	1	1	kg	
Hong Kong	PIS	PM	*Allium fistulosum*	1	2	kg	
Hong Kong	PIS	PM	*Allium* sp.	2	45.46	kg	
Hong Kong	PIS	PM	*Brassica* sp.	1	12	kg	
Hong Kong	PIS	PM	*Coriandrum* sp.	1	2	kg	
Hong Kong	PIS	PM	*Cucumis* sp.	1	2	kg	
Hong Kong	PIS	PM	*Rhapis* sp.	1	5,000	Plant unit	
Hong Kong	USPS	PM	*Allium* sp.	3	52	kg	
Hong Kong	USPS	PM	*Amaranthus* sp.	1	3	kg	
Hong Kong	USPS	PM	*Apium* sp.	1	1	kg	
Hong Kong	USPS	PM	*Brassica* sp.	15	245	kg	
Hong Kong	USPS	PM	*Coriandrum* sp.	1	10	kg	
Hong Kong	USPS	PM	*Momordica* sp.	1	1	kg	
Hong Kong	USPS	PM	*Raphanus* sp.	1	3	kg	
Hong Kong	USPS	PM	*Solanum* sp.	1	1	kg	
India	PIS	PM	*Camellia* sp.	1	36	kg	
India	PIS	PM	*Vanilla* sp.	1	500	Plant unit	
Indonesia	PIS	LU	*Potamogeton* Sp.	2	150	Plant unit	
Indonesia	PIS	PM	*Acorus* sp.	12	335	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Indonesia	PIS	PM	*Aglaonema* sp.	1	7	Plant unit	
Indonesia	PIS	PM	*Alocasia* sp.	1	7	Plant unit	
Indonesia	PIS	PM	*Alternanthera sessilis*	6	155	Plant unit	
Indonesia	PIS	PM	*Alternanthera* sp.	54	11,349	Plant unit	
Indonesia	PIS	PM	*Alyssoides* sp.	1	2	kg	
Indonesia	PIS	PM	*Amherstia* sp.	1	3	Plant unit	
Indonesia	PIS	PM	*Ammannia* sp.	28	1,735	Plant unit	
Indonesia	PIS	PM	*Ammocharis* sp.	1	25	Plant unit	
Indonesia	PIS	PM	*Ammoricia* sp.	7	225	Plant unit	
Indonesia	PIS	PM	*Amordica* sp.	7	705	Plant unit	
Indonesia	PIS	PM	*Anubias* sp.	60	6,372	Plant unit	
Indonesia	PIS	PM	*Aponogeton* sp.	50	5,622	Plant unit	
Indonesia	PIS	PM	*Aquilaria malaccensis*	1	1	kg	
Indonesia	PIS	PM	*Aquilaria malaccensis*	not given	10	Plant unit	
Indonesia	PIS	PM	*Arenga* sp.	1	0.08	kg	
Indonesia	PIS	PM	*Artocarpus heterophyllus*	2	13	Plant unit	
Indonesia	PIS	PM	*Asplenium* sp.	1	7	Plant unit	
Indonesia	PIS	PM	*Bacopa* sp.	56	9,932	Plant unit	
Indonesia	PIS	PM	*Barringtonia* sp.	1	1.3	kg	
Indonesia	PIS	PM	*Barringtonia* sp.	not given	2	Plant unit	
Indonesia	PIS	PM	*Bauhinia* sp.	1	10	Plant unit	
Indonesia	PIS	PM	*Blyxa* sp.	50	7,314	Plant unit	
Indonesia	PIS	PM	*Cabomba* sp.	56	50,572	Plant unit	
Indonesia	PIS	PM	*Callitris* sp.	1	1	Plant unit	
Indonesia	PIS	PM	*Calyptrocalyx* sp.	1	0.2	kg	
Indonesia	PIS	PM	*Calyptrocalyx* sp.	not given	150	Plant unit	
Indonesia	PIS	PM	*Cardamine* sp.	13	750	Plant unit	
Indonesia	PIS	PM	*Caryota* sp.	1	0.04	kg	
Indonesia	PIS	PM	*Ceratophyllum* sp.	5	205	Plant unit	
Indonesia	PIS	PM	*Ceratopteris* sp.	28	1,665	Plant unit	
Indonesia	PIS	PM	*Chlorophytum* sp.	36	3,165	Plant unit	
Indonesia	PIS	PM	*Cordyline* sp.	15	639	Plant unit	
Indonesia	PIS	PM	*Crassula* sp.	39	3,320	Plant unit	
Indonesia	PIS	PM	*Croton* sp.	1	50	Plant unit	
Indonesia	PIS	PM	*Cryptocoryne* sp.	58	31,912	Plant unit	
Indonesia	PIS	PM	*Cupressus* sp.	1	19	Plant unit	
Indonesia	PIS	PM	*Cyperus* sp.	12	730	Plant unit	
Indonesia	PIS	PM	*Cyrtosperma* sp.	1	2	Plant unit	
Indonesia	PIS	PM	*Dahlia* sp.	1	1	Plant unit	
Indonesia	PIS	PM	*Dalbergia* sp.	1	3	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Indonesia	PIS	PM	*Dracaena sanderiana*	2	75	Plant unit	
Indonesia	PIS	PM	*Dracaena* sp.	56	3,597	Plant unit	
Indonesia	PIS	PM	*Drymophloeus* sp.	1	0.04	kg	
Indonesia	PIS	PM	*Drynaria* sp.	1	1	Plant unit	
Indonesia	PIS	PM	*Durio* sp.	1	1	kg	
Indonesia	PIS	PM	*Durio* sp.	not given	58	Plant unit	
Indonesia	PIS	PM	*Durio zibethinus*	1	43	Plant unit	
Indonesia	PIS	PM	*Echinodorus* sp.	77	28,650	Plant unit	General cargo: *Cercospora* sp. (pathogen); Permit cargo: *Cercospora* sp. (pathogen), *Phoma* sp. (pathogen), species of Homoptera (arthropod), species of Insecta (arthropod), species of Pseudococcidae (arthropod)
Indonesia	PIS	PM	*Echinopsis* sp.	1	76	Plant unit	
Indonesia	PIS	PM	*Egeria* sp.	27	1,435	Plant unit	
Indonesia	PIS	PM	*Eichhornia* sp.	1	50	Plant unit	
Indonesia	PIS	PM	*Elatostema* sp.	1	5	Plant unit	
Indonesia	PIS	PM	*Eleocharis* sp.	54	38,020	Plant unit	
Indonesia	PIS	PM	*Elodea* sp.	38	5,980	Plant unit	
Indonesia	PIS	PM	*Epiphyllum* sp.	1	2	Plant unit	
Indonesia	PIS	PM	*Etlingera* sp.	1	2	Plant unit	
Indonesia	PIS	PM	*Eusteralis* sp.	30	3,375	Plant unit	
Indonesia	PIS	PM	*Garcinia dulcis*	1	0.1	kg	
Indonesia	PIS	PM	*Garcinia dulcis*	not given	10	Plant unit	
Indonesia	PIS	PM	*Garcinia mangostana*	1	30	Plant unit	
Indonesia	PIS	PM	*Glossostigma* sp.	35	578	Plant unit	
Indonesia	PIS	PM	*Gronophyllum* sp.	1	0.04	kg	
Indonesia	PIS	PM	*Gronophyllum* sp.	not given	200	Plant unit	
Indonesia	PIS	PM	*Gymnocoronis* sp.	27	1,050	Plant unit	
Indonesia	PIS	PM	*Hemigraphis* sp.	37	2,110	Plant unit	
Indonesia	PIS	PM	*Heteranthera* sp.	39	3,505	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Indonesia	PIS	PM	*Hydrocotyle* sp.	39	3,105	Plant unit	
Indonesia	PIS	PM	*Hygrophila* sp.	67	14,546	Plant unit	Permit cargo: *Phoma* sp. (pathogen), species of Aleyrodidae, species of Aphididae, species of Pseudococcidae
Indonesia	PIS	PM	*Lagarosiphon major*	13	650	Plant unit	
Indonesia	PIS	PM	*Lepisanthes* sp.	1	2	kg	
Indonesia	PIS	PM	*Lepisanthes* sp.	not given	11	Plant unit	
Indonesia	PIS	PM	*Licuala* sp.	1	0.04	kg	
Indonesia	PIS	PM	*Licuala* sp.	not given	50	Plant unit	
Indonesia	PIS	PM	*Lilaeopsis* sp.	16	5,185	Plant unit	
Indonesia	PIS	PM	*Limnophila sessiliflora*	1	25	Plant unit	
Indonesia	PIS	PM	*Limnophila* sp.	25	1,395	Plant unit	
Indonesia	PIS	PM	*Lindera* sp.	2	75	Plant unit	
Indonesia	PIS	PM	*Lindernia* sp.	39	3,055	Plant unit	
Indonesia	PIS	PM	*Lobelia* sp.	47	2,160	Plant unit	Permit cargo: species of Hemiptera (arthropod)
Indonesia	PIS	PM	*Ludwigia* sp.	58	19,237	Plant unit	Permit cargo: species of Mollusca
Indonesia	PIS	PM	*Lycopodium* sp.	1	49	Plant unit	
Indonesia	PIS	PM	*Lysimachia* sp.	50	6,650	Plant unit	
Indonesia	PIS	PM	*Mangifera indica*	1	1	Plant unit	Baggage: *Aulacaspis tubercularis* (arthropod)
Indonesia	PIS	PM	*Maniltoa* sp.	1	900	Plant unit	
Indonesia	PIS	PM	*Marattia* sp.	1	1	Plant unit	
Indonesia	PIS	PM	*Marsilea* sp.	14	730	Plant unit	
Indonesia	PIS	PM	*Mayaca fluviatilis*	4	400	Plant unit	
Indonesia	PIS	PM	*Mayaca* sp.	55	5,351	Plant unit	
Indonesia	PIS	PM	*Micranthemum* Sp.	46	8,307	Plant unit	
Indonesia	PIS	PM	*Microsorum* sp.	57	21,540	Plant unit	Permit cargo: *Herpetogramma* sp. (arthropod), species of

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
							Margarodidae (arthropod)
Indonesia	PIS	PM	*Myriophyllum* sp.	55	9,235	Plant unit	
Indonesia	PIS	PM	*Nesaea* sp.	36	3,685	Plant unit	
Indonesia	PIS	PM	*Nomaphila* sp.	46	10,585	Plant unit	Permit cargo: *Cladosporium* sp. (pathogen), *Planococcus* sp. (arthropod), species of Aleyrodidae (arthropod), species of Aphididae (arthropod), species of Pseudococcidae (arthropod)
Indonesia	PIS	PM	*Nuphar* sp.	41	1,437	Plant unit	
Indonesia	PIS	PM	*Nymphaea* sp.	13	777	Plant unit	
Indonesia	PIS	PM	*Nymphoides* sp.	8	517	Plant unit	
Indonesia	PIS	PM	*Ophiopogon* sp.	39	1,222	Plant unit	Permit cargo: *Succinea* sp. (mollusc)
Indonesia	PIS	PM	*Osmoxylon* sp.	1	5	Plant unit	
Indonesia	PIS	PM	*Ottelia alismoides*	5	235	Plant unit	
Indonesia	PIS	PM	*Pandanus* sp.	1	13	Plant unit	Permit cargo: species of Pseudococcidae (arthropod)
Indonesia	PIS	PM	*Philodendron* sp.	1	25	Plant unit	
Indonesia	PIS	PM	*Pinanga* sp.	1	0.04	kg	
Indonesia	PIS	PM	*Platycerium* sp.	2	50	Plant unit	
Indonesia	PIS	PM	*Pogostemon* sp.	11	1,830	Plant unit	
Indonesia	PIS	PM	*Potamogeton* Sp.	41	5,710	Plant unit	
Indonesia	PIS	PM	*Ptychosperma* sp.	1	500	Plant unit	
Indonesia	PIS	PM	*Rhapis* sp.	1	400	Plant unit	
Indonesia	PIS	PM	*Riccia* sp.	1	1	kg	
Indonesia	PIS	PM	*Riccia* sp.	not given	1	Plant unit	
Indonesia	PIS	PM	*Richea* sp.	1	1	Plant unit	
Indonesia	PIS	PM	*Rorippa nasturtium-aquaticum*	1	60	Plant unit	
Indonesia	PIS	PM	*Rorippa* sp.	11	525	Plant unit	
Indonesia	PIS	PM	*Rotala* sp.	60	20,305	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Indonesia	PIS	PM	*Rothmannia* sp.	1	610	Plant unit	
Indonesia	PIS	PM	*Sagittaria sagittifolia*	1	200	Plant unit	
Indonesia	PIS	PM	*Sagittaria* sp.	59	9,860	Plant unit	Permit cargo: *Cercospora* sp. (pathogen), species of Aphididae (arthropod)
Indonesia	PIS	PM	*Saraca* sp.	1	20	Plant unit	
Indonesia	PIS	PM	*Saururus* sp.	19	505	Plant unit	
Indonesia	PIS	PM	*Schismatoglottis* sp.	1	2	Plant unit	
Indonesia	PIS	PM	*Spathiphyllum* sp.	40	2,045	Plant unit	Permit cargo: *Aleurothrixus* sp. (arthropod), species of Pseudococcidae (arthropod), species of Tortricidae (arthropod)
Indonesia	PIS	PM	*Stenocereus* sp.	1	1	Plant unit	
Indonesia	PIS	PM	*Syngonium* sp.	15	425	Plant unit	
Indonesia	PIS	PM	*Synnema* sp.	29	2,310	Plant unit	
Indonesia	PIS	PM	*Syzygium* sp.	1	48	Plant unit	
Indonesia	PIS	PM	*Tectona* sp.	1	675	Plant unit	General cargo: *Cryptotermes* sp. (arthropod)
Indonesia	PIS	PM	*Tectona* sp.	2	60	kg	
Indonesia	PIS	PM	Thryptomene sp.	1	40	Plant unit	
Indonesia	PIS	PM	*Thuja* sp.	1	3	Plant unit	
Indonesia	PIS	PM	*Tonina* sp.	45	2,065	Plant unit	
Indonesia	PIS	PM	*Trapa* sp.	6	95	Plant unit	
Indonesia	PIS	PM	*Trichocoronis* sp.	6	532	Plant unit	
Indonesia	PIS	PM	*Trichomanes* sp.	28	1,140	Plant unit	
Indonesia	PIS	PM	*Vallisneria* sp.	60	40,696	Plant unit	Permit cargo: species of Mollusca
Indonesia	PIS	PM	*Vesicularia* - Use Moss - Bryophyta	12	23	Plant unit	
Indonesia	PIS	PM	*Watsonia* sp.	1	2	Plant unit	
Indonesia	PIS	PM	*Wrightia* sp.	1	2,000	Plant unit	
Ireland	PIS	PM	*Astelia* sp.	1	10	Plant unit	
Ireland	PIS	PM	*Phormium* sp.	4	156	Plant unit	
Israel	USPS	PM	*Cucumis sativus*	1	1	kg	
Italy	PIS	PM	*Cordyline* sp.	1	48	kg	
Italy	PIS	PM	*Nymphaea* sp.	1	0.2	kg	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Japan	Airport	CF	*Dendrobium* sp.	247	302,895	Stems	
Japan	Airport	CF	Lotus	1	100	Stems	
Japan	Airport	CF	Oxypetalum	1	50	Stems	
Japan	Airport	CF	Paeonia	1	10	Stems	
Japan	Airport	CF	*Rosa* sp.	3	425	Stems	
Japan	Airport	CF	Stemona	1	60	Stems	
Japan	Airport	FV	Arrowroot	2	100	kg	
Japan	Airport	FV	Asparagus	1	40	kg	Permit cargo: *Chrysodeixis eriosoma* (arthropod)
Japan	Airport	FV	Burdock	120	1,615	kg	
Japan	Airport	FV	Carrot	108	1,423	kg	
Japan	Airport	FV	Cucumber	133	6,537	kg	
Japan	Airport	FV	Dasheen	6	76	kg	
Japan	Airport	FV	Eggplant	111	1,148	kg	
Japan	Airport	FV	Ginger, Bracts	339	903	kg	
Japan	Airport	FV	Leek	70	439	kg	
Japan	Airport	FV	Lily Bulb	1	5	kg	
Japan	Airport	FV	Lotus Root	63	254	kg	
Japan	Airport	FV	Melon	38	817	kg	
Japan	Airport	FV	Mushroom	592	33,059	kg	
Japan	Airport	FV	Onion	54	362	kg	
Japan	Airport	FV	Pepper	98	313	kg	
Japan	Airport	FV	Perilla	7	12	kg	
Japan	Airport	FV	Radish	208	10,942	kg	
Japan	Airport	FV	Sand Pear	3	147	kg	
Japan	Airport	FV	Strawberry	68	968	kg	
Japan	Airport	FV	Sweet Potato	1	100	kg	
Japan	Airport	FV	Tomato	109	1,253	kg	
Japan	Airport	FV	Wasabi	113	177	kg	
Japan	Airport	FV	Yam	176	3,099	kg	
Japan	Maritime	FV	Apple	4	102,810	kg	
Japan	Maritime	FV	Squash	5	2,301	kg	
Japan	Maritime	FV	Waterchestnut	3	1,350	kg	
Japan	Maritime	FV	Burdock	28	23,349.5	kg	
Japan	Maritime	FV	Dasheen	1	540	kg	
Japan	Maritime	FV	Onion	1	800	kg	
Japan	Maritime	FV	Sand Pear	11	141,825	kg	
Japan	Maritime	FV	Yam	89	48,950	kg	
Japan	Maritime	PM	*Allium* sp.	1	3	kg	
Japan	Maritime	PM	*Cucumis* sp.	1	1	kg	
Japan	Maritime	PM	*Raphanus* sp.	1	1	kg	Permit cargo: *Delia* sp. (arthropod), *Listroderes* sp. (arthropod), species of

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
							Aphididae (arthropod), species of Lepidoptera (arthropod), species of Pyraustinae (arthropod)
Japan	Maritime	PM	*Solanum* sp.	1	1	kg	Permit cargo: species of Aphididae (arthropod), species of Thripidae (arthropod), species of Thysanoptera (arthropod)
Japan	Maritime	PM	*Vigna* sp.	1	9	kg	
Japan	PIS	PM	*Aerides* sp.	1	5	Plant unit	
Japan	PIS	PM	*Ascocentrum* sp.	1	8	Plant unit	
Japan	PIS	PM	*Camellia* sp.	2	4,040	Plant unit	
Japan	PIS	PM	*Cattleya* sp.	1	2	Flask	
Japan	PIS	PM	*Cattleya* sp.	9	440	Plant unit	
Japan	PIS	PM	*Coelogyne* sp.	1	16	Plant unit	
Japan	PIS	PM	*Cucurbita moschata*	1	0.908	kg	
Japan	PIS	PM	*Daucus carota*	1	0.03	kg	
Japan	PIS	PM	*Dendrobium* sp.	3	6,503	Plant unit	
Japan	PIS	PM	*Encyclia* sp.	1	1	Plant unit	
Japan	PIS	PM	*Epidendrum* sp.	1	1	Plant unit	
Japan	PIS	PM	*Ficinia* Sp.	2	18	Plant unit	
Japan	PIS	PM	*Gardenia* sp.	1	3	Plant unit	Baggage: *Thrips* sp. (arthropod), *Thrips florum* (arthropod)
Japan	PIS	PM	*Laelia* sp.	1	3	Plant unit	
Japan	PIS	PM	*Monochoria* sp.	1	0.001	kg	
Japan	PIS	PM	*Nelumbo nucifera*	1	14	Plant unit	
Japan	PIS	PM	*Nuphar* sp.	1	16	Plant unit	
Japan	PIS	PM	*Nymphaea* sp.	2	47	Plant unit	
Japan	PIS	PM	*Phalaenopsis* sp.	2	405	Plant unit	
Japan	PIS	PM	*Raphanus sativus*	1	0.94	kg	Permit cargo: species of Plutellidae, species of Syrphidae, species of

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
							Thysanoptera, species of Tortricidae; Mail: species of Aphididae
Japan	PIS	PM	*Rhapis* sp.	3	712	Plant unit	
Japan	PIS	PM	*Salix* sp.	1	19	Plant unit	
Japan	PIS	PM	*Solanum melongena*	1	1.362	kg	
Japan	PIS	PM	*Sophronitis* sp.	1	1	Plant unit	
Japan	PIS	PM	*Spinacia oleracea*	1	2.27	kg	
Japan	PIS	PM	*Vanda* sp.	1	42	Plant unit	
Japan	PIS	PM	*Vigna unguiculata* ssp. *unguiculata*	1	13.62	kg	
Japan	USPS	PM	*Allium* sp.	1	2	kg	
Japan	USPS	PM	*Anthriscus* sp.	1	10	kg	
Japan	USPS	PM	*Benincasa* sp.	1	7	kg.	
Japan	USPS	PM	*Brassica* sp.	10	62	kg	
Japan	USPS	PM	*Chrysanthemum* sp.	1	22	kg	
Japan	USPS	PM	*Corchorus* sp.	1	11	kg	
Japan	USPS	PM	*Cucumis sativus*	6	13	kg	Permit cargo: species of Crambidae
Japan	USPS	PM	*Cucumis* sp.	1	1	kg	
Japan	USPS	PM	*Glycine max*	2	72	kg	
Japan	USPS	PM	*Lagenaria* sp.	3	11	kg	
Japan	USPS	PM	*Luffa* sp.	1	3	kg	
Japan	USPS	PM	*Momordica* sp.	4	35	kg	
Japan	USPS	PM	*Perilla* sp.	1	55	kg	
Japan	USPS	PM	*Raphanus* sp.	5	149	kg	
Japan	USPS	PM	*Spinacia* sp.	2	77	kg	
Korea, South	Airport	FV	Grape	1	52	kg	
Korea, South	Airport	FV	Pear	1	17	kg	
Korea, South	Airport	FV	Persimmon	1	1,120	kg	
Korea, South	Airport	FV	Sand Pear	1	3,400	kg	Permit cargo: species of Carposinidae (arthropod), species of Pseudococcidae (arthropod), species of Tortricidae

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
							(arthropod)
Korea, South	Maritime	FV	Garlic	1	18,500	kg	
Korea, South	Maritime	FV	Grape	1	5,100	kg	
Korea, South	Maritime	FV	Sand Pear	86	1,449,360	kg	
Korea, South	PIS	PM	*Cymbidium* sp.	1	7	Plant unit	
Korea, South	PIS	PM	*Phalaenopsis* sp.	1	30,000	Plant unit	
Korea, South	PIS	PM	*Zea mays*	2	80	kg	
Korea, South	USPS	PM	*Allium* sp.	2	4	kg	
Korea, South	USPS	PM	*Capsicum* sp.	1	1	kg	
Korea, South	USPS	PM	*Codonopsis* sp.	1	1	kg	
Korea, South	USPS	PM	*Cucumis sativus*	1	1	kg	
Korea, South	USPS	PM	*Lactuca* sp.	2	2	kg	
Korea, South	USPS	PM	*Lycopersicon esculentum*	1	1	kg	
Korea, South	USPS	PM	*Perilla* sp.	1	2	kg	
Korea, South	USPS	PM	*Platycodon* sp.	1	1	kg	
Korea, South	USPS	PM	*Raphanus* sp.	1	2	kg	
Korea, South	USPS	PM	*Solanum* sp.	1	1	kg	
Laos	PIS	PM	*Tectona* sp.	1	70	kg	
Malaysia	PIS	PM	*Adenium* sp.	2	11	Plant unit	
Malaysia	PIS	PM	*Allamanda* sp.	1	5	Plant unit	
Malaysia	PIS	PM	*Alocasia* sp.	1	20	Plant unit	
Malaysia	PIS	PM	*Alpinia* sp.	1	20	Plant unit	
Malaysia	PIS	PM	*Annona* sp.	1	19	Plant unit	
Malaysia	PIS	PM	*Aquilaria malaccensis*	1	100	Plant unit	
Malaysia	PIS	PM	*Bauhinia* sp.	3	820	Plant unit	
Malaysia	PIS	PM	*Bougainvillea* sp.	6	2,650	Plant unit	
Malaysia	PIS	PM	*Caladium* sp.	1	10	Plant unit	
Malaysia	PIS	PM	*Calamus* sp.	1	10	Plant unit	
Malaysia	PIS	PM	*Calliandra* sp.	1	5	Plant unit	
Malaysia	PIS	PM	*Canna* sp.	1	60	Plant unit	
Malaysia	PIS	PM	*Carica papaya*	1	1	Gram	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Malaysia	PIS	PM	*Cassia* sp.	1	25	Plant unit	
Malaysia	PIS	PM	*Chamaedorea* sp.	1	2,000	Plant unit	
Malaysia	PIS	PM	*Chrysalidocarpus* sp.	1	20	Plant unit	
Malaysia	PIS	PM	*Codiaeum* sp.	2	140	Plant unit	
Malaysia	PIS	PM	*Cordyline* sp.	3	220	Plant unit	
Malaysia	PIS	PM	*Costus* sp.	2	30	Plant unit	
Malaysia	PIS	PM	*Curcuma* sp.	1	1,200	Plant unit	
Malaysia	PIS	PM	*Cyrtostachys* sp.	2	105	Plant unit	
Malaysia	PIS	PM	*Dendrobium* sp.	1	1	Flask	
Malaysia	PIS	PM	*Dendrobium* sp.	not given	15	Plant unit	
Malaysia	PIS	PM	*Dimocarpus longan*	1	14	Plant unit	
Malaysia	PIS	PM	*Dracaena sanderiana*	9	85,008	Plant unit	
Malaysia	PIS	PM	*Dracaena* sp.	10	62,093	Plant unit	Permit cargo: species of Diaspididae (arthropod)
Malaysia	PIS	PM	*Dypsis* sp.	4	1,270	Plant unit	
Malaysia	PIS	PM	*Excoecaria* sp.	3	405	Plant unit	
Malaysia	PIS	PM	*Furcraea* sp.	1	5	Plant unit	
Malaysia	PIS	PM	*Gardenia* sp.	2	15	Plant unit	
Malaysia	PIS	PM	*Heliconia* sp.	2	150	Plant unit	
Malaysia	PIS	PM	*Hylocereus* sp.	1	60	Plant unit	
Malaysia	PIS	PM	*Ixora* sp.	1	10	Plant unit	
Malaysia	PIS	PM	*Jatropha* sp.	2	10	Plant unit	
Malaysia	PIS	PM	*Johannesteijsmannia* sp.	1	5	Plant unit	
Malaysia	PIS	PM	*Kopsia* sp.	2	70	Plant unit	
Malaysia	PIS	PM	*Lagerstroemia indica*	1	10	Plant unit	
Malaysia	PIS	PM	*Lagerstroemia* sp.	1	10	Plant unit	
Malaysia	PIS	PM	*Lantana* sp.	1	5	Plant unit	
Malaysia	PIS	PM	*Mangifera indica*	1	33	Plant unit	
Malaysia	PIS	PM	*Manilkara zapota*	1	2	Plant unit	
Malaysia	PIS	PM	*Maranta* sp.	1	10	Plant unit	
Malaysia	PIS	PM	Mokara	1	10	Plant unit	
Malaysia	PIS	PM	*Monstera deliciosa*	1	5	Plant unit	
Malaysia	PIS	PM	*Monstera* sp.	2	40	Plant unit	
Malaysia	PIS	PM	*Murraya* sp.	1	50	Plant unit	
Malaysia	PIS	PM	*Mussaenda* sp.	1	10	Plant unit	
Malaysia	PIS	PM	*Nepenthes* sp.	1	360	Plant unit	
Malaysia	PIS	PM	*Ophiopogon* sp.	2	70	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Malaysia	PIS	PM	*Pachira aquatica*	1	40	Plant unit	
Malaysia	PIS	PM	*Pachira* sp.	1	100	Plant unit	
Malaysia	PIS	PM	*Pandanus* sp.	1	5	Plant unit	
Malaysia	PIS	PM	*Peltophorum* sp.	1	5	Plant unit	
Malaysia	PIS	PM	*Philodendron* sp.	1	5	Plant unit	
Malaysia	PIS	PM	*Pleomele* sp.	1	5	Plant unit	
Malaysia	PIS	PM	*Plumeria* sp.	1	10	Plant unit	
Malaysia	PIS	PM	*Pouteria* sp.	1	13	Plant unit	
Malaysia	PIS	PM	*Pseuderanthemum* sp.	1	10	Plant unit	
Malaysia	PIS	PM	*Ravenala* sp.	1	10	Plant unit	
Malaysia	PIS	PM	*Rhapis* sp.	5	2,125	Plant unit	
Malaysia	PIS	PM	*Rhodophiala* sp.	1	5	Plant unit	
Malaysia	PIS	PM	*Roystonea* sp.	1	5	Plant unit	
Malaysia	PIS	PM	*Samanea* sp.	2	15	Plant unit	
Malaysia	PIS	PM	*Sansevieria* sp.	3	160	Plant unit	
Malaysia	PIS	PM	*Veitchia* sp.	2	2,100	Plant unit	
Malaysia	PIS	PM	*Zamia* sp.	1	5	Plant unit	
Malaysia	PIS	PM	*Zephyranthes* sp.	1	40	Plant unit	
Malaysia	PIS	PM	*Zyzygium* sp.	1	4	Plant unit	
Mexico	PIS	PM	*Psidium guajava*	1	0.5	kg	
Micronesia	Airport	FV	Betel-Nut	1	525	kg	
Micronesia	PIS	PM	*Ageratum* sp.	2	12	Plant unit	
Micronesia	PIS	PM	*Aglaia* sp.	1	5	Plant unit	
Micronesia	PIS	PM	*Aleurites* sp.	1	5	Plant unit	
Micronesia	PIS	PM	*Alocasia* sp.	1	5	Plant unit	
Micronesia	PIS	PM	*Asplenium* sp.	1	6	Plant unit	
Micronesia	PIS	PM	*Barringtonia* sp.	1	6	Plant unit	
Micronesia	PIS	PM	*Cananga* sp.	1	5	Plant unit	
Micronesia	PIS	PM	*Canavalia* sp.	1	5	Plant unit	
Micronesia	PIS	PM	*Capsicum* sp.	1	5	Plant unit	
Micronesia	PIS	PM	*Carica papaya*	1	5	Plant unit	
Micronesia	PIS	PM	*Cinnamomum* sp.	2	11	Plant unit	
Micronesia	PIS	PM	*Citrus* sp.	1	6	Plant unit	Baggage: *Aonidiella* sp. (arthropod)
Micronesia	PIS	PM	*Clerodendrum* sp.	1	6	Plant unit	
Micronesia	PIS	PM	*Clinostigma* sp.	1	5	Plant unit	
Micronesia	PIS	PM	*Cordyline* sp.	1	6	Plant unit	
Micronesia	PIS	PM	*Curcuma* sp.	1	6	Plant unit	
Micronesia	PIS	PM	*Cyathea* sp.	1	5	Plant unit	
Micronesia	PIS	PM	*Cyperus* sp.	2	11	Plant unit	
Micronesia	PIS	PM	*Davallia* sp.	3	15	Plant unit	
Micronesia	PIS	PM	*Elaeocarpus* sp.	2	10	Plant unit	
Micronesia	PIS	PM	*Eleusine* sp.	3	16	Plant unit	
Micronesia	PIS	PM	*Eugenia* sp.	1	5	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Micronesia	PIS	PM	*Eurya* sp.	1	5	Plant unit	
Micronesia	PIS	PM	*Ficus* sp.	2	16	Plant unit	
Micronesia	PIS	PM	*Garcinia* sp.	2	10	Plant unit	
Micronesia	PIS	PM	*Hedychium* sp.	1	5	Plant unit	
Micronesia	PIS	PM	*Hibiscus* sp.	2	11	Plant unit	
Micronesia	PIS	PM	*Hoya* sp.	1	5	Plant unit	
Micronesia	PIS	PM	*Hymenocallis* sp.	1	6	Plant unit	
Micronesia	PIS	PM	*Ipomoea* sp.	2	11	Plant unit	
Micronesia	PIS	PM	*Ixora* sp.	2	17	Plant unit	
Micronesia	PIS	PM	*Ludwigia* sp.	1	6	Plant unit	
Micronesia	PIS	PM	*Mammea* sp.	1	5	Plant unit	
Micronesia	PIS	PM	*Marattia* sp.	2	10	Plant unit	
Micronesia	PIS	PM	*Melastoma malabathricum*	2	11	Plant unit	
Micronesia	PIS	PM	*Metroxylon* sp.	1	5	Plant unit	
Micronesia	PIS	PM	*Microsorum* sp.	2	11	Plant unit	
Micronesia	PIS	PM	*Morinda* sp.	2	11	Plant unit	
Micronesia	PIS	PM	*Nephrolepis* sp.	1	6	Plant unit	
Micronesia	PIS	PM	*Phyllanthus* sp.	1	6	Plant unit	
Micronesia	PIS	PM	*Piper* sp.	1	12	Plant unit	
Micronesia	PIS	PM	*Premna* sp.	2	11	Plant unit	
Micronesia	PIS	PM	*Rhizophora* sp.	2	10	Plant unit	
Micronesia	PIS	PM	*Saccharum* sp.	1	5	Plant unit	
Micronesia	PIS	PM	*Scaevola* sp.	1	5	Plant unit	
Micronesia	PIS	PM	*Tacca* sp.	1	5	Plant unit	
Micronesia	PIS	PM	*Terminalia* sp.	1	6	Plant unit	
Micronesia	PIS	PM	*Thelypteris* sp.	2	11	Plant unit	
Micronesia	PIS	PM	*Zingiber* sp.	1	6	Plant unit	
Netherlands	Airport	CF	Alpinia	1	60	Stems	Permit cargo: *Planococcus* sp. (arthropod)
Netherlands	Airport	CF	Alstroemeria	2	350	Stems	
Netherlands	Airport	CF	Amaryllis	2	67	Stems	
Netherlands	Airport	CF	Anthurium	2	934	Stems	
Netherlands	Airport	CF	Aralia	1	100	Stems	
Netherlands	Airport	CF	Aspidistra	2	7	Stems	
Netherlands	Airport	CF	Bouvardia	1	40	Stems	
Netherlands	Airport	CF	Chrysanthemum	1	240	Stems	
Netherlands	Airport	CF	Cymbidium	1	60	Stems	
Netherlands	Airport	CF	*Delphinium* sp.	1	40	Stems	
Netherlands	Airport	CF	Dendrobium	2	160	Stems	
Netherlands	Airport	CF	Dracaena	1	10	Stems	
Netherlands	Airport	CF	*Echinops* sp.	1	45	Stems	
Netherlands	Airport	CF	Heliconia	1	31	Stems	Permit cargo: species of Lycaenidae (arthropod)
Netherlands	Airport	CF	*Hypericum* sp.	1	600	Stems	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Netherlands	Airport	CF	Leucospermum	1	160	Stems	
Netherlands	Airport	CF	*Liatris* sp.	1	40	Stems	
Netherlands	Airport	CF	*Lilium* sp.	2	380	Stems	
Netherlands	Airport	CF	Lysimachia	1	50	Stems	
Netherlands	Airport	CF	Monstera	2	140	Stems	
Netherlands	Airport	CF	Nerine	1	100	Stems	
Netherlands	Airport	CF	Ornithogalum	2	280	Stems	
Netherlands	Airport	CF	*Philodendron* sp.	1	10	Stems	
Netherlands	Airport	CF	Protea	1	40	Stems	
Netherlands	Airport	CF	*Rosa* sp.	1	280	Stems	
Netherlands	Airport	CF	Ruscus	2	80	Stems	
Netherlands	Airport	CF	*Solidago* sp.	1	50	Stems	
Netherlands	Airport	CF	Strelitzia	1	122	Stems	
Netherlands	Airport	CF	Zantedeschia	1	70	Stems	
Netherlands	Airport	PM	*Dendrobium* sp.	1	7,000	Plant unit	
Netherlands	PIS	PM	*Anthurium* sp.	3	7,000	Plant unit	
Netherlands	PIS	PM	*Oxalis* sp.	1	10,000	Plant unit	
New Zealand	Airport	CF	*Cymbidium* sp.	69	15,204	Stems	
New Zealand	Airport	FV	Apple	2	9	kg	
New Zealand	Airport	FV	Apricot	2	1,110	kg	
New Zealand	Airport	FV	Asparagus	9	10,671	kg	
New Zealand	Airport	FV	Blueberry	16	3,482.5	kg.	
New Zealand	Airport	FV	Cape Gooseberry	1	272	kg	
New Zealand	Airport	FV	Cherry	3	1,950	kg	
New Zealand	Airport	FV	Kiwi	1	118	kg	
New Zealand	Airport	FV	Onion	1	48,080	Each	
New Zealand	Airport	FV	Pumpkin	1	11,000	kg	
New Zealand	Airport	FV	Strawberry	57	51,917	kg	Permit cargo: species of Tortricidae (arthropod)
New Zealand	Airport	PM	*Citrus* sp.	1	1,000	Plant unit	
New Zealand	Maritime	FV	Macadamia	3	49,125	kg	
New Zealand	Maritime	FV	Pear	6	177,287	kg	
New Zealand	Maritime	FV	Sand Pear	4	62,922	kg	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
New Zealand	Maritime	FV	Squash	22	316,760	kg	
New Zealand	Maritime	FV	Apple	46	2,990,291	kg	
New Zealand	Maritime	FV	Kiwi	11	189,852	kg	
New Zealand	Maritime	FV	Onion	not given	11,129	kg	
New Zealand	Maritime	FV	Onion	60	2,518,205	kg	
New Zealand	PIS	PM	*Agapanthus* sp.	2	9,000	Plant unit	
New Zealand	PIS	PM	*Agonis* sp.	1	20	Plant unit	
New Zealand	PIS	PM	*Blechnum* sp.	1	55	Plant unit	
New Zealand	PIS	PM	*Cedrus* sp.	1	0.05	kg	
New Zealand	PIS	PM	*Chamaelaucium* sp.	1	40	Plant unit	
New Zealand	PIS	PM	*Cryptomeria* sp.	1	0.23	kg	
New Zealand	PIS	PM	*Cupressus* sp.	1	0.05	kg	
New Zealand	PIS	PM	*Cyathea* sp.	1	32	Plant unit	
New Zealand	PIS	PM	*Dicksonia* sp.	1	10	Plant unit	
New Zealand	PIS	PM	*Erica* sp.	1	40	Plant unit	
New Zealand	PIS	PM	*Grevillea* sp.	1	60	Plant unit	
New Zealand	PIS	PM	*Leucadendron* sp.	1	100	Plant unit	
New Zealand	PIS	PM	*Passiflora* sp.	1	0.6	kg	
New Zealand	PIS	PM	*Phormium* sp.	1	145	Plant unit	
New Zealand	PIS	PM	*Protea* sp.	1	120	Plant unit	
New Zealand	PIS	PM	*Telopea* sp.	1	120	Plant unit	
New Zealand	PIS	PM	*Zephyranthes* sp.	1	7	kg	
Norfolk Island	PIS	PM	*Howea* sp.	4	28,000	Plant unit	
Norfolk Island	PIS	PM	*Rhapis* sp.	1	100	Plant unit	
Palau	PIS	PM	*Allophylus* sp.	1	3	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Palau	PIS	PM	*Alpinia* sp.	1	3	Plant unit	
Palau	PIS	PM	*Averrhoa* sp.	1	3	Plant unit	
Palau	PIS	PM	*Barringtonia* sp.	1	3	Plant unit	
Palau	PIS	PM	*Callicarpa* sp.	1	3	Plant unit	
Palau	PIS	PM	*Cassytha* sp.	1	3	Plant unit	
Palau	PIS	PM	*Cordyline* sp.	1	3	Plant unit	
Palau	PIS	PM	*Flacourtia* sp.	1	3	Plant unit	
Palau	PIS	PM	*Hibiscus* sp.	1	3	Plant unit	
Palau	PIS	PM	*Lycopodium* sp.	1	3	Plant unit	
Palau	PIS	PM	*Morinda* sp.	1	3	Plant unit	
Palau	PIS	PM	*Mussaenda* sp.	1	3	Plant unit	
Palau	PIS	PM	*Poa* sp.	1	3	Plant unit	
Palau	PIS	PM	*Premna* sp.	1	3	Plant unit	
Palau	PIS	PM	*Psidium* sp.	1	3	Plant unit	
Palau	PIS	PM	*Scaevola* sp.	1	3	Plant unit	
Palau	PIS	PM	*Spondias* sp.	1	3	Plant unit	
Palau	PIS	PM	*Terminalia* sp.	1	3	Plant unit	
Panama	PIS	PM	*Calathea* sp.	1	0.5	kg	
Panama	PIS	PM	*Etlingera* sp.	1	0.5	kg.	
Panama	PIS	PM	*Heliconia* sp.	1	0.5	kg	
Philippines	Airport	FV	Garlic	1	2	kg	
Philippines	Airport	FV	Ginger, Bracts	1	8	kg	
Philippines	Airport	FV	Mango	18	21,420	kg	Baggage: *Aulacaspis tubercularis* (arthropod), *Sternochetus mangiferae* (arthropod), species of Diaspididae (arthropod), species of Pseudococcidae (arthropod)
Philippines	PIS	PM	*Adiantum* sp.	1	1	Plant unit	
Philippines	PIS	PM	*Aglaomorpha* sp.	1	1	Plant unit	
Philippines	PIS	PM	*Aglaonema* sp.	1	38	Plant unit	
Philippines	PIS	PM	*Alocasia* sp.	2	12	Plant unit	
Philippines	PIS	PM	*Ananas comosus*	79	11,781,450	Plant unit	
Philippines	PIS	PM	*Angiopteris* sp.	1	8	Plant unit	
Philippines	PIS	PM	*Asplenium* sp.	1	3	Plant unit	
Philippines	PIS	PM	*Begonia* sp.	1	6	Plant unit	
Philippines	PIS	PM	*Blechnum* sp.	1	1	Plant unit	
Philippines	PIS	PM	*Bolbitis* sp.	1	4	Plant unit	
Philippines	PIS	PM	*Bougainvillea* sp.	1	35	Plant unit	
Philippines	PIS	PM	*Cordyline* sp.	1	500	Plant unit	
Philippines	PIS	PM	*Cryptanthus* sp.	2	1,800	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Philippines	PIS	PM	*Davallia* sp.	1	3	Plant unit	
Philippines	PIS	PM	*Dieffenbachia* sp.	1	8	Plant unit	
Philippines	PIS	PM	*Diplazium* sp.	1	5	Plant unit	
Philippines	PIS	PM	*Dipteris* sp.	1	1	Plant unit	
Philippines	PIS	PM	*Dracaena sanderiana*	3	295	Plant unit	
Philippines	PIS	PM	*Dracaena* sp.	3	42	Plant unit	
Philippines	PIS	PM	*Duranta* sp.	1	300	Plant unit	
Philippines	PIS	PM	*Elaphoglossum* sp.	1	6	Plant unit	
Philippines	PIS	PM	*Euphorbia* sp.	1	1,200	Plant unit	
Philippines	PIS	PM	*Goniophlebium* sp.	1	1	Plant unit	
Philippines	PIS	PM	*Hippeastrum* sp.	1	14	Plant unit	
Philippines	PIS	PM	*Hymenophyllum* sp.	1	9	Plant unit	
Philippines	PIS	PM	*Lecanopteris* sp.	1	1	Plant unit	
Philippines	PIS	PM	*Lycopodium* sp.	2	57	Plant unit	
Philippines	PIS	PM	*Microsorum* sp.	1	4	Plant unit	
Philippines	PIS	PM	*Ophiopogon* sp.	1	4	Plant unit	
Philippines	PIS	PM	*Pachira aquatica*	2	220	Plant unit	
Philippines	PIS	PM	*Platycerium* sp.	1	45	Plant unit	
Philippines	PIS	PM	*Polypodium* sp.	1	1	Plant unit	
Philippines	PIS	PM	*Pteris* sp.	1	4	Plant unit	
Philippines	PIS	PM	*Pyrrosia* sp.	1	4	Plant unit	
Philippines	PIS	PM	*Schismatoglottis* sp.	1	2	Plant unit	
Philippines	PIS	PM	*Selaginella* sp.	1	12	Plant unit	
Philippines	PIS	PM	*Spathiphyllum* sp.	1	1	Plant unit	
Philippines	PIS	PM	*Stenochlaena* sp.	1	1	Plant unit	
Philippines	PIS	PM	*Tectaria* sp.	1	9	Plant unit	
Philippines	PIS	PM	*Thelypteris* sp.	1	4	Plant unit	
Philippines	PIS	PM	*Zamioculcas* sp.	1	6	Plant unit	
Singapore	PIS	PM	*Acorus* sp.	1	25	Plant unit	
Singapore	PIS	PM	*Aglaonema* sp.	1	25	Plant unit	
Singapore	PIS	PM	*Alternanthera sessilis*	3	105	Plant unit	
Singapore	PIS	PM	*Alternanthera* sp.	4	2,985	Plant unit	
Singapore	PIS	PM	*Ammannia* sp.	3	700	Plant unit	
Singapore	PIS	PM	*Amordica* sp.	1	75	Plant unit	
Singapore	PIS	PM	*Amorphophallus* sp.	1	7	Plant unit	
Singapore	PIS	PM	*Annona* sp.	1	1	Plant unit	
Singapore	PIS	PM	*Anubias* sp.	4	570	Plant unit	
Singapore	PIS	PM	*Aponogeton* sp.	4	520	Plant unit	
Singapore	PIS	PM	*Aranda* sp.	1	850	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Singapore	PIS	PM	*Areca* sp.	1	0.5	kg	
Singapore	PIS	PM	*Arenga* sp.	1	0.5	kg	
Singapore	PIS	PM	*Artocarpus* sp.	3	54	Plant unit	
Singapore	PIS	PM	*Baccaurea* sp.	1	50	Gram	
Singapore	PIS	PM	*Bacopa* sp.	4	2,325	Plant unit	
Singapore	PIS	PM	*Barclaya* sp.	1	25	Plant unit	
Singapore	PIS	PM	*Blyxa* sp.	4	1,390	Plant unit	
Singapore	PIS	PM	*Bolbitis* sp.	2	300	Plant unit	
Singapore	PIS	PM	*Cabomba* sp.	4	6,830	Plant unit	
Singapore	PIS	PM	*Ceratopteris* sp.	2	75	Plant unit	
Singapore	PIS	PM	*Chlorophytum* sp.	3	190	Plant unit	
Singapore	PIS	PM	*Crassula* sp.	3	500	Plant unit	
Singapore	PIS	PM	*Crinum* sp.	1	125	Plant unit	
Singapore	PIS	PM	*Cryptocoryne* sp.	4	3,940	Plant unit	
Singapore	PIS	PM	*Cyrtostachys* sp.	1	0.5	kg	
Singapore	PIS	PM	*Didiplis* sp.	1	25	Plant unit	
Singapore	PIS	PM	*Dimocarpus* sp.	1	4	Plant unit	
Singapore	PIS	PM	*Dracaena* sp.	4	550	Plant unit	
Singapore	PIS	PM	*Durio* sp.	1	0.5	kg	
Singapore	PIS	PM	*Durio* sp.	2	46	Plant unit	
Singapore	PIS	PM	*Echinodorus* sp.	6	4,980	Plant unit	
Singapore	PIS	PM	*Egeria* sp.	4	475	Plant unit	
Singapore	PIS	PM	*Elaeis* sp.	1	0.1	kg	
Singapore	PIS	PM	*Eleocharis* sp.	4	6,075	Plant unit	
Singapore	PIS	PM	*Elodea* sp.	4	300	Plant unit	
Singapore	PIS	PM	*Etlingera* sp.	1	1	Plant unit	
Singapore	PIS	PM	*Garcinia mangostana*	1	2	Plant unit	
Singapore	PIS	PM	*Garcinia* sp.	1	0.01	kg	
Singapore	PIS	PM	*Garcinia* sp.	not given	8	Plant unit	
Singapore	PIS	PM	*Glossostigma* sp.	4	96	Plant unit	
Singapore	PIS	PM	*Gymnocoronis* sp.	3	175	Plant unit	
Singapore	PIS	PM	*Hemigraphis* sp.	4	590	Plant unit	
Singapore	PIS	PM	*Heteranthera* sp.	4	250	Plant unit	
Singapore	PIS	PM	*Hydrocotyle* sp.	4	1,100	Plant unit	
Singapore	PIS	PM	*Hygrophila* sp.	8	6,400	Plant unit	
Singapore	PIS	PM	*Kaempferia* sp.	1	2	Plant unit	
Singapore	PIS	PM	*Lagarosiphon major*	2	50	Plant unit	
Singapore	PIS	PM	*Licuala* sp.	1	0.5	kg	
Singapore	PIS	PM	*Limnophila sessiliflora*	1	25	Plant unit	
Singapore	PIS	PM	*Limnophila* sp.	1	50	Plant unit	
Singapore	PIS	PM	*Lindernia* sp.	4	300	Plant unit	
Singapore	PIS	PM	*Livistona* sp.	1	0.5	kg	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Singapore	PIS	PM	*Lobelia* sp.	4	460	Plant unit	
Singapore	PIS	PM	*Ludwigia* sp.	4	3,525	Plant unit	
Singapore	PIS	PM	*Lysimachia* sp.	4	1,955	Plant unit	
Singapore	PIS	PM	*Marsilea* sp.	2	180	Plant unit	
Singapore	PIS	PM	*Mayaca* sp.	3	875	Plant unit	
Singapore	PIS	PM	*Michelia* sp.	1	1	Plant unit	
Singapore	PIS	PM	*Micranthemum* sp.	3	1,188	Plant unit	
Singapore	PIS	PM	*Microsorum* sp.	4	1,780	Plant unit	
Singapore	PIS	PM	*Myriophyllum* sp.	4	2,090	Plant unit	
Singapore	PIS	PM	*Nephelium* sp.	3	16	Plant unit	
Singapore	PIS	PM	*Nesaea* sp.	4	1,425	Plant unit	
Singapore	PIS	PM	*Normanbya normanbyi*	1	0.5	kg	
Singapore	PIS	PM	*Nuphar* sp.	3	135	Plant unit	
Singapore	PIS	PM	*Nymphaea* sp.	2	40	Plant unit	
Singapore	PIS	PM	*Ophiopogon* sp.	4	135	Plant unit	
Singapore	PIS	PM	*Pinanga* sp.	1	0.5	kg	
Singapore	PIS	PM	*Pogostemon* sp.	4	1,125	Plant unit	
Singapore	PIS	PM	*Potamogeton* sp.	4	1,850	Plant unit	
Singapore	PIS	PM	*Pouteria* sp.	1	1	Plant unit	
Singapore	PIS	PM	*Psidium guajava*	1	1	Plant unit	
Singapore	PIS	PM	*Psidium* sp.	1	3	Plant unit	
Singapore	PIS	PM	*Quisqualis* sp.	1	1	Plant unit	
Singapore	PIS	PM	*Rotala* sp.	4	2,675	Plant unit	
Singapore	PIS	PM	*Sagittaria* sp.	4	1,970	Plant unit	
Singapore	PIS	PM	*Salacca* sp.	1	12	Plant unit	
Singapore	PIS	PM	*Saururus* sp.	1	55	Plant unit	
Singapore	PIS	PM	*Selaginella* sp.	2	200	Plant unit	
Singapore	PIS	PM	*Spathiphyllum* sp.	4	70	Plant unit	
Singapore	PIS	PM	*Spondias* sp.	1	25	Plant unit	
Singapore	PIS	PM	*Syzygium* sp.	1	2	Plant unit	
Singapore	PIS	PM	*Tonina* sp.	4	295	Plant unit	
Singapore	PIS	PM	*Trichomanes* sp.	3	85	Plant unit	
Singapore	PIS	PM	*Vallisneria* sp.	4	5,280	Plant unit	
Solomon Islands	PIS	PM	*Metroxylon* sp.	1	80	kg	
Solomon Islands	PIS	PM	*Rhapis* sp.	1	1.6	kg	
South Africa	Airport	CF	*Erythrina*	2	50	Stems	
South Africa	PIS	MC	Permit Pathogen	8	28.5	kg	
South Africa	PIS	PM	*Camellia* sp.	3	2,600	Plant unit	
South Africa	PIS	PM	*Erythrina* sp.	1	1	Plant unit	
South Africa	PIS	PM	*Strelitzia* sp.	1	22	kg	
South Africa	USPS	PM	*Allium* sp.	1	11	kg	
South Africa	USPS	PM	*Asparagus* sp.	2	16	kg	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Spain	PIS	PM	*Euterpe* sp.	1	200	Gram	
Spain	PIS	PM	*Hibiscus* sp.	1	12	Plant unit	
Sri Lanka	PIS	PM	*Areca* sp.	1	1	kg	
Sri Lanka	PIS	PM	*Nepenthes* sp.	2	599	Plant unit	
Suriname	PIS	PM	*Annona* sp.	1	0.1	kg	
Suriname	PIS	PM	*Areca* sp.	2	4	kg.	
Suriname	PIS	PM	*Euterpe* sp.	2	0.3	kg	
Suriname	PIS	PM	*Heliconia* sp.	1	2	Plant unit	
Suriname	PIS	PM	*Morinda* sp.	1	0.1	kg	
Suriname	PIS	PM	*Theobroma* sp.	1	0.1	kg	
Sweden	PIS	PM	*Hoya* sp.	1	29	Plant unit	
Switzerland	PIS	PM	*Zea mays*	1	100	kg	
Tahiti	PIS	PM	*Artocarpus* sp.	1	73	Plant unit	
Taiwan	Airport	FV	Bamboo Shoot	10	638	kg	
Taiwan	Airport	FV	Burdock	1	20	kg	
Taiwan	Airport	FV	Mushroom	106	40,857	kg	
Taiwan	Airport	PM	*Apium* sp.	1	1	kg	
Taiwan	Airport	PM	*Brassica* sp.	1	31	kg	
Taiwan	Airport	PM	*Cattleya* sp.	2	8,520	Plant unit	
Taiwan	Airport	PM	*Chrysanthemum* sp.	1	3	kg	
Taiwan	Airport	PM	*Coriandrum* sp.	1	1	kg	
Taiwan	Airport	PM	*Dendrobium* sp.	20	671,175	Plant unit	
Taiwan	Airport	PM	*Lactuca* sp.	1	10	kg	
Taiwan	Airport	PM	*Lycopersicon esculentum*	1	1	kg	
Taiwan	Airport	PM	*Oncidium* sp.	2	84,420	Plant unit	
Taiwan	Airport	PM	*Paphiopedilum* sp.	3	7,300	Plant unit	
Taiwan	Airport	PM	*Phalaenopsis* sp.	10	291,280	Plant unit	
Taiwan	PIS	PM	*Adenium* sp.	1	0.001	kg	Mail: *Planococcus* sp. (arthropod)
Taiwan	PIS	PM	*Adenium* sp.	not given	16	Plant unit	
Taiwan	PIS	PM	*Adenium* sp.	23	1,383	Plant unit	
Taiwan	PIS	PM	*Aerangis ellisii*	1	10	Flask	
Taiwan	PIS	PM	*Anoectochilus* sp.	1	20	Flask	
Taiwan	PIS	PM	*Arachis* sp.	1	12	Plant unit	
Taiwan	PIS	PM	*Artocarpus* sp.	1	0.2	kg	
Taiwan	PIS	PM	*Brassica* sp.	1	0.454	kg	
Taiwan	PIS	PM	*Camellia* sp.	1	40	kg	
Taiwan	PIS	PM	*Carica papaya*	2	1.5	kg	
Taiwan	PIS	PM	*Cattleya* sp.	1	3,600	Plant unit	
Taiwan	PIS	PM	*Cattleya* sp.	11	5,548	Flask	
Taiwan	PIS	PM	*Chrysalidocarpus* sp.	1	0.4	kg	
Taiwan	PIS	PM	*Citrullus lanatus*	2	20.44	kg	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Taiwan	PIS	PM	*Cucumis melo*	1	9.12	kg	
Taiwan	PIS	PM	*Cycnoches* sp.	4	151	Flask	
Taiwan	PIS	PM	*Cymbidium* sp.	1	250	Flask	
Taiwan	PIS	PM	*Cymbidium* sp.	2	5,800	Plant unit	
Taiwan	PIS	PM	*Dendrobium* sp.	1	37	Plant unit	
Taiwan	PIS	PM	*Dendrobium* sp.	7	1,469	Flask	
Taiwan	PIS	PM	*Dracaena sanderiana*	2	62,640	Plant unit	
Taiwan	PIS	PM	*Dracaena* sp.	3	42,220	Plant unit	
Taiwan	PIS	PM	*Epidendrum* sp.	1	185	Flask	
Taiwan	PIS	PM	*Ficus* sp.	1	2,100	Plant unit	
Taiwan	PIS	PM	*Garcinia* sp.	1	0.86	kg	Baggage: species of Pseudococcidae (arthropod)
Taiwan	PIS	PM	*Hyophorbe* sp.	2	0.3	kg	
Taiwan	PIS	PM	*Ipomoea aquatica*	3	90.8	kg	
Taiwan	PIS	PM	*Lycopersicon esculentum*	1	0.03	kg	
Taiwan	PIS	PM	*Oncidium* sp.	15	5,224	Flask	
Taiwan	PIS	PM	*Pachira* sp.	1	23	Plant unit	
Taiwan	PIS	PM	*Paphiopedilum* sp.	13	9,479	Flask	
Taiwan	PIS	PM	*Phalaenopsis* sp.	32	32,534	Flask	
Taiwan	PIS	PM	*Phalaenopsis* sp.	34	297,682	Plant unit	
Taiwan	PIS	PM	*Phaseolus* sp.	1	360,000	Plant unit	
Taiwan	PIS	PM	*Raphanus sativus*	2	6.77	kg	
Taiwan	PIS	PM	*Rhapis* sp.	2	7.86	kg	
Taiwan	PIS	PM	*Rhapis* sp.	12	171,064	Plant unit	
Taiwan	PIS	PM	*Rhynchostylis* sp.	2	100	Flask	
Taiwan	PIS	PM	*Vanda* sp.	1	46	Flask	
Taiwan	PIS	PM	*Zephyranthes* sp.	1	11	Plant unit	
Taiwan	PIS	PM	*Zygopetalum* sp.	1	40	Flask	
Taiwan	USPS	PM	*Adenium* sp.	1	3	Plant unit	
Taiwan	USPS	PM	*Adenium* sp.	2	2	kg	
Taiwan	USPS	PM	*Allium* sp.	22	416	kg	
Taiwan	USPS	PM	*Amaranthus* sp.	2	2	kg	
Taiwan	USPS	PM	*Asparagus* sp.	2	2	kg	
Taiwan	USPS	PM	*Benincasa* sp.	5	4	kg	
Taiwan	USPS	PM	*Brassica* sp.	25	67	kg	
Taiwan	USPS	PM	*Capsicum* sp.	6	3	kg	
Taiwan	USPS	PM	*Carica papaya*	39	53	kg	
Taiwan	USPS	PM	*Citrullus* sp.	19	99	kg	
Taiwan	USPS	PM	*Cucumis melo*	9	7	kg	
Taiwan	USPS	PM	*Cucumis sativus*	8	24	kg	
Taiwan	USPS	PM	*Cucumis* sp.	2	3	kg	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Taiwan	USPS	PM	*Cucurbita* sp.	3	10	kg	
Taiwan	USPS	PM	*Glycine max*	1	1	kg	
Taiwan	USPS	PM	*Ipomoea aquatica*	13	460	kg	
Taiwan	USPS	PM	*Lactuca* sp.	1	1	kg	
Taiwan	USPS	PM	*Lagenaria* sp.	9	10	kg	
Taiwan	USPS	PM	*Luffa* sp.	2	2	kg	
Taiwan	USPS	PM	*Lycopersicon esculentum*	4	4	kg	
Taiwan	USPS	PM	*Momordica* sp.	5	4	kg	
Taiwan	USPS	PM	*Raphanus* sp.	13	40	kg	
Taiwan	USPS	PM	*Solanum* sp.	8	8	kg	
Taiwan	USPS	PM	*Spinacia* sp.	1	1	kg	
Taiwan	USPS	PM	*Vigna* sp.	18	114.3	kg	
Taiwan	USPS	PM	*Zea mays*	1	3	kg	
Tanzania	PIS	MC	Permit Pathogen	2	8	kg	
Thailand	Airport	CF	*Anthurium* sp.	1	50	Stems	
Thailand	Airport	CF	Calotropis	1	20	Stems	
Thailand	Airport	CF	Chrysanthemum	1	20	Stems	
Thailand	Airport	CF	Cordyline	328	12,817	Stems	
Thailand	Airport	CF	*Dendrobium* sp.	8946	10,385,365	Stems	
Thailand	Airport	CF	*Jasminum* sp.	1	300	Stems	
Thailand	Airport	CF	Lotus	107	5,778	Stems	
Thailand	Airport	CF	*Nelumbo* sp.	5	530	Stems	
Thailand	Airport	CF	Pandanus	129	13,011	Stems	
Thailand	Airport	CF	*Polypodium* sp.	531	41,104	Stems	
Thailand	Airport	CF	Polyscias	1	10	Stems	
Thailand	Airport	CF	*Rosa* sp.	1	100	Stems	
Thailand	Airport	FV	Betel-Nut	1	558	kg	
Thailand	Airport	FV	Mushroom	7	574	kg	
Thailand	Airport	PM	*Angraecum* sp.	1	800	Plant unit	
Thailand	Airport	PM	*Apium* sp.	1	1	kg	
Thailand	Airport	PM	*Cattleya* sp.	30	264,720	Plant unit	
Thailand	Airport	PM	*Citrullus* sp.	1	17	kg	
Thailand	Airport	PM	*Coriandrum* sp.	1	2	kg	
Thailand	Airport	PM	*Cucumis* sp.	1	19	kg	
Thailand	Airport	PM	*Cucurbita* sp.	1	10	kg	
Thailand	Airport	PM	*Cycnoches* sp.	1	80	Plant unit	
Thailand	Airport	PM	*Cymbidium* sp.	3	9,440	Plant unit	
Thailand	Airport	PM	*Dendrobium* sp.	67	2,152,069	Plant unit	Permit cargo: *Adoretus sinicus* (arthropod), *Contarinia* sp. (arthropod), *Helicoverpa armigera* (arthropod),

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
							Nilaparvata lugens (arthropod), *Nysius* sp. (arthropod), *Spodoptera litura* (arthropod), *Spodoptera* sp. (arthropod), *Succinea tenella* (mollusc), *Succinea* cf. *horticola* (mollusc), *Succinea* sp. (mollusc), *Thrips palmi* (arthropod), species of Cicadellidae, species of Cydnidae, species of Lepidoptera (arthropod), species of Noctuidae; General cargo: *Succinea tenella* (mollusc), species of Noctuidae (arthropod); Baggage: *Succinea tenella* (mollusc), species of Formicidae (arthropod)
Thailand	Airport	PM	*Epidendrum* sp.	2	5,280	Plant unit	
Thailand	Airport	PM	*Grammatophyllum* sp.	1	800	Plant unit	
Thailand	Airport	PM	*Lycopersicon* sp.	1	2	kg	
Thailand	Airport	PM	*Ocimum* sp	1	3	kg	
Thailand	Airport	PM	*Oncidium* sp.	20	375,360	Plant unit	
Thailand	Airport	PM	*Paphiopedilum* sp.	11	183,700	kg	
Thailand	Airport	PM	*Phalaenopsis* sp.	10	136,480	Plant unit	
Thailand	Airport	PM	*Vanda* sp.	3	5,580	Plant unit	
Thailand	PIS	PM	*Acanthus* sp.	1	12	Plant unit	
Thailand	PIS	PM	*Acomis* sp.	1	6	Plant unit	
Thailand	PIS	PM	*Adenium* sp.	1	110	Gram	
Thailand	PIS	PM	*Adenium* sp.	not	250	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
				given			
Thailand	PIS	PM	*Adenium* sp.	46	10,516	Plant unit	
Thailand	PIS	PM	*Aeridovanda* sp.	1	11	Plant unit	
Thailand	PIS	PM	*Agave* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Aglaia* sp.	1	25	Plant unit	
Thailand	PIS	PM	*Aglaonema* sp.	9	703	Plant unit	
Thailand	PIS	PM	*Allagoptera* sp.	1	59	Plant unit	
Thailand	PIS	PM	*Allamanda* sp.	2	26	Plant unit	
Thailand	PIS	PM	*Alocasia* sp.	7	151	Plant unit	
Thailand	PIS	PM	*Aloe* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Alpinia* sp.	8	21	Plant unit	
Thailand	PIS	PM	*Alternanthera* sp.	3	222	Plant unit	
Thailand	PIS	PM	*Amherstia* sp.	2	21	Plant unit	
Thailand	PIS	PM	*Ammannia* sp.	1	2	Plant unit	
Thailand	PIS	PM	*Amorphophallus* sp.	1	0.1	kg	
Thailand	PIS	PM	*Amorphophallus* sp.	not given	16	Plant unit	
Thailand	PIS	PM	*Amorphophallus* sp.	3	143	Plant unit	
Thailand	PIS	PM	*Annona* sp.	4	29	Plant unit	Baggage: *Planococcus* sp. (arthropod on. *A. cherimola*)
Thailand	PIS	PM	*Annona* sp.	2	0.101	kg	
Thailand	PIS	PM	*Anthurium* sp.	1	0.1	kg	
Thailand	PIS	PM	*Anthurium* sp.	2	10	Plant unit	
Thailand	PIS	PM	*Anubias* sp.	3	340	Plant unit	
Thailand	PIS	PM	*Aphananthe* sp.	1	2	Plant unit	
Thailand	PIS	PM	*Aponogeton* sp.	1	90	Plant unit	
Thailand	PIS	PM	*Arachniodes* sp.	1	2	Plant unit	
Thailand	PIS	PM	*Archontophoenix* sp.	1	4.1	kg	
Thailand	PIS	PM	*Areca* sp.	1	200	Gram	
Thailand	PIS	PM	*Areca* sp.	not given	16	Plant unit	
Thailand	PIS	PM	*Areca* sp.	2	1.6	kg	
Thailand	PIS	PM	*Arenga* sp.	1	1.7	kg	
Thailand	PIS	PM	*Arenga* sp.	not given	4	Plant unit	
Thailand	PIS	PM	*Arenga* sp.	2	230	Plant unit	
Thailand	PIS	PM	*Aristolochia* sp.	1	0.1	kg	
Thailand	PIS	PM	*Artabotrys* sp.	1	0.2	kg	
Thailand	PIS	PM	*Artocarpus heterophyllus*	3	133	Plant unit	
Thailand	PIS	PM	*Artocarpus* sp.	1	11	Plant unit	
Thailand	PIS	PM	*Ascocenda* sp.	6	171	Flask	
Thailand	PIS	PM	*Ascocenda* sp.	20	4,624	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Thailand	PIS	PM	*Ascocentrum* sp.	1	9	Plant unit	
Thailand	PIS	PM	*Ascocentrum* sp.	2	16	Flask	
Thailand	PIS	PM	*Asconopsis* sp.	1	30	Plant unit	
Thailand	PIS	PM	*Asparagus* sp.	1	5	Plant unit	
Thailand	PIS	PM	*Aspidistra* sp.	1	7	Plant unit	
Thailand	PIS	PM	*Asplenium* sp.	1	3	Plant unit	
Thailand	PIS	PM	*Attalea* sp.	1	0.1	kg	
Thailand	PIS	PM	*Averrhoa carambola*	1	10	Plant unit	
Thailand	PIS	PM	*Baccaurea* sp.	1	0.1	kg	
Thailand	PIS	PM	*Baccaurea* sp.	5	94	Plant unit	
Thailand	PIS	PM	*Bacopa* sp.	2	291	Plant unit	
Thailand	PIS	PM	*Bauhinia* sp.	1	9	Plant unit	
Thailand	PIS	PM	*Bauhinia* sp.	2	1.001	kg	
Thailand	PIS	PM	*Beaumontia* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Begonia* sp.	2	2	Plant unit	
Thailand	PIS	PM	*Blyxa* sp.	1	60	Plant unit	
Thailand	PIS	PM	*Bouea* sp.	1	1.8	kg	
Thailand	PIS	PM	*Bouea* sp.	3	113	Plant unit	
Thailand	PIS	PM	*Bougainvillea* sp.	2	609	Plant unit	
Thailand	PIS	PM	*Brownea* sp.	1	0.1	kg	
Thailand	PIS	PM	*Bulbophyllum* sp.	4	35	Flask	
Thailand	PIS	PM	*Cabomba* sp.	1	575	Plant unit	
Thailand	PIS	PM	*Caladium* sp.	4	14	Plant unit	
Thailand	PIS	PM	*Calamus* sp.	1	0.1	kg	
Thailand	PIS	PM	*Calathea* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Calliandra* sp.	1	2	Plant unit	
Thailand	PIS	PM	*Calotropis* sp.	1	6	Plant unit	
Thailand	PIS	PM	*Calyptrocalyx* sp.	1	0.3	kg	
Thailand	PIS	PM	*Calyptrocalyx* sp.	not given	10	Plant unit	
Thailand	PIS	PM	*Cananga* sp.	3	114	Plant unit	
Thailand	PIS	PM	*Capsicum* sp.	2	0.3	kg	
Thailand	PIS	PM	*Carica papaya*	2	0.04	kg	
Thailand	PIS	PM	*Carmona* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Caryota* sp.	1	3.2	kg	
Thailand	PIS	PM	*Caryota* sp.	not given	4	Plant unit	
Thailand	PIS	PM	*Cassia* sp.	1	0.2	kg	
Thailand	PIS	PM	*Cattleya* sp.	78	21,656	Flask	
Thailand	PIS	PM	*Cattleya* sp.	not given	21,680	Plant unit	
Thailand	PIS	PM	*Cattleya* sp.	76	563,532	Plant unit	
Thailand	PIS	PM	*Ceratopteris* sp.	1	25	Plant unit	
Thailand	PIS	PM	*Cerbera* sp.	1	0.1	kg	
Thailand	PIS	PM	*Cestrum* sp.	1	10	Plant unit	
Thailand	PIS	PM	*Chamaedorea* sp.	1	0.4	kg	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Thailand	PIS	PM	*Chiloschista* sp.	1	24	Plant unit	
Thailand	PIS	PM	*Chlorophytum* sp.	2	17	Plant unit	
Thailand	PIS	PM	*Chrysalidocarpus* sp.	1	210	Plant unit	
Thailand	PIS	PM	*Chrysophyllum* sp.	1	60	Plant unit	Baggage: species of Pseudococcidae (arthropod)
Thailand	PIS	PM	*Citrullus* sp.	1	23	kg	
Thailand	PIS	PM	*Citrus* sp.	1	78	Plant unit	Baggage: *Parlatoria ziziphi* (arthropod)
Thailand	PIS	PM	*Clerodendrum* sp.	2	26	Plant unit	
Thailand	PIS	PM	*Coccoloba* sp.	1	0.1	kg	
Thailand	PIS	PM	*Codiaeum* sp.	2	73	Plant unit	Baggage: *Planococcus minor* (arthropod on *C. variegatum*)
Thailand	PIS	PM	*Coelogyne* sp.	1	3	Flask	
Thailand	PIS	PM	*Colmanara* sp.	1	800	Plant unit	
Thailand	PIS	PM	*Colmanara* sp.	2	148	Flask	
Thailand	PIS	PM	*Colocasia* sp.	2	70	Plant unit	
Thailand	PIS	PM	*Copernicia* sp.	1	0.1	kg	
Thailand	PIS	PM	*Cordyline* sp.	10	213	Plant unit	
Thailand	PIS	PM	*Corypha* sp.	1	14.2	kg	
Thailand	PIS	PM	*Costus* sp.	8	67	Plant unit	
Thailand	PIS	PM	*Crassula* sp.	1	50	Plant unit	
Thailand	PIS	PM	*Crinum* sp.	1	0.1	kg	
Thailand	PIS	PM	*Crinum* sp.	2	34	Plant unit	
Thailand	PIS	PM	*Croton* sp.	3	211	Plant unit	Permit cargo: species of Pseudococcidae (arthropod)
Thailand	PIS	PM	*Cryptocoryne* sp.	2	585	Plant unit	
Thailand	PIS	PM	*Curcuma* sp.	12	8,981	Plant unit	
Thailand	PIS	PM	*Cycas debaoensis*	1	8.5	kg	
Thailand	PIS	PM	*Cycas* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Cycas* sp.	2	25.6	kg	
Thailand	PIS	PM	*Cymbidium* sp.	4	7,420	Plant unit	
Thailand	PIS	PM	*Cymbidium* sp.	7	158	Flask	
Thailand	PIS	PM	*Cyperus* sp.	1	30	Plant unit	
Thailand	PIS	PM	*Cyrtostachys* sp.	2	0.11	kg	
Thailand	PIS	PM	*Cyrtostachys* sp.	21	7,792	Plant unit	
Thailand	PIS	PM	*Degarmoara* sp.	1	25	Flask	
Thailand	PIS	PM	*Dendrobium* sp.	63	23,028	Flask	
Thailand	PIS	PM	*Dendrobium* sp.	not	3	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
				given			
Thailand	PIS	PM	*Dendrobium* sp.	132	2,577,629	Plant unit	
Thailand	PIS	PM	*Desmos* sp.	2	200	Plant unit	
Thailand	PIS	PM	*Dieffenbachia* sp.	6	55	Plant unit	
Thailand	PIS	PM	*Dischidia* sp.	2	9	Plant unit	
Thailand	PIS	PM	*Dombeya* sp.	1	30	Plant unit	
Thailand	PIS	PM	*Doritaenopsis* sp.	1	9	Flask	
Thailand	PIS	PM	*Doritis* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Doritis* sp.	6	148	Flask	
Thailand	PIS	PM	*Doryopteris* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Dracaena sanderiana*	2	902	Plant unit	
Thailand	PIS	PM	*Dracaena* sp.	12	12,613	Plant unit	
Thailand	PIS	PM	*Drymoglossum* sp.	1	19	Plant unit	
Thailand	PIS	PM	*Drymophloeus* sp.	1	128	Plant unit	
Thailand	PIS	PM	*Drynaria* sp.	5	241	Plant unit	
Thailand	PIS	PM	*Durio* sp.	1	1	kg	
Thailand	PIS	PM	*Dyakia* sp.	1	100	Plant unit	
Thailand	PIS	PM	*Dypsis* sp.	1	5	Plant unit	
Thailand	PIS	PM	*Echinodorus* sp.	3	126	Plant unit	Quarters: *Cercospora* sp. (pathogen on *E. cordifolius*)
Thailand	PIS	PM	*Ehretia* sp.	1	50	Plant unit	
Thailand	PIS	PM	*Elaeis* sp.	1	5.4	kg	
Thailand	PIS	PM	*Elaeis* sp.	not given	43	Plant unit	
Thailand	PIS	PM	*Elaeocarpus* sp.	1	3	Plant unit	
Thailand	PIS	PM	*Elaphoglossum* sp.	1	3	Plant unit	
Thailand	PIS	PM	*Eleocharis* sp.	1	115	Plant unit	
Thailand	PIS	PM	*Elodea* sp.	1	100	Plant unit	
Thailand	PIS	PM	*Embothrium* sp.	1	4	Plant unit	
Thailand	PIS	PM	*Entada* sp.	1	1	kg	
Thailand	PIS	PM	*Epidendrum* sp.	3	11,520	Plant unit	
Thailand	PIS	PM	*Epidendrum* sp.	4	505	Flask	
Thailand	PIS	PM	*Epipremnum* sp.	2	2	Plant unit	
Thailand	PIS	PM	*Erythrina* sp.	1	0.1	kg	Baggage: *Andaspis* sp. (arthropod)
Thailand	PIS	PM	*Etlingera* sp.	10	57	Plant unit	Baggage: *Thrips* sp. (arthropod)
Thailand	PIS	PM	*Eucrosia* sp.	1	7	Plant unit	
Thailand	PIS	PM	*Eugenia* sp.	1	0.1	kg	
Thailand	PIS	PM	*Eugenia* sp.	not given	10	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Thailand	PIS	PM	*Euonymus* sp.	1	100	Plant unit	
Thailand	PIS	PM	*Euphorbia* sp.	147	212,316	Plant unit	Permit cargo: species of Thripidae (arthropod); Baggage: *Succinea tenella* (mollusc), species of Thysanoptera (arthropod)
Thailand	PIS	PM	*Fagraea* sp.	1	10	Plant unit	
Thailand	PIS	PM	*Fatshedera* sp.	1	2	Plant unit	
Thailand	PIS	PM	*Ficus* sp.	1	5	Plant unit	
Thailand	PIS	PM	*Fittonia* sp.	1	50	Plant unit	
Thailand	PIS	PM	*Flacourtia* sp.	1	0.1	kg	
Thailand	PIS	PM	*Garcinia mangostana*	6	1,348	Plant unit	Baggage: species of Pseudococcidae (arthropod)
Thailand	PIS	PM	*Garcinia mangostana*	4	8.9	kg	
Thailand	PIS	PM	*Garcinia* sp.	1	0.5	kg	
Thailand	PIS	PM	*Garcinia* sp.	not given	3	Plant unit	
Thailand	PIS	PM	*Gardenia* sp.	2	1	kg	
Thailand	PIS	PM	*Gardenia* sp.	not given	11	Plant unit	
Thailand	PIS	PM	*Globba* sp.	4	175	Plant unit	
Thailand	PIS	PM	*Glossostigma* sp.	1	10	Plant unit	
Thailand	PIS	PM	*Grammatophyllum* sp.	11	29,094	Plant unit	
Thailand	PIS	PM	*Grammatophyllum* sp.	6	730	Flask	
Thailand	PIS	PM	*Gronophyllum* sp.	1	0.1	kg	
Thailand	PIS	PM	*Gulubia* sp.	1	70.8	kg	
Thailand	PIS	PM	*Gymnocoronis* sp.	1	25	Plant unit	
Thailand	PIS	PM	*Haworthia* sp.	1	2	Plant unit	
Thailand	PIS	PM	*Hedychium* sp.	2	26	Plant unit	
Thailand	PIS	PM	*Heliconia* sp.	1	0.1	kg	
Thailand	PIS	PM	*Heliconia* sp.	not given	7	Plant unit	
Thailand	PIS	PM	*Heliconia* sp.	14	680	Plant unit	
Thailand	PIS	PM	*Heteranthera* sp.	1	50	Plant unit	
Thailand	PIS	PM	*Hippeastrum* sp.	3	23	Plant unit	
Thailand	PIS	PM	*Homalomena* sp.	3	7	Plant unit	
Thailand	PIS	PM	*Howea* sp.	1	270	Plant unit	
Thailand	PIS	PM	*Hoya* sp.	9	10,148	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Thailand	PIS	PM	*Hydrocleys* sp.	1	4	Plant unit	
Thailand	PIS	PM	*Hydrocotyle* sp.	2	52	Plant unit	
Thailand	PIS	PM	*Hygrophila* sp.	1	525	Plant unit	
Thailand	PIS	PM	*Hymenocallis* sp.	1	40	Plant unit	
Thailand	PIS	PM	*Iguanura* sp.	1	200	Gram	
Thailand	PIS	PM	*Iguanura* sp.	not given	12.2	kg	
Thailand	PIS	PM	*Iguanura* sp.	2	31	Plant unit	
Thailand	PIS	PM	*Impatiens* sp.	1	0.001	kg	
Thailand	PIS	PM	*Impatiens* sp.	not given	4	Plant unit	
Thailand	PIS	PM	*Intsia* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Ixora* sp.	4	328	Plant unit	Baggage: species of Aphididae (arthropod)
Thailand	PIS	PM	*Jasminum* sp.	1	2	Plant unit	Baggage: *Hendecasis duplifascialis*, species of Pyralidae (arthropods on *J. sambac*)
Thailand	PIS	PM	*Johannesteijsmannia* sp.	1	127.5	kg	
Thailand	PIS	PM	*Kaempferia* sp.	4	55	Plant unit	
Thailand	PIS	PM	*Kagawara* sp.	1	10	Flask	
Thailand	PIS	PM	*Kagawara* sp.	3	830	Plant unit	
Thailand	PIS	PM	*Kerriodoxa elegans*	1	100	Plant unit	
Thailand	PIS	PM	*Kingidium* sp.	1	2	Plant unit	
Thailand	PIS	PM	*Lagerstroemia* sp.	1	3	Plant unit	
Thailand	PIS	PM	*Lansium domesticum*	1	50	Plant unit	
Thailand	PIS	PM	*Lansium* sp.	1	0.5	kg	
Thailand	PIS	PM	*Lasia* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Lea* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Lecanopteris* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Lepisanthes* sp.	1	0.1	kg	
Thailand	PIS	PM	*Leucothoe* sp.	1	14	Plant unit	
Thailand	PIS	PM	*Licuala* sp.	1	200	Gram	
Thailand	PIS	PM	*Licuala* sp.	4	17.1	kg	
Thailand	PIS	PM	*Licuala* sp.	not given	612	Plant unit	
Thailand	PIS	PM	*Lilaeopsis* sp.	1	325	Plant unit	
Thailand	PIS	PM	*Lilium* sp.	2	34	Plant unit	
Thailand	PIS	PM	*Limnocharis* sp.	1	6	Plant unit	
Thailand	PIS	PM	*Limnophila* sp.	1	25	Plant unit	
Thailand	PIS	PM	*Lindernia* sp.	1	200	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Thailand	PIS	PM	*Liriope* sp.	1	4	Plant unit	
Thailand	PIS	PM	*Lithocarpus* sp.	1	1	kg	
Thailand	PIS	PM	*Livistona* sp.	2	2.525	kg	
Thailand	PIS	PM	*Lobelia* sp.	1	10	Plant unit	
Thailand	PIS	PM	*Ludwigia* sp.	2	54	Plant unit	
Thailand	PIS	PM	*Lycopodium* sp.	5	94	Plant unit	Permit cargo: *Adoretus* sp. (arthropod), species of Rutelinae (arthropod)
Thailand	PIS	PM	*Lysimachia* sp.	1	100	Plant unit	
Thailand	PIS	PM	*Macodes* sp.	2	105	Flask	
Thailand	PIS	PM	*Magnolia* sp.	1	25	Plant unit	
Thailand	PIS	PM	*Malpighia* sp.	1	6	Plant unit	
Thailand	PIS	PM	*Mammea* sp.	1	0.1	kg	
Thailand	PIS	PM	*Manettia* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Mangifera indica*	5	143	Plant unit	
Thailand	PIS	PM	*Manilkara* sp.	3	54	Plant unit	
Thailand	PIS	PM	*Marsilea* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Mayaca* sp.	1	65	Plant unit	
Thailand	PIS	PM	*Medinilla* sp.	1	2	Plant unit	
Thailand	PIS	PM	*Melianthus* sp.	1	0.1	kg	
Thailand	PIS	PM	*Melientha* sp.	1	25	Plant unit	
Thailand	PIS	PM	*Memecylon* sp.	1	5	Plant unit	
Thailand	PIS	PM	*Mesua* sp.	1	0.1	kg	
Thailand	PIS	PM	*Michelia* sp.	4	101	Plant unit	
Thailand	PIS	PM	*Micranthemum* Sp.	1	175	Plant unit	
Thailand	PIS	PM	*Microsorum* sp.	8	1,218	Plant unit	
Thailand	PIS	PM	*Mokara* sp.	3	425	Flask	
Thailand	PIS	PM	*Mokara* sp.	5	9,550	Plant unit	
Thailand	PIS	PM	*Monochoria* sp.	1	4	Plant unit	
Thailand	PIS	PM	*Mussaenda* sp.	1	3	Plant unit	
Thailand	PIS	PM	*Myriophyllum* sp.	2	151	Plant unit	
Thailand	PIS	PM	*Myrmecodia* sp.	1	1	Flask	
Thailand	PIS	PM	*Nelumbo nucifera*	1	0.01	kg	
Thailand	PIS	PM	*Nelumbo nucifera*	not given	20	Plant unit	Permit cargo: *Spodoptera litura* (arthropod)
Thailand	PIS	PM	*Nelumbo nucifera*	2	65	Plant unit	
Thailand	PIS	PM	*Nelumbo* sp.	3	5.28	kg	
Thailand	PIS	PM	*Nelumbo* sp.	6	433	Plant unit	
Thailand	PIS	PM	Nenga sp.	1	25	Plant unit	
Thailand	PIS	PM	*Neofinetia falcata*	2	200	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Thailand	PIS	PM	*Neostylis* sp.	1	10	Plant unit	
Thailand	PIS	PM	*Nepenthes* sp.	2	89	Plant unit	
Thailand	PIS	PM	*Nephelium lappaceum*	4	650	Plant unit	Baggage: species of Pseudococcidae (arthropod)
Thailand	PIS	PM	*Nephrolepis* sp.	2	2	Plant unit	
Thailand	PIS	PM	*Nesaea* sp.	1	125	Plant unit	
Thailand	PIS	PM	*Nymphaea* sp.	1	1	kg	
Thailand	PIS	PM	*Nymphaea* sp.	21	6,566	Plant unit	
Thailand	PIS	PM	*Nymphoides* sp.	1	5	Plant unit	
Thailand	PIS	PM	*Odontocidium* sp.	1	32	Plant unit	
Thailand	PIS	PM	*Odontonia* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Oncidium* sp.	70	45,253	Flask	
Thailand	PIS	PM	*Oncidium* sp.	22	80,201	Plant unit	
Thailand	PIS	PM	*Ophioglossum* sp.	1	8	Plant unit	
Thailand	PIS	PM	*Ophiopogon* sp.	2	55	Plant unit	
Thailand	PIS	PM	*Orchidantha* sp.	1	13	Plant unit	
Thailand	PIS	PM	*Oroxylum* sp.	1	0.1	kg	
Thailand	PIS	PM	*Osmanthus* sp.	1	10	Plant unit	
Thailand	PIS	PM	*Pachira aquatica*	1	2	Plant unit	
Thailand	PIS	PM	*Pachira* sp.	2	1.5	kg	
Thailand	PIS	PM	*Pandanus* sp.	1	2	kg	
Thailand	PIS	PM	*Pandanus* sp.	4	31	Plant unit	
Thailand	PIS	PM	*Paphiopedilum* sp.	14	6,007	Flask	
Thailand	PIS	PM	*Papilionanthe* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Paraphalaenopsis* sp.	1	5	Flask	
Thailand	PIS	PM	*Paris* sp.	1	10	Plant unit	
Thailand	PIS	PM	*Passiflora* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Pelatantheria* sp.	1	14	Plant unit	
Thailand	PIS	PM	*Pellaea* sp.	1	2	Plant unit	
Thailand	PIS	PM	*Peperomia* sp.	2	5	Plant unit	
Thailand	PIS	PM	*Phalaenopsis* sp.	7	29,777	Plant unit	
Thailand	PIS	PM	*Phalaenopsis* sp.	20	3,274	Flask	
Thailand	PIS	PM	*Phaseolus* sp.	1	0.1	kg	
Thailand	PIS	PM	*Philodendron* sp.	5	44	Plant unit	
Thailand	PIS	PM	*Philodendron* sp.	4	25	Plant unit	
Thailand	PIS	PM	*Phoenix* sp.	1	1.8	kg	
Thailand	PIS	PM	*Phoenix* sp.	not given	10	Plant unit	
Thailand	PIS	PM	*Phyllanthus* sp.	1	66	Plant unit	
Thailand	PIS	PM	*Phyllanthus* sp.	2	0.6	kg	
Thailand	PIS	PM	*Pieris formosa* x *japonica*	1	23	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Thailand	PIS	PM	*Pieris japonica*	1	2	Plant unit	
Thailand	PIS	PM	*Pilea* sp.	1	2	Plant unit	
Thailand	PIS	PM	*Pinanga* sp.	1	200	Gram	
Thailand	PIS	PM	*Pinanga* sp.	not given	183	Plant unit	
Thailand	PIS	PM	*Pinanga* sp.	3	1.11	kg	
Thailand	PIS	PM	*Pisonia* sp.	1	5	Plant unit	
Thailand	PIS	PM	*Pithecellobium* sp.	1	30	Plant unit	
Thailand	PIS	PM	*Platycerium* sp.	6	249	Plant unit	
Thailand	PIS	PM	*Plumeria* sp.	15	377	Plant unit	
Thailand	PIS	PM	*Pogostemon* sp.	1	50	Plant unit	
Thailand	PIS	PM	*Polianthes* sp.	1	1,350	Plant unit	
Thailand	PIS	PM	*Polyalthia* sp.	1	6	kg	
Thailand	PIS	PM	*Polyalthia* sp.	8	13,025	Plant unit	Baggage: *Araecerus* sp. (arthropod on *P. longifolia*)
Thailand	PIS	PM	*Polypodium* sp.	2	62	Plant unit	
Thailand	PIS	PM	*Polyscias* sp.	2	5	Plant unit	
Thailand	PIS	PM	*Pontederia* sp.	1	4	Plant unit	
Thailand	PIS	PM	*Potamogeton* sp.	1	100	Plant unit	
Thailand	PIS	PM	*Pseuderanthemum* sp.	1	5	Plant unit	
Thailand	PIS	PM	*Psidium guajava*	4	103	Plant unit	
Thailand	PIS	PM	*Pterocarpus* sp.	1	20	Plant unit	
Thailand	PIS	PM	*Ptychosperma* sp.	2	459	Plant unit	
Thailand	PIS	PM	*Ptychosperma* sp.	4	130.6	kg	
Thailand	PIS	PM	*Punica granatum*	1	12	Plant unit	
Thailand	PIS	PM	*Pyrrosia* sp.	3	92	Plant unit	
Thailand	PIS	PM	*Randia culeata*	1	0.5	kg	
Thailand	PIS	PM	*Raphia* sp.	1	1.1	kg	
Thailand	PIS	PM	*Ravenea* sp.	1	2	Plant unit	
Thailand	PIS	PM	*Renanthera* sp.	1	109	Flask	
Thailand	PIS	PM	*Renanthera* sp.	5	67	Plant unit	
Thailand	PIS	PM	*Rhapis* sp.	8	2,077	Plant unit	
Thailand	PIS	PM	*Rhipsalis* sp.	1	7	Plant unit	
Thailand	PIS	PM	*Rhododendron* sp.	1	27	Plant unit	
Thailand	PIS	PM	*Rhoeo* sp.	1	20	Plant unit	
Thailand	PIS	PM	*Rhynchocentrum* sp.	2	405	Plant unit	
Thailand	PIS	PM	*Rhynchostylis gigantea*	2	26	Flask	
Thailand	PIS	PM	*Rhynchostylis gigantea*	3	1,080	Plant unit	
Thailand	PIS	PM	*Rhynchostylis* sp.	5	2,420	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Thailand	PIS	PM	*Rhynchostylis* sp.	8	264	Flask	
Thailand	PIS	PM	*Rhynchovandanthe* sp.	1	20	Plant unit	
Thailand	PIS	PM	*Rorippa* sp.	1	75	Plant unit	
Thailand	PIS	PM	*Rotala* sp.	1	290	Plant unit	
Thailand	PIS	PM	*Sagittaria* sp.	3	260	Plant unit	
Thailand	PIS	PM	*Salacca* sp.	1	0.5	kg	
Thailand	PIS	PM	*Sanchezia* sp.	1	5	Plant unit	
Thailand	PIS	PM	*Sandoricum* sp.	1	0.5	kg	
Thailand	PIS	PM	*Sansevieria* sp.	2	6	Plant unit	
Thailand	PIS	PM	*Saraca* sp.	5	2,110	Plant unit	
Thailand	PIS	PM	*Satakentia* sp.	3	376	Plant unit	
Thailand	PIS	PM	*Sauropus* sp.	1	0.1	kg	
Thailand	PIS	PM	*Schefflera* sp.	1	0.1	kg	
Thailand	PIS	PM	*Selaginella* sp.	2	121	Plant unit	
Thailand	PIS	PM	*Sesbania* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Siphokentia* sp.	1	0.1	kg	
Thailand	PIS	PM	*Solandra* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Solanum melongena*	1	0.35	kg	
Thailand	PIS	PM	*Solanum melongena*	not given	2	Plant unit	
Thailand	PIS	PM	*Spathiphyllum* sp.	3	31	Plant unit	
Thailand	PIS	PM	*Spathoglottis* sp.	1	1	Flask	
Thailand	PIS	PM	*Spathoglottis* sp.	not given	8	Plant unit	
Thailand	PIS	PM	*Spondias* sp.	1	0.1	kg	
Thailand	PIS	PM	*Spondias* sp.	not given	10	Plant unit	
Thailand	PIS	PM	*Sterculia* sp.	1	0.05	kg	
Thailand	PIS	PM	*Streblus* sp.	1	8	Plant unit	
Thailand	PIS	PM	*Strobilanthes* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Strophanthus* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Suregada* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Syagrus* sp.	1	10.2	kg	
Thailand	PIS	PM	*Syagrus* sp.	not given	31	Plant unit	
Thailand	PIS	PM	*Syngonium* sp.	2	900	Plant unit	
Thailand	PIS	PM	*Syzygium* sp.	1	3	Plant unit	
Thailand	PIS	PM	*Tabernaemontana* sp.	1	6	Plant unit	
Thailand	PIS	PM	*Tacca* sp.	4	92	Plant unit	
Thailand	PIS	PM	*Talauma* – Use (=) *Magnolia*	not given	25	Plant unit	
Thailand	PIS	PM	*Tamarindus indica*	1	0.5	kg	
Thailand	PIS	PM	*Tapeinochilos* sp.	1	0.1	kg	
Thailand	PIS	PM	*Thalia* sp.	1	4	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Thailand	PIS	PM	*Thevetia* sp.	1	6	Plant unit	
Thailand	PIS	PM	*Tonina* sp.	1	25	Plant unit	
Thailand	PIS	PM	*Trachycarpus* sp.	1	200	Plant unit	
Thailand	PIS	PM	*Tradescantia* sp.	1	10	Plant unit	
Thailand	PIS	PM	*Trapa* sp.	1	1	kg	
Thailand	PIS	PM	*Trapa* sp.	not given	8	Plant unit	
Thailand	PIS	PM	*Trichocoronis* sp.	2	60	Plant unit	
Thailand	PIS	PM	*Trichomanes* sp.	1	80	Plant unit	
Thailand	PIS	PM	*Tristellateia* sp.	1	3	Plant unit	
Thailand	PIS	PM	*Vallisneria* sp.	1	735	Plant unit	
Thailand	PIS	PM	*Vanda* sp.	31	19,067	Plant unit	
Thailand	PIS	PM	*Vanda* sp.	17	1,008	Flask	
Thailand	PIS	PM	*Vandachostylis* sp.	3	45	Plant unit	
Thailand	PIS	PM	*Vanilla* sp.	1	5	Plant unit	
Thailand	PIS	PM	*Vascostylis* sp.	1	65	Plant unit	
Thailand	PIS	PM	*Veitchia* sp.	3	78	Plant unit	
Thailand	PIS	PM	*Vesicularia* – Use *Moss – Bryophyta*	1	1	kg	
Thailand	PIS	PM	*Vigna* sp.	1	15	kg	
Thailand	PIS	PM	*Wallichia* sp.	4	386	Plant unit	Permit cargo: species of Psyllidae (arthropod); Baggage: species of Pseudococcidae (arthropod)
Thailand	PIS	PM	*Wodyetia bifurcata*	2	1.33	kg	
Thailand	PIS	PM	*Wrightia* sp.	5	637	Plant unit	
Thailand	PIS	PM	*Xanthosoma* sp.	1	5	Plant unit	
Thailand	PIS	PM	*Xiphidium* sp.	1	5	Plant unit	
Thailand	PIS	PM	*Zamia* sp.	1	2	Plant unit	
Thailand	PIS	PM	*Zamioculcas* sp.	1	2	Plant unit	
Thailand	PIS	PM	*Zamioculcas zamiifolia*	1	10	Plant unit	
Thailand	PIS	PM	*Zephyranthes* sp.	1	1	Plant unit	
Thailand	PIS	PM	*Zingiber* sp.	1	0.1	kg	
Thailand	PIS	PM	*Zingiber* sp.	11	173	Plant unit	
Thailand	PIS	PM	*Zygopetalum* sp.	10	569	Flask	
Thailand	USPS	PM	*Adenium* sp.	1	1	kg	
Thailand	USPS	PM	*Adenium* sp.	not given	600	Plant unit	
Thailand	USPS	PM	*Brassica* sp.	1	1	kg	
Thailand	USPS	PM	*Capsicum* sp.	2	4	kg	
Thailand	USPS	PM	*Citrullus* sp.	1	4	kg	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Thailand	USPS	PM	*Cucumis melo*	1	1	kg	
Thailand	USPS	PM	*Garcinia mangostana*	1	1	kg	
Thailand	USPS	PM	*Luffa* sp.	1	1	kg	
Thailand	USPS	PM	*Solanum* sp.	2	2	kg	
Tonga	Airport	CF	*Alyxia* sp.	84	9,543	Stems	Baggage: *Adoretus* sp. (arthropod), *Ceroplastes rubens* (arthropod), *Coccus* sp. (arthropod), *Elsinoe alyxiae* (pathogen), (arthropod), species of *Orchamoplatus mammaeferus* Diaspididae, species of Tortricidae
Tonga	Airport	FV	Dasheen	1	93	kg	
Tonga	Airport	FV	Kava	2	250	kg	
Tonga	Airport	FV	Yam	1	60	kg	
Tonga	Airport	PM	*Vanilla* sp.	1	208	kg	
Tonga	Maritime	FV	Yam	1	9,240	kg	
Tonga	PIS	PM	*Alocasia* sp.	1	13	Plant unit	
United Kingdom	PIS	PM	*Calochortus* sp.	1	0.001	kg	
United Kingdom	PIS	PM	*Cyclamen* sp.	1	0.001	kg	
United Kingdom	PIS	PM	*Lilium* sp.	1	0.025	kg	
United Kingdom	PIS	PM	*Rhodophiala* sp.	1	0.001	kg	
Vanuatu	Airport	FV	Kava	3	870	kg	
Viet Nam	PIS	PM	*Annona* sp.	1	50	Plant unit	Baggage: species of Pseudococcidae (arthropod on *A. cherimola*)
Viet Nam	PIS	PM	*Artocarpus heterophyllus*	1	25	Plant unit	
Viet Nam	PIS	PM	*Artocarpus* sp.	1	50	Plant unit	
Viet Nam	PIS	PM	*Chrysophyllum* sp.	1	50	Plant unit	
Viet Nam	PIS	PM	*Lansium domesticum*	1	50	Plant unit	

Origin	Pathway	Ctype[a]	Commodity	# of ship.[b]	Quantity	Units	Reportable Pests Intercepted[c]
Viet Nam	PIS	PM	*Lansium* sp.	1	40	Plant unit	
Viet Nam	PIS	PM	*Mangifera indica*	1	25	Plant unit	
Viet Nam	PIS	PM	*Mangifera* sp.	1	49	Plant unit	
Viet Nam	PIS	PM	*Nephelium lappaceum*	1	50	Plant unit	Baggage: *Araecerus* sp. (arthropod on *Nephelium* sp.), species of Pseudococcidae (arthropod)
Viet Nam	PIS	PM	*Psidium* sp.	1	53	Plant unit	Baggage: *Tetraleurodes* sp. (arthropod)
Viet Nam	PIS	PM	*Sandoricum* sp.	1	50	Plant unit	

Source: AQAS 2007

[a] CType: CF = cut flowers; FV = fruit or vegetable; PM = plant material

[b] # of ship. = total number of shipments regardless of weight or amount.

[c] Reportable pests intercepted are pests that were intercepted on plant hosts entering Hawai'i between 2004 and 2006 that match plant hosts that were imported into Hawai'i during those years. Only pests reported as being intercepted on permit or general cargo were affiliated with commodity imports. This is not a comprehensive list of reportable pests intercepted, e.g., pests intercepted only in baggage, ship's stores, quarters, or other situations are not included.

Table A25-2: Reportable Pests Intercepted on the Commodities Entering as Permit or General Cargo

Country	Commodity	Where Intercepted	Reportable Pest
Australia	*Rhopalobaste* sp.	Permit cargo	*Palmicultor browni* (arthropod)
	Pinus sp.	Permit cargo	species of Pseudococcidae (arthropod)
Fiji	*Colocasia esculenta*	Permit cargo	*Paraputo leveri* (arthropod), species of Pseudococcidae (arthropod)
		Baggage	species of Pseudococcidae (arthropod)
Malaysia	*Exocaria* sp.	Permit cargo	*Conchaspis* sp. (arthropod)
Thailand	Orchidaceae	Permit cargo	*Cladosporium* sp. (pathogen), *Succinea tenella* (mollusc), species of Lepidoptera (arthropod), species of Noctuidae (arthropod)
		General cargo	*Fromundus pygmaeus* (arthropod), *Spodoptera litura* (arthropod), *Succinea tenella* (mollusc)

Source: USDA 2007a

Note: The commodities were not listed in the PPQ280 database (possibly not entered into the database or listed under a different host name).

Table A25-3: Fresh Fruits and Vegetables, with Accompanying Pests, from the U.S. Mainland Entered Hawai'i during the Period January 1, 2004 to December 31, 2006

Commodity	Shipments (lbs) in 2004	Shipments (lbs) in 2005	Shipments (lbs) in 2006	Pests not known to occur in Hawai'i that were intercepted on shipments of the commodity[a]
Apple	8,792,614	10,383,099	10,147,479	Air baggage: *Aonidiella aurantii* (arthropod); Air cargo: *Schizothyrium pomi* (pathogen), *Venturia inaequalis* (pathogen)
Apricot	75,398	88,128	59,160	Air cargo: *Hemerobius* sp. (arthropod)
Artichoke	275,063	409,903	356,354	Air cargo: *Pamlaria cynarae* (pathogen)
Asparagus	1,324,432	1,273,647	1,515,540	Air cargo: *Delia* sp. (arthropod), *Harmonia axyridis* (arthropod - shipment originated in Mexico, but was shipped domestically from CA)
Avocado	1,297,942	1,549,132	1,696,165	Air cargo: Avocado scab disease
Banana				Air cargo: *Dysmicoccus* sp. nr. *bispinosus* (arthropod - three interceptions made on shipments originating in Ecuador, but shipped domestically from CA); Unspecified pathway: *D. texensis* (arthropod - three interceptions made on shipments originating from Ecuador or South/Central America, but shipped domestically).
Banana: Apple	36,495	41,058	31,013	
Banana: Cavendish	13,439,028	12,440,183	14,735,130	
Banana: Specialty	107,420	101,158	113,030	
Basil	2,397	3,995	4,560	Air cargo: *Liriomyza* sp. (arthropod), *Macrosteles* sp. (arthropod), *Alternaria* sp. (pathogen)
Beans: Green	443,039	514,908	489,938	
Beans: Long	24,145	28,085	29,236	
Beans: Specialty	23,705	35,628	137,131	Air baggage: *Cydia dehaisiana* (arthropod)
Berries: Other	566,858	594,764	667,049	
Bittermelon	57,695	129,544	90,890	Air cargo: *Alternaria* sp. (pathogen - origin was Mexico)
Broccoli	4,541,738	4,783,896	4,790,831	
Broccoli: Process	130	30,319	94,624	
Burdock	75,978	87,957	73,373	
Cabbage: Chinese	1,456,083	979,193	903,781	Air cargo: *Aceratagallia* sp. (arthropod), *Ceraphron* sp. (arthropod), *Lygus lineolaris* (arthropod), *Microtheca ochroloma* (arthropod), *Nysius raphanus* (arthropod)
Cabbage: Green	3,769,169	2,838,283	2,641,604	Air cargo: *Aceratagalia* sp. (arthropod), *Deroceras reticulatum* (arthropod)
Cabbage: Kai Choi	21,052	28,021	25,011	

Commodity	Shipments (lbs) in 2004	Shipments (lbs) in 2005	Shipments (lbs) in 2006	Pests not known to occur in Hawai'i that were intercepted on shipments of the commodity[a]
Cabbage: Other	62,588	74,232	74,403	Air cargo: *Aceratagallia californica* (arthropod), *Aceratagallia* sp. (arthropod), *Autographa californica* (arthropod), *Bactericera cockerelli* (arthropod), *Delia* sp. (arthropod), *Geocoris tristicolor* (arthropod), *Geocoris* sp. (Arthropod), *Hellula* sp. (arthropod), *Hemerobius* sp. (arthropod), *Lygus elisus* (arthropod), *Lygus lineolaris* (arthropod), *Lygus* sp. (arthropod), *Macrosteles* sp. (arthropod), *Microtheca orchrolama* (arthropod), *Nysius raphanus* (arthropod - at least one interception was on a shipment originating from Mexico but shipped domestically from CA), *Myzus ascalonicus* (arthropod), *Nysius* sp. (arthropod), *Schwenkfeldina* sp. (arthropod), *Spodoptera praefica* (arthropod), *Syrphus* sp. (arthropod), *Thaumatomyia* sp. (arthropod); Pathway unspecified: *Agrotis subteraneae* (arthropod), *Chrysopius* sp. (arthropod)
Cabbage: Pak Choi	103,527	110,268	129,232	
Cabbage: Process	52,245	58,174	36,425	
Cabbage: Red	243,036	236,853	237,610	Air cargo: *Aceratagallia* sp. (arthropod), *Syrphus* sp. (arthropod)
Caimito	0	140	570	
Carrot	8,675,563	9,530,519	9,584,213	
Cauliflower	864,086	688,424	741,177	
Celery	4,305,277	4,182,800	4,636,244	Air cargo: *Diabrotica balteata* (arthropod), *Hemerobius* sp. (arthropod - shipment originated from Mexico but shipped domestically from CA), *Lygus elisus* (arthropod - shipment originated from Mexico but shipped domestically from CA), *Nysius raphanus* (arthropod), *Nysius* sp. (arthropod); Ship cargo: *Delia* sp. (arthropod)
Cherimoya	10,587	3,497	32,427	
Cherry	1,011,305	1,162,220	1,621,675	
Chestnut	48,228	72,141	47,050	
Citrus: Other	63,374	65,681	44,278	Air cargo: *Aonidiella aurantii* (arthropod), *Marmara gulosa* (arthropod); Ship cargo: *Marmara gulosa* (arthropod)
Corn: Sweet	1,208,968	1,015,046	615,948	Air cargo: *Puccinia polygoni* (pathogen); Air baggage: *Melanaphis sorghi* (arthropod); Pathway unspecified: *Rhopalosiphum padi* (arthropod - Mexico origin)
Cucumber	521,340	890,103	663,745	
Cucumber: English	142,690	143,426	146,922	
Cucumber: Japanese	27,444	22,663	20,707	
Daikon: General				Air cargo: *Fusarium* sp. (pathogen)
Daikon: Chinese	2,750	1,500	870	
Daikon: Japanese	600	30	300	

Commodity	Shipments (lbs) in 2004	Shipments (lbs) in 2005	Shipments (lbs) in 2006	Pests not known to occur in Hawai'i that were intercepted on shipments of the commodity[a]
Daikon: Korean	0	849,923	4,639	
Daikon: Process	0	16,525	0	
Dasheen	71,672	52,915	83,755	
Durian	6,000	0	0	
Eggplant: General				Air cargo: *Lygus elisius* (arthropod)
Eggplant: Long	314,163	568,246	500,894	
Eggplant: Round	225,932	240,185	174,883	
Endive/Escarole	147,182	178,317	159,623	Air cargo: *Aceratagallia* sp. (arthropod), *Delia radicum* (arthropod), *Lygus hesperus* (arthropod), *Lygus linedaris* (arthropod), *Macrosteles* sp. (arthropod), *Microtheca ochroloma* (arthropod), *Nysius raphanus* (arthropod), *Nysius* sp. (arthropod); Ship cargo: *Geocoris* sp. (arthropod), *Macrosteles* sp. (arthropod), *Nysius raphanus* (arthropod), *Nysius* sp. (arthropod); Pathway unspecified: *Hemerobius* sp. (arthropod)
Fruit: Other	163,323	147,340	77,064	
Fruit: Tropical	134,908	131,895	130,336	
Garlic	1,004,340	1,262,456	1,416,686	
Ginger root	278,049	109,051	49,133	
Grape	6,925,406	8,108,539	7,808,816	Air cargo: *Planococcus ficus* (arthropod)
Grapefruit	1,382,696	1,184,107	1,236,088	Air cargo: *Marmara gulosa* (arthropod); Ship cargo: *Aonidiella aurantii* (arthropod); Air baggage: *Aonidiella aurantii* (arthropod)
Greens: Oriental	201,051	138,154	168,729	
Greens: Other	308,046	389,958	393,366	Air cargo: *Autographa californica* (arthropod), *Acrosternum hilare* (arthropod), *Bactericera cockerelli* (arthropod), *Cameraria gaultheriella* (arthropod), *Delia* sp. (arthropod), *Lygus lineolaris* (arthropod), *Myzus ascalonicus* (arthropod), *Nysius raphanus* (arthropod), *Nysius* sp. (arthropod), *Syrphus* sp. (arthropod); Ship cargo: *Bactericera cockerelli* (arthropod), *Nysius raphanus* (arthropod); Federal Express: *Cameraria gaultheriella*; Pathway unspecified: *Autographa californica* (arthropod)
Guava: Process	130	0	100	
Herbs and Spices	65,076	79,101	81,299	Air cargo: *Aphis menthaeradicis* (arthropod), *Erisiphe* sp. (pathogen), *Limax marginatus* (mollusc), *Oidium* sp. (pathogen), *Orthosia hibisci* (arthropod), *Peronospora lamii* (pathogen), *Puccinia* sp. (pathogen), *Succinea* sp. (mollusc)
Kiwi	366,239	463,156	619,042	
Leek	119,864	158,660	176,493	Air cargo: *Empoasca* sp. (arthropod)

Commodity	Shipments (lbs) in 2004	Shipments (lbs) in 2005	Shipments (lbs) in 2006	Pests not known to occur in Hawai'i that were intercepted on shipments of the commodity[a]
Lemon	2,930,645	3,122,685	3,063,077	Air cargo: *Aonidiella aurantii* (arthropod); Air baggage: *Aonidiella aurantii* (arthropod), *Marmara gulosa* (arthropod); Ship cargo: *Aonidiella aurantii* (arthropod); Pathway unspecified: *Lygus* sp. (arthropod)
Lettuce: Head	7,299,718	6,431,618	6,526,409	
Lettuce: Manoa	0	120	0	
Lettuce: Other	178,761	145,171	152,590	Air cargo: *Acalymna vittatus* (arthropod), *Aceratagallia californica* (arthropod), *Aceratagallia* sp. (arthropod), *Acyrthosiphon lactucae* (arthropod), *Acyrthosiphon euphorbiae* (arthropod), *Aeolothrips* sp. (arthropod), *Aphis* sp. (arthropod), *Autographa californica* (arthropod), *Bactericera cockerelli* (arthropod), *Berytinus* sp. (arthropod), *Centorhynchus* sp. (arthropod), *Ceroxys latusculus* (arthropod), *Chlorochroa sayi* (arthropod), *Chrysopa* sp. (arthropod), *Delia* sp. (arthropod), *Deltocephalinus* sp. (arthropod), *Empoasca* sp. (arthropod), *Erythroneura* sp. (arthropod), *Evania* sp. (arthropod), *Frankliniella aztecus* (arthropod), *Geocoris tristicolor* (arthropod), *Geocoris* sp. (arthropod), *Hemerobius* sp. (arthropod), *Lestremia* sp. (arthropod), *Lordithon* sp. (arthropod), *Lygus elisus* (arthropod), *Lygus hesperas* (arthropod), *Lygus lineolaris* (arthropod), *Macrosiphum* sp. (arthropod), *Macrosteles* sp. (arthropod), *Microdochium panattonianum* (pathogen), *Misumenops* sp. (arthropod), *Nabis* sp. (arthropod), *Notoxus* sp. (arthropod)
Lettuce: Processed	6,046,469	5,673,346	6,633,087	
Lettuce: Red/Green	2,261,322	2,076,540	2,420,695	
Lettuce: Specialty	638,825	557,108	548,530	
Lime	957,652	1,101,241	1,137,461	Air cargo: *Aonidiella aurantii* (arthropod), *Marmara gulosa* (arthropod - shipment originated from Mexico but shipped domestically from CA); Pathway unspecified: *Nysius raphanus* (arthropod - shipment originated from Mexico but shipped domestically from CA)
Longan	8,755	732	0	
Lotus root	48,449	53,230	64,133	
Luau leaf	0	0	869	
Lychee	89,788	23,326	95,680	
Mandarin	287,036	600,645	389,938	
Mango	994,361	1,445,970	1,469,309	Air cargo: *Aonidiella aurantii* (arthropod), *Aulacaspis tubercularis* (arthropod), *Greenidea mangiferae* (arthropod), *Pseudocaecilius* sp. (arthropod); Ship cargo: *Aonidiella aurantii* (arthropod); Pathway unspecified: *Phoma* sp. (pathogen)
Melon: Cantaloupe	4,985,144	6,181,700	6,215,944	
Melon: Honeydew	2,096,839	1,937,565	2,855,238	

Commodity	Shipments (lbs) in 2004	Shipments (lbs) in 2005	Shipments (lbs) in 2006	Pests not known to occur in Hawai'i that were intercepted on shipments of the commodity[a]
Melon: Other	217,454	240,677	288,213	
Melon: Seedless Watermelon	1,532,397	1,800,206	2,405,572	
Melon: Watermelon	492,751	991,806	1,162,053	
Mushroom	0	2,398	3,217	
Mushroom: Button	2,533,675	2,719,336	2,340,266	
Mushroom: Special	414,608	444,685	423,881	
Nectarine	1,956,454	1,698,358	1,658,572	
Ong Choi	11,265	60	80	
Onion				Pathway unspecified: *Nysius raphanus* (arthropod)
Onion: Dry	13,133,405	16,156,408	15,378,400	
Onion: Green	320,493	204,969	264,866	Air cargo: *Lestremia* sp. (arthropod), *Lygaeus kalmii* (arthropod)
Onion: Specialty	106,857	101,815	126,195	
Orange	11,695,682	13,442,511	12,550,205	Air cargo: *Aonidiella aurantii* (arthropod), *Chrysomphalus* sp. (arthropod), *Marmara gulosa* (arthropod); Ship cargo: *Aonidiella aurantii* (arthropod), *Marmara gulosa* (arthropod); Pathway unspecified: *Liriomyza* sp. (arthropod)
Papaya	3,394	11,406	5,602	Air cargo: Papaya ring spot virus (pathogen - shipment originated from Mexico)
Papaya: Processed	0	120	0	
Parsley				Air cargo: *Aceratagallia* sp. (arthropod), *Aelothrips* sp. (arthropod), *Alternaria petroselini* (pathogen), *Alternaria radicina* (pathogen), *Delia* sp. (arthropod), *Chlorochroa ligata* (arthropod), *Dyaphis apiifolia* (arthropod), *Hemerobius* sp. (arthropod), *Hyadaphis foeniculi* (arthropod), *Macrosteles* sp. (arthropod), *Melagromyza* sp. (arthropod), *Microtheca ochroloma* (arthropod), *Nysius raphanus* (arthropod), *Puccinia nitida* (pathogen), *Syrphus* sp. (arthropod)
Parsley: American	99,839	105,390	119,279	Air cargo: *Macrosteles* sp. (arthropod), *Zelus* sp. (arthropod)
Parsley: Chinese	59,330	68,375	103,488	
Passion fruit: Processed	123	0	40	
Pea: General				Air cargo: *Mayetiola* sp. (arthropod), *Nysius raphanus* (arthropod)
Pea: Chinese	214,084	216,481	210,460	
Pea: Sugar Snap	87,603	89,526	73,022	Air cargo: *Liriomyza* sp.
Peach	1,827,057	1,686,005	2,063,540	
Peanut	86,725	127,350	116,530	

Commodity	Shipments (lbs) in 2004	Shipments (lbs) in 2005	Shipments (lbs) in 2006	Pests not known to occur in Hawai'i that were intercepted on shipments of the commodity[a]
Pear	2,915,837	2,129,155	2,503,812	
Pepper: General				Air cargo: *Alternaria* sp. (pathogen), *Aulacorthum magnoliae* (arthropod), *Bactericera cockerelli* (arthropod), *Chiposia* sp. (arthropod), *Geocoris tristicolor* (arthropod), *Hemerobius* sp. (arthropod), *Hyperaspis* sp. (arthropod), *Liriomyza* sp. (arthropod - some shipments originated from Mexico but were shipped domestically through CA), *Lygus* sp. (arthropod), *Macrosletes* sp., *Microtheca ochroloma* (arthropod), *Nysius* sp. (arthropod), *Orius* sp. (arthropod), *Rhizoecus* sp. (arthropod), *Theridia murarium* (arthropod); Pathway unspecified: *Syrphus* sp.
Pepper: Hot	263,828	317,462	309,365	
Pepper: Sweet	1,747,046	2,091,414	2,353,883	
Persimmon	912,205	945,292	907,279	
Pineapple	160	0	380	
Plum	1,114,106	1,211,558	1,101,644	
Potato: Chipper	12,349,486	13,750,828	13,168,455	
Potato: Seed	0	0	300	
Potato: Table	17,956,886	20,308,283	20,811,710	
Pumpkin	592,457	256,650	142,973	
Radish	10,378	9,315	5,274	
Rambutan	250	0	0	
Romaine	7,106,544	7,922,485	7,792,587	See lettuce above
Roots: Other	215,542	289,556	328,136	
Soybean	564	2,001	4,301	
Spinach				Air cargo: *Aceratagallia* sp. (arthropod), *Alternaria* sp. (pathogen), *Cladosporium macrocarpum* (pathogen), *Empoasca* sp. (arthropod), *Geocoris* sp. (arthropod), *Lygus* sp. (arthropod), *Nysius raphanus* (arthropod)
Spinach: American	1,620,028	1,628,187	1,168,269	
Spinach: Chinese	1,640	60	400	
Sprouts	10,520	4,351	6,581	
Squash				Air cargo: *Acalymma vittatum* (arthropod)
Squash: Hechima	10,485	33,515	39,453	
Squash: Hyotan	42,056	96,255	44,745	
Squash: Italian	896,255	991,640	1,339,726	
Squash: Kabocha	265,916	368,056	308,038	
Squash: Other	837,945	908,791	946,499	

Commodity	Shipments (lbs) in 2004	Shipments (lbs) in 2005	Shipments (lbs) in 2006	Pests not known to occur in Hawai'i that were intercepted on shipments of the commodity[a]
Squash: Togan	180	2,918	35,090	
Starfruit	12,566	17,841	25,167	
Strawberry	2,573,679	3,617,952	3,523,209	Air cargo: *Acyrthosiphon lactucae* (arthropod), *Acyrthosiphon rogersii* (arthropod), *Aphis ruborum* (arthropod), *Chaetosiphon fragaefolii* (arthropod), *Chaetosiphon jacobi* (arthropod), *Chaetosiphon minor* (arthropod), *Chaetosiphon thomasi* (arthropod), *Chaetosiphon* sp. (arthropod), *Myzus ascalonicus* (arthropod), *Nysius raphanus* (arthropod), *Nysius* sp. (arthropod), *Syrphus* sp. (arthropod)
Sweet potato	1,064,294	1,052,929	1,200,585	Air cargo: *Ferrisia* sp. (arthropod), *Nysius raphanus* (arthropod), *Pseudococcus* sp. (arthropod)
Tangelo	93,083	73,166	85,182	
Tangerine	843,470	1,175,719	1,763,891	Air cargo: *Aonidiella aurantii* (arthropod), *Marmara gulosa* (arthropod); Air baggage: *Aonidiella aurantii* (arthropod)
Taro	823,921	554,745	476,272	
Taro: Chipper	160,696	137,061	466,929	
Taro: Process	360	585	44,788	
Tomato	2,957,402	4,894,736	4,267,350	Air cargo: *Nysius raphanus* (arthropod)
Tomato: Other	479,869	512,402	525,118	
Tomato: Plum	345,340	749,937	701,116	
Unavailable	0	850	7,445	
Unspecified	21,490,025	18,904,928	24,042,505	
Vegetables: Other	196,925	469,366	473,660	Air cargo: *Nysius raphanus* (arthropod)
Vegetables: Processed	270,423	308,570	174,904	
Watercress	33,060	30,319	43,896	Air cargo: *Aleratagallia* sp. (arthropod), *Delia* sp. (arthropod), *Empoasca* sp. (arthropod), *Euschistus tristigmus* (arthropod), *Lygus* sp. (arthropod), *Macrosteles* sp. (arthropod), *Microtheca ochroloma* (arthropod), *Microtheca* sp. (arthropod), *Myzus ascalonicus* (arthropod), *Myzus* sp. (arthropod), *Nysius raphanus* (arthropod), *Nysius* sp. (arthropod), *Physella herterostropha* (arthropod), *Physella* sp. (arthropod), *Succinea* sp. (mollusc), *Syrphus* sp. (arthropod)
Yam bean root	63,760	64,595	84,808	

Sources for produce shipments and intercepted pests: Vierra 2007 and HDOA 2007c, respectively. Data for exact origins of the commodites are not available.

[a] Limited verification of pest status in Hawai'i was conducted using online databases, such as the Bishop Museum's Hawai'i Biological Survey Databases and the Crop Protection Compendium (CABI 2006), and scientific literature.

Table A25-4: Reportable Pests Intercepted for Hawai'i in Aircraft Cargo Holds and Cabins between January 1, 1990 and June 16, 2007

Reportable Pest[a]	Number Intercepted
Acrididae, species of	6
Acroleucus vicinalis (Lygaeidae)	1
Acrolophidae, species of	1
Adoretus sinicus (Scarabaeidae)	1
Aeolus nigromaculatus (Elateridae)	1
Agrius sp. (Sphingidae)	1
Agromyzidae, species of	1
Agrotis sp. (Noctuidae)	1
Aleyrodidae, species of	1
Allonemobius sp. (Gryllidae)	1
Altica sp. (Chrysomelidae)	1
Alticinae, species of (Chrysomelidae)	2
Amphimallon solstitialis (Scarabaeidae)	1
Amphimallon sp. (Scarabaeidae)	1
Anastrepha sp. (Tephritidae)	2
Anaxipha sp. (Gryllidae)	6
Ancognatha scarabaeoides (Scarabaeidae)	6
Ancognatha sp. (Scarabaeidae)	49
Ancognatha ustulata (Scarabaeidae)	9
Anomala sp. (Scarabaeidae)	21
Aphididae, species of	2
Apioninae, species of (Curculionidae)	3
Archophileurus sp. (Scarabaeidae)	1
Arcte coerula (Noctuidae)	1
Arctiidae, species of	15
Athlia rustica (Scarabaeidae)	1
Atractomorpha sp. (Pyrgomorphidae)	1
Atta sexdens (Formicidae)	3
Atta sp. (Formicidae)	6
Aulacaspis tubercularis (Diaspididae)	1
Aulacophora indica (Chrysomelidae)	1
Aulacophora nigripennis (Chrysomelidae)	1
Banasa sp. (Pentatomidae)	1
Barybas sp. (Scarabaeidae)	1
Berecynthus hastator (Pentatomidae)	1
Blapstinus sp. (Tenebrionidae)	7
Blissus sp. (Blissidae)	1

Reportable Pest[a]	Number Intercepted
Blitopertha sp. (Scarabaeidae)	1
Bostrichidae, species of	3
Calligrapha sp. (Chrysomelidae)	1
Callopistria sp. (Noctuidae)	1
Cassidinae, species of (Chrysomelidae)	1
Caulopsis microprora (Tettigoniidae)	1
Caulopsis sp. (Tettigoniidae)	1
Cerambycidae, species of	4
Ceraspis centralis (Scarabaeidae)	1
Ceratitis capitata (Tephritidae)	1
Cercopidae, species of	1
Chlorotettix sp. (Cicadellidae)	3
Chrysomelidae, species of	6
Cicadellidae, species of	14
Cicadidae, species of	2
Cixiidae, species of	3
Cleogonus sp. (Curculionidae)	1
Colaspis sp. (Chrysomelidae)	9
Conocephalus saltator (Tettigoniidae)	1
Conocephalus sp. (Tettigoniidae)	11
Conoderus pictus (Elateridae)	2
Conoderus sp. (Elateridae)	3
Conotrachelus sp. (Curculionidae)	3
Cornu aspersum (Helicidae)	1
Crambidae, species of	3
Crambinae, species of (Crambidae)	1
Ctenuchidae, species of	3
Curculionidae, species of	12
Cyclocephala mafaffa (Scarabaeidae)	1
Cyclocephala sp. (Scarabaeidae)	28
Cydnidae, species of	14
*Dallasiellus bacchinu*s (Cydnidae)	6
Delphacidae, species of	6
Deltocephalinae, species of (Cicadellidae)	1
Dichromorpha sp. (Acrididae)	1
Diplotaxis sp. (Scarabaeidae)	8
Draeculacephala clypeata (Cicadellidae)	1
Dynastinae, species of	16

Reportable Pest[a]	Number Intercepted
(Scarabaeidae)	
Dyscinetus sp. (Scarabaeidae)	1
Earias insulana (Noctuidae)	1
Ecpantheria sp. (Arctiidae)	1
Elateridae, species of	6
Endotricha sp. (Pyralidae)	1
Eneopterinae, species of (Gryllidae)	1
Epitragus sp. (Tenebrionidae)	3
Epitrix sp. (Chrysomelidae)	1
*Erinnyi*s sp. (Sphingidae)	1
Euconocephalus sp. (Tettigoniidae)	2
Euetheola sp. (Scarabaeidae)	4
Eulepidotis guttata (Noctuidae)	3
Eumolpinae, species of (Chrysomelidae)	2
Euphoria sp. (Scarabaeidae)	4
Eurychilella sp. (Miridae)	1
Euschistus sp. (Pentatomidae)	2
Exitianus sp. (Cicadellidae)	1
Exophthalmus sp. (Curculionidae)	1
Flatidae, species of	1
Formicidae, species of	1
Galerucinae, species of (Chrysomelidae)	4
Gelechiidae, species of	16
Geniates sp. (Scarabaeidae)	3
Geometridae, species of	7
Gonodonta sp. (Noctuidae)	3
Gryllidae, species of	4
Gryllinae, species of (Gryllidae)	1
Gryllodes sp. (Gryllidae)	1
Gryllotalpa sp. (Gryllotalpidae)	2
Gryllus capitatus (Gryllidae)	1
Gryllus sp. (Gryllidae)	85
Herminiinae, species of (Noctuidae)	1
Herpetogramma sp. (Crambidae)	1
Horistonotus sp. (Elateridae)	1
Lagriinae, species of (Tenebrionidae)	1
Lepidoptera, species of	9
Leucania inconspicua (Noctuidae)	1
Leucothyreus sp. (Scarabaeidae)	2
Ligyrus sp. (Scarabaeidae)	9
Limacodidae, species of	1
Liogenys macropelma (Scarabaeidae)	2
Liogenys quadridens (Scarabaeidae)	1
Liogenys sp. (Scarabaeidae)	6
Lycaenidae, species of	1
Lygaeidae, species of	9
Macropygium sp. (Pentatomidae)	1
Malacorhinus irregularis (Chrysomelidae)	1
Maladera sp. (Scarabaeidae)	1
Manopus sp. (Scarabaeidae)	3
Melanaethus spinolai (Cydnidae)	2
Melipotis sp. (Noctuidae)	3
Meloidae, species of	1
Melolontha sp. (Scarabaeidae)	1
Melolonthinae, species of (Scarabaeidae)	13
Membracidae, species of	2
Messor sp. (Formicidae)	1
Metaleptea brevicornis (Acrididae)	1
Metamasius hemipterus (Dryophthoridae)	2
Miogryllus convolutus (Gryllidae)	1
Miridae, species of	11
Myrmicinae, species of (Formicidae)	6
Neochetina eichhorniae (Erirhinidae)	1
Neoconocephalus punctipes (Tettigoniidae)	3
Neoconocephalus sp. (Tettigoniidae)	28
Noctuidae, species of	236
Nymphalidae, species of	1
Nysius sp. (Lygaeidae)	5
Oecophoridae, species of	1
Olethreutinae, species of (Tortricidae)	1
Oncometopia sp. (Cicadellidae)	1
Orphulella punctata (Acrididae)	1
Orthoptera, species of	1
Palpita sp. (Crambidae)	1
Paragonatas divergens (Rhyparochromidae)	1
Pareuchaetes insulata (Arctiidae)	1
Parlatoria ziziphi (Diaspididae)	2
Pentatomidae, species of	9
Phaneroptera furcifera (Tettigoniidae)	1
Pheidole sp. (Formicidae)	1
Phelypera distigma (Curculionidae)	1
Phyllobius sp. (Curculionidae)	1
Phyllophaga sp. (Scarabaeidae)	105
Physonota attenuata (Chrysomelidae)	1

Reportable Pest[a]	Number Intercepted
Physonota sp. (Chrysomelidae)	1
Pintalia sp. (Cixiidae)	2
Plautia stali (Pentatomidae)	1
Plectris sp. (Scarabaeidae)	14
Plusiinae, species of (Noctuidae)	1
Pococera sp. (Pyralidae)	1
Prepops latipennis (Miridae)	1
Prosapia sp. (Cercopidae)	1
Protaetia orientalis (Scarabaeidae)	1
Psylla sp. (Psyllidae)	1
Pteronemobius sp. (Gryllidae)	1
Pycnoderes sp. (Miridae)	1
Pyralidae, species of	83
Pyraustinae, species of (Crambidae)	1
Pyrgocorypha sp. (Tettigoniidae)	1
Pyrrhocoridae, species of	2
Rhabdopterus sp. (Chrysomelidae)	1
Rhopalidae, species of	2
Rhynchophorinae, species of (Curculionidae)	2
Rhyparochromidae, species of	5
Rutelinae, species of (Scarabaeidae)	3
Samea ecclesialis (Crambidae)	1
Saturniidae, species of	1
Scarabaeidae, species of	6
Solenopsis sp. (Formicidae)	1
Sphingidae, species of	29
Sphingonotus sp. (Acrididae)	1
Spodoptera cosmioides (Noctuidae)	1
Spodoptera sp. (Noctuidae)	3
Stenacris vitreipennis (Acrididae)	1
Strategus sp. (Scarabaeidae)	1
Systena s-littera (Chrysomelidae)	1
Tenebrionidae, species of	2
Tetrigidae, species of	1
Tettigoniidae, species of	6
Texananus sp. (Cicadellidae)	1
Tineidae, species of	4
Tomarus sp. (Scarabaeidae)	15
Trachea atriplicis (Noctuidae)	1
Typhlocybinae, species of (Cicadellidae)	1
Typophorus sp. (Chrysomelidae)	1
Grand Total	1,205

Source: USDA 2007a

[a] Records exclude pest interceptions made on military aircraft and those for which discrepancies in the data are suspected (i.e., in cases in which it is questionable that the pest was actually intercepted in an aircraft cargo hold or cabin).