Movement of *Moringa oleifera* Pods from Hawaii into the Continental United States

A Qualitative Pathway-Initiated Risk Assessment

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Executive Summary
This document assesses the risks associated with the movement of fresh pods of *Moringa* species (particularly *Moringa oleifera*) from Hawaii into the continental United States. A search of print and electronic sources identified seven (7) pests of quarantine significance that exist in Hawaii and could be introduced into the continental United States in shipments of fresh *Moringa* pods.

Quarantine-significant pests likely to follow the pathway:

Aleurodicus dispersus Russell (Hemiptera: Aleyrodidae)
Aonidiella inornata (McKenzie) (Hemiptera: Diaspididae)
Bactrocera cucurbitae (Coquillett) (Diptera: Tephritidae)
Bactrocera dorsalis (Hendel) (Diptera: Tephritidae)
Ceratitis capitata (Wiedemann) (Diptera: Tephritidae)
Coccus viridis (Green) (Hemiptera: Pseudococcidae)
Pseudococcus cryptus Hempel (Hemiptera: Pseudococcidae)

The quarantine pests were analyzed based on international principles and internal guidelines as described in the PPQ Guidelines for Pathway-Initiated Pest Risk Assessments, Version 5.02 (USDA, 2002). This document examines pest biology in the context of the Consequences and Likelihood of Introduction. The pests likely to follow the pathway pose phytosanitary risks to U.S. agriculture. *Bactrocera cucurbitae*, *B. dorsalis*, and *Ceratitis capitata* received a High Pest Risk Potential. *Aleurodicus dispersus*, *Aonidiella inornata*, *Coccus viridis*, and *Pseudococcus cryptus* received a Pest Risk Potential of Medium. Port-of-entry inspection, as a sole mitigative measure, is insufficient to safeguard U.S. agriculture from these pests; additional phytosanitary measures are necessary to reduce risk.

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I. Introduction

The Animal and Plant Health Inspection Service (APHIS) of the United States Department of Agriculture (USDA) prepared this risk assessment to examine plant pest risks associated with the movement of fresh *Moringa* (malong-gay, horse-radish tree, ben tree) pods from Hawaii into the continental United States.

This qualitative pest risk assessment estimates risk in the qualitative terms of "High," "Medium" and "Low" rather than probabilities or frequencies. The details of the methodology and rating criteria can be found in the document: *Pathway-Initiated Pest Risk Assessment: Guidelines for Qualitative Assessments, Version 5.02* (USDA, 2002).

International plant protection organizations, such as the North American Plant Protection Organization (NAPPO) and the International Plant Protection Convention (IPPC) of the United Nations Food and Agriculture Organization (FAO), provide guidance for conducting pest risk analyses. The methods used for initiating, conducting and reporting information in this pest risk assessment are consistent with these guidelines. Biological and phytosanitary terms are taken from the NAPPO Glossary of Phytosanitary Terms (Anonymous, 1999) and the Definitions and Abbreviations (Introduction Section) in International standards for Phytosanitary Measures, Import Regulations: Guidelines for Pest Risk Analysis (IPPC, 1996) and the Glossary of Phytosanitary Terms (IPPC, 2004).

II. Risk Assessment

Pest risk assessment is a component of the overall pest risk analysis. The Guidelines for Pest Risk Analysis (IPPC, 1996) describe three stages in pest risk analysis. This document satisfies the requirements of FAO Stages 1, Initiation, and 2, Risk Assessment, by separately considering each area of inquiry.

2.1 Initiating Event

This pest risk assessment is commodity-based or "pathway-initiated" because the USDA was requested by the Hawaii Department of Agriculture authorization for the movement of fresh *Moringa* pods (fruit) from Hawaii into the continental United States. This is a potential pathway for the introduction of plant pests on the fruit. The authority to regulate fruit and vegetable movement is codified at 7 C.F.R. § 318.13. At this time, Hawaii has not provided any information concerning how Moringa is cultivated and harvested, or what types of basic post-harvest processes are in place. Consequently, this risk assessment assumes that processing is limited to the visual culling of damaged and diseased fruit at the time of harvest.

Initially, the request for this risk assessment was for *Moringa oleifera*, the most widely cultivated species in the genus; however, this risk assessment was conducted at the genus level because the name "Moringa" is a common name for *M. oleifera*, and the scientific name for the entire genus. (Thus, pest literature references may be referring to either one or both.) Secondly, *M. oleifera* is not the only species in the genus cultivated; *M. stenopetala* is also cultivated and present in Hawaii (Olson, 1999). One internet reference indicated that *M. stenopetala* had some better qualities and, perhaps, should be commercially cultivated (Price, 1985). Other species of Moringa demonstrate potential utility as well (Palada, 1996); therefore, to avoid nomenclature ambiguity, and to maximize the potential use of this document, this risk assessment was conducted at the genus level. The following compiled pest list presented includes pests and pathogens of Moringa. Expanding this pest risk assessment to include the entire genus added a dozen or so additional pests. *Moringa oleifera* is the most widely cultivated species, as compared to other species that are only locally cultivated in Africa (Olson, 1999).

2.2 Assessment of the Weediness of *Moringa oleifera*

Moringa is the only genus in the family Moringaceae. The genus is composed of 13 species distributed from eastern Africa to India, and include *M. arborea*, *M. borziana*, *M. concanensis*, *M. drouhardii*, *M. hildebrandtii*, *M. longtituba*, *M. oleifera*, *M. ovalifolia*, *M. peregrine*, *M. pygmaea*, *M. stenopetala*, *M. rivae*, and *M. ruspoliana* (Olson, 1999). The most widely known and cultivated species is *M. oleifera*. This genus accommodates the following uses: its leaves are used as a vegetable or salad green; the pods as a vegetable similar to green beans; the roots as a condiment like horseradish; and the seeds for cooking oils and lubricant. Fruit pods can grow up to 1.2 meters in length, depending on the variety (Olson, 1999; Palada, 1996).

One of the first steps in a commodity risk assessment is the assessment of the weediness potential of the commodity following the USDA's 5.02 Guidelines (USDA, 2002). Table 1 depicts the weediness potential of *M. oleifera*. The other *Moringa* species were also assessed, but were not presented because there was no strong indication that any of them would become invasive in the United States. One reference did list *M. stenopetala* and *M. peregrine* as a weed (Randall, 2006); however, a single reference is insufficient evidence to determine invasiveness for these two species.

Table 1. Assessment of the weediness potential of *Moringa oleifera* (Moringaceae).

	Common Names: Moringa, ben-oil-tree, drumstick, horseradish-tree, benzolive-tree (USDA-ARS, 2006)
	Synonyms: *Moringa pterygosperma*, *M. aptera* (Olson, 1999)
Phase 1:	Distribution in the USA: *Moringa oleifera* is native to the foothills of the Himalayas in India, but is now widely cultivated in India, Asia, east Africa, and other areas of the world (Olson, 1999). It has been introduced to California and Florida where, perhaps, it is locally cultivated (Palada, 1996); however, in Hawaii, it is commercially cultivated.
Phase 2:	Invasive / Weed Status: Listing as weed
No	(Holm *et al.*, 1977; Reed, 1977; Gunn and Ritchie, 1982; Holm *et al.*, 1991; Holm *et al.*, 1997; Weber, 2003; Skinner *et al.*, 2005; Swearingen, 2005; WSSA, 2005; 7 CFR § 360, January 1, 2005).
Yes	A Global Compendium of Weeds (Randall, 2006)
Yes	Other scientific literature. (ECOPORT, 2006; IRC, 2006; Liogier & Martorell, 2000; Palada, 1996)
Phase 3:	Summary and Conclusions:
	Colonizing after cultivation, *M. oleifera* is considered a weed by several sources (see above). It has naturalized in southern Florida and Puerto Rico (IRC, 2006; Liogier & Martorell, 2000). *Moringa oleifera* quickly grows and reproduces from seeds and cuttings (Palada, 1996). Its growth rate has been described as being second to *Leucanea* (Palada, 1996), which is a highly invasive tropical and subtropical legume. Despite these references, there is no indication that it is a significant weed, capable of reducing biodiversity, and transforming ecosystems, as some invasive plants do. Furthermore, because it has already been introduced into the continental United States, where it is under cultivation (Palada, 1996), and is not being officially controlled, *M. oleifera* does not meet the definition of a quarantine pest (IPPC, 2004); as a result, it is recommended that the PRA process for the importation of fresh *Moringa* fruit continue.
	Conclusion: Proceed with the pest risk assessment.

2.3 Previous Risk Assessments, Decision History, and Pest Interceptions

There is one previous risk assessment for *Moringa oleifera* from Hawaii completed by the Hawaiian Department of Agriculture in October 1999 (on file with CPHST-PERAL, Raleigh, NC).

In 1998, the entry of *M. oleifera* (fruit) was denied from Mexico because of interceptions of *Anastrepha* larvae on *Moringa* pods; no literature is available for which species of *Anastrepha* were associated with *Moringa.*

In 1993, the entry of *M. oleifera* (fruit) was denied from India because of lack of approved treatments for *Stictodiplosis moringae* and *Noorda moringae.*

In 1993, the entry of *M. oleifera* (leaves, stems, and fruit) was denied from Puerto Rico because of lack of approved treatment for *Anastrepha* spp.

In 1992, the entry of *M. oleifera* (leaves, stems, and fruit) was denied from Jamaica because of lack of approved treatment for *Anastrepha* spp.

In 1992, the entry of *M. oleifera* (fruit) was denied from the Dominican Republic because of lack of approved treatment for *Anastrepha* spp.

In 1992, the entry of *M. oleifera* (leaves) was approved from Hawaii with inspection.

In 1992, the entry of *M. oleifera* (leaves, stems, and fruit) was denied from Mexico because of lack of FIFRA Section 18 exemption for *Anastrepha* spp.

In 1990, the entry of *M. oleifera* (leaves) was approved from Cook Island with inspection.

In 1988, the entry of *M. oleifera* (leaves and fruit) was approved from Fiji with inspection.

In 1988, the entry of *M. oleifera* (fruit) was denied from Guatemala because of lack of pest data and possible fruit fly host.

Table 2. Pests intercepted on *Moringa* at U.S. ports between 1985 and 2005 (PIN 309, 2005)

Pest	Fruit	Leaf	Stem	Other	Total
Acari, species of		1			1
Achilidae, species of (Achilidae)				1	1
Adoretus sinicus Burmeister (Scarabaeidae)		63	8		71
Agromyzidae, species of (Agromyzidae)	2	506	8	1	517
Aleurodicinae, species of (Aleyrodidae)		1			1
Aleurodicus dispersus Russell (Aleyrodidae)	1	141	2	1	145
Aleurodicus sp. (Aleyrodidae)	1	3			4
Aleyrodidae, species of (Aleyrodidae)	1	27		1	29
Amorbia sp. (Tortricidae)		1			1
Anastrepha sp. (Tephritidae)	2				2
Aonidiella inornata Mckenzie (Diaspididae)	1				1
Aphididae, species of (Aphididae)		10		1	11
Araecerus sp. (Anthribidae)	1				1
Buprestidae, species of (Buprestidae)		1			1
Cerambycidae, species of (Cerambycidae)		1			1
Chrysodeixis eriosoma (Doubleday) (Noctuidae)		6			6
Cicadellidae, species of (Cicadellidae)		40	2	1	43
Coccidae, species of (Coccidae)	7	2	1		10
Coccus viridis (Green) (Coccidae)		4			4
Coelomycetes, species of	1				1
Crambidae, species of (Crambidae)	2				2
Curculionidae, species of (Curculionidae)	1				1
Dacus sp. (Tephritidae)	1				1
Diaphania sp. (Crambidae)	1				1
Diaspididae, species of (Diaspididae)	1	1		2	4
Draeculacephala sp. (Cicadellidae)		1			1
Drepanococcus sp. (Coccidae)	1				1

Pest	Fruit	Leaf	Stem	Other	Total
Dysmicoccus sp. (Pseudococcidae)	3				3
Etiella sp. (Pyralidae)		1			1
Ferrisia sp. (Pseudococcidae)	1				1
Flatidae, species of (Flatidae)		3			3
Fusarium sp.	1				1
Gelechiidae, species of (Gelechiidae)	1				1
Glaphyriinae, species of (Crambidae)				1	1
Gyponana sp. (Cicadellidae)		1			1
Hemiptera, species of		2			2
Heteroptera, species of		2			2
Homoptera, species of		9		1	10
Hypothenemus sp. (Scolytidae)	1	1			2
Insecta, species of	1	2			3
Lagocheirus sp. (Cerambycidae)				1	1
Lepidoptera, species of		3		1	4
Liriomyza sp. (Agromyzidae)		1			1
Maruca vitrata (Fabricius) (Crambidae)	1				1
Membracidae, species of (Membracidae)	1	2			3
Microsphaeropsis sp.				1	1
Miridae, species of (Miridae)	1	9		2	12
Noctuidae, species of (Noctuidae)		7			7
Odontaleyrodes sp. (Aleyrodidae)	1				1
Orchamoplatus mammaeferus (Aleyrodidae)		3			3
Parlatoria crypta Mckenzie (Diaspididae)	1				1
Pealius misrae Singh (Aleyrodidae)		6			6
Pentatomidae, species of (Pentatomidae)		2			2
Phenacoccus parvus Morrison (Pseudococcidae)	1				1
Phomopsis sp.				1	1
Phyllosticta sp.		1			1
Pieridae, species of (Pieridae)		27			27
Planococcus minor (Maskell) (Pseudococcidae)	1				1
Platynota sp. (Tortricidae)		1			1
Protaetia fusca (Herbst) (Scarabaeidae)		1			1
Pseudaonidia sp. (Diaspididae)	1				1
Pseudococcidae, species of (Pseudococcidae)	5	7	1		13
Pseudococcus sp. (Pseudococcidae)	4	1			5
Psychidae, species of (Psychidae)		1			1
Psyllidae, species of (Psyllidae)		1			1
Pyralidae, species of (Pyralidae)	1	3		1	5
Pyrausta sp. (Pyralidae)	1				1
Pyraustinae, species of (Crambidae)	25	4	1	3	33
Spodoptera sp. (Noctuidae)		1			1
Stephanitis sp. (Tingidae)		1			1
Sybra alternans (Wiedemann) (Cerambycidae)		2			2
Tephritidae, species of (Tephritidae)	1				1
Tetraleurodes sp. (Aleyrodidae)		1			1
Tetranychus sp. (Tetranychidae)		1			1

Pest	Fruit	Leaf	Stem	Other	Total
Tettigoniidae, species of (Tettigoniidae)				1	1
Thripidae, species of (Thripidae)	5	6	1		12
Thrips sumatrensis Priesner (Thripidae)	2				2
Tineidae, species of (Tineidae)	2			1	3
Tortricidae, species of (Tortricidae)		1			1
Trachylepidia sp. (Pyralidae)	1				1
Veronicella sp. (Veronicellidae)	1				1
Xestocephalus sp. (Cicadellidae)		1			1
Xiphidiopsis lita Hebard (Tettigoniidae)		1			1
Total	**88**	**925**	**24**	**22**	**1059**

2.4 Pest Categorization—Identification of pests associated with *Moringa oleifera* in Hawaii

In this risk assessment, Table 3 reports the pests associated with *Moringa* if, and only if, populations of that pest are also reported in Hawaii. Interception records are included, with the identification mostly at the genus level. This table should not be interpreted to infer that all pests known to affect *Moringa* species are listed. The following table only presents information about a pest's presence, U.S. quarantine status, and its likelihood to follow the pathway into the United States. From this table, quarantine pests likely to follow the pathway are selected for further analysis.

Table 3: Summary of pests associated with *Moringa* species in Hawaii.

Organism	Distribution [1]	Plant Part(s)	Quaran-tine Pest	Follow Pathway	Host	References
ARTHROPODA						
ACARI						
Tetranychidae						
Tetranychus neocaledonicus André	HI, US	Leaves, Fruit	No	Yes	*M. oleifera*	Bolland, *et al.*, 1998; Singh *et al*., 1983
COLEOPTERA						
Cerambycidae						
Coptops aedifactor Fabricius	HI	Stems	Yes	No	*M. oleifera*	Butani & Verma, 1981; HTAC, 2005; Nair, 1975
Lagocheirus sp.[2]	HI, US	Stems	Yes	No	*M. oleifera*	Arnett, 2000; HTAC, 2005; PIN 309, 2005
Sybra alternans (Wiedemann)	HI	Stems, Leaves	Yes	No[3]	*M. oleifera*, *Moringa* sp.	Chen, *et al.*, 2000; HTAC, 2005; Knowledge Master, 2005; PIN 309, 2005

Organism	Distribution [1]	Plant Part(s)	Quaran-tine Pest	Follow Pathway	Host	References
Scarabaeidae						
Adoretus sinicus Burmeister	HI	Leaves, Roots, Stems	Yes	No[4]	*M. oleifera*, *Moringa* sp.	CABI, 2004; Gressitt, 1954; HTAC, 2005; PIN 309, 2005; Stanaway, *et al.*, 2001; USDA, 1992
Protaetia fusca (Herbst)	HI	Flower	Yes	No	*M. oleifera*	CABI, 2004; Gressitt, 1954; HTAC, 2005; PIN 309, 2005; USDA, 1992
Scolytidae						
Hypothenemus eruditus	HI, US	Roots, Stems, Leaves, Fruit, & Seeds	No	Yes	*M. oleifera*	Wood, 1982
Hypothenemus sp.[2]	HI, US	Flowers, Leaves, Pods	Yes	Yes	*M. oleifera*	Arnett Jr., *et al.*, 2002; HTAC, 2005; PIN 309, 2005
DIPTERA						
Agromyzidae						
Liriomyza sativa Blanchard	HI, US	Leaves	No	No	*Moringa* sp.	CABI, 2005; Spencer, 1973
Liriomyza sp.[2]	HI, US	Leaves	Yes	NO	*M. oleifera*	CABI, 2005; HTAC, 2005; PIN 309, 2005
Tephritidae						
Tephritidae species	HI	Pods	Yes	Yes[5]		PIN 309, 2005
HEMIPTERA						
Aleyrodidae						
Aleurodicus dispersus Russell	HI, US (FL)	Leaves, Pods	Yes	Yes	*M. oleifera*, *Moringa* sp.	CABI, 2004; HTAC, 2005; Lambkin, 1999; Perdew, 2005; PIN 309, 2005
Aleurodicus sp. [2]	HI, US (FL)	Leaves, Pods[8]	Yes	Yes	*M. oleifera*, *Moringa* sp.	CABI, 2005; PIN 309, 2005
Bemisia tabaci Gennadius	HI, US	Flowers, Leaves	No	No	*M. oleifera*	CABI, 2005; Mau & Kessing, 1992; Mound & Halsey 1978

Organism	Distribution [1]	Plant Part(s)	Quaran-tine Pest	Follow Pathway	Host	References
Orchamoplatus mammaeferus (Quaintance & Baker)	HI	Leaves	Yes	No	*Moringa* sp.	HTAC, 2005; PIN 309, 2005
Aphididae						
Aphis craccivora Koch	HI, US	Leaves, Flower buds	No	No	*M. oleifera*, *Moringa* sp.	CABI, 2004; Murthy & Regupathy, 1992; Perdew, 2005; Ramachandran, et al., 1980
Cicadellidae						
Gyponana sp.[2]	HI	Leaves	Yes	No	*Moringa* sp.	PIN 309, 2005
Coccidae						
Coccus hesperidum L.	HI, US	Leaves, Stems	No	Yes	*M. oleifera*	Murray, 1976; ScaleNet, 2005
Coccus viridis (Green)	HI, US (FL)	Stems, Leaves, & Pods	[Yes][9]	Yes	*Moringa* sp.	CABI, 2005; PIN 309, 2005
Diaspididae						
Aonidiella inornata McKenzie	HI, US (TX)	Leaves, Stems, Pods	Yes	Yes	*M. oleifera*	Ben-Dov and German, 2003; Gressitt, 1954; PIN 309, 2005
Hemiberlesia lataniae (Signoret)	HI, US	Leaves, Stems, Pods	No	Yes	*M. oleifera*	CABI, 2004; ScaleNet, 2005
Howardia biclavis (Comstock)	HI, US	Bark & Stems	No	No	*M. oleifera*	ScaleNet, 2005
Pinnaspis strachani (Cooley)	HI, US (CA, FL)	Leaves, Stems, Pods	No	Yes	*M. oleifera*	CABI, 2004; ScaleNet, 2005
Pseudococcidae						
Dysmicoccus sp.[2]	HI, US	Leaves, Pods, Stems	Yes	Yes	*M. oleifera*	PIN 309, 2005;
Phenacoccus parvus Morrison	HI, US (FL)	Fruit	Yes	No[11]	*Moringa* sp.	HTAC, 2005; PIN 309, 2005; ScaleNet, 2005
Pseudococcus cryptus Hempel	HI	Roots, Shoots, Leaves, & Fruit	Yes	Yes	*M. oleifera*	Avidov & Harpaz 1969; ScaleNet, 2005; Williams & Watson, 1988
Pseudococcus jackbeardsleyi Gimpel & Miller	HI, US (FL, TX)	Leaves, Pods	No	Yes	*M. oleifera*	CABI, 2004; ScaleNet, 2005

Organism	Distribution [1]	Plant Part(s)	Quarantine Pest	Follow Pathway	Host	References
Pseudococcus sp.[2] Westwood	HI, US	Leaves & Pods	Yes	Yes	*Moringa* sp.	PIN 309, 2005; ScaleNet, 2005
LEPIDOPTERA						
Noctuidae						
Chrysodeixis eriosoma (Doubleday)	HI	Leaves, Pods	Yes	No[6]	*M. oleifera*, *Moringa* sp.	CABI, 2005; HTAC, 2005; PIN 309, 2005
Spodoptera litura (Fabricius)	HI	Roots, Tubers, & Leaves	Yes	No	*M. oleifera*	CABI, 2005; HTAC, 2005; NHM, 2005
Spodoptera sp.[2]	HI, US	Leaves, Pods	Yes	No[6]	*M. oleifera*	HTAC, 2005; PIN 309, 2005; Zhang, 1994
Pyralidae						
Ephestia kuehniella Zeller	HI, US	Roots, Leaves, Flower, Fruit, & Seed	No	Yes	*M. oleifera*	CABI, 2005; HTAC, 2005; NHM, 2005
Maruca vitrata Fabricius	HI	Fruit & Seeds	Yes	No[12]	*M. oleifera*	CABI, 2005; Machuka, *et al*., 1999; PIN 309, 2005
Tortricidae						
Amorbia sp.[2]	HI, US	Pod, Stem	Yes	Yes	*M. oleifera*	Arnett, Jr., 2000; HTAC, 2005; Mau & Kessing, 1992a; PIN 309, 2005
Platynota sp.[2]	HI, US	Leaves & Fruit	Yes	No[10]	*Moringa* sp.	Baker, *et al*., 2005; PIN 309, 2005; Pfeiffer, 2005
ORTHOPTERA						
Cicadellidae						
Draeculacephala sp.[2]	HI, US	Leaves	Yes	No	*M. oleifera*	Arnett, Jr., 2000; PIN 309, 2005
Tettigoniidae						
Xiphidiopsis lita Hebard	HI	Leaves	Yes	No[6]	*M. oleifera*	HTAC, 2005; PIN 309, 2005
MOLLUSCA						
Achatina fulica Bowdich	HI	Leaves, Pods, Roots, Stems	Yes	No[6]	*Moringa* sp.	CABI, 2004; Jav, 2004

Organism	Distribution [1]	Plant Part(s)	Quaran-tine Pest	Follow Pathway	Host	References
FUNGI[7]						
Botryodiplodia theobromae Pat.	HI, US	Stems, Leaves, Fruit	No	Yes	*M. oleifera*	Farr, *et al.*, n.d.
Cladosporium herbarum (Pers.) Link	HI, US	Wood, Stems, Leaves, & Fruit	No	Yes	*M. oleifera*	Farr, *et al.*, n.d.
Drechslera hawaiiensis M.B. Ellis Syn: *Bipolaris hawaiiensis*	HI, US (FL)	Leaves & Fruit	No	Yes	*M. oleifera*	Farr, *et al.*, n.d.; Kshirsagar & Souza 1989;
Lecanidion atratum (Hedw.)	HI, US	Bark, Stem, & Wood	No	No	*M. oleifera*	Farr, *et al.*, n.d.
Leveillula taurica (Lev.) G. Arnaud	HI, US	Stems, Leaves, Flowers, Fruit	No	Yes	*M. oleifera*	CABI, 2005; ECOPORT, 2006
Polyporus gilvus (Schwein.:Fr.) Pat.	HI, US	Dead Wood & Stems	No	No	*M. oleifera*	ECOPORT, 2006, Farr, *et al.*, n.d.

[1]CA = California; FL = Florida; HI = Hawaii; TX = Texas; U.S. = United States
[2]Quarantine pests identified only to the order, family or generic levels are not further analyzed in this risk assessment (*See* Section 2.5 discussion).
[3]*Sybra alternans* is a long-horned beetle that is a wood-boring pest of trees as a larva, and is also a secondary pest of many hosts (Knowledge Master, 2005).
[4]*Adoretus sinicus* is a scarab beetle that feeds on the roots of many hosts as a larva, and, as an adult, feeds on leaves (Stanaway *et al.*, 2001). Adults are nocturnal, relatively large, and conspicuous (Mau & Kessing, 1991); thus, they would not be expected to follow the pathway on leaves. Since 1985, they have been intercepted 71 times on the leaves and stems of *Moringa* sp., in passenger baggage and permit cargo (PIN 309, 2005). Clearly, this species can follow the pathway on leaves. Because this species is strongly attracted to lights (Mau & Kessing, 1991), it is probably a hitchhiker and not a pest. It is unlikely that it will follow the pathway on *Moringa* fruit.
[5]One specimen of Tephritidae sp. was intercepted on the fruit of *Moringa* sp. from Hawaii (PIN 309, 2005). *Bactrocera cucurbitae*, *B. dorsalis*, and *Ceratitis capitata* are common species of Tephritidae present in Hawaii (CABI, 2004; HTAC, 2005). Data were presented from surveys of *Moringa oleifera* in southeast Asia and did not include any findings of fruit flies (Allwood *et al.*, 1999); however, the fruit flies were further analyzed.
[6]Large bodied, surface feeding pest that would not likely follow the pathway.
[7]"Very little information is known about pathogens on this host. A survey of the world literature in the electronic databases from 1969 to date did not list plant pathogens on this host from this area" (USDA, 1992). "This tree is not affected by any serious disease in India either in nurseries or in plantations" (ICFRE, 1994). A compound found in the flowers and roots of the moringa tree, pterygospermin, has powerful antibiotic and fungicidal effects (Das *et al.*, 1957).
[8]Due to limited information, association with host plant organs was based on other members of the genus.
[9]Given its limited distribution, the United States considers this a quarantine pest.
[10]*Platynota* spp. are generally leaf rolling caterpillars (Baker *et al*., 2005) that may damage and feed on fruit when leaves become stuck to fruit (Pfeiffer, 2005); thus, they are unlikely to follow the pathway.
[11]*Phenacoccus parvus* was intercepted once by U.S. port inspectors on a Moringa sp. fruit from the Phillipines coming

through on personal baggage (PIN 309, 2005). *Phenacoccus parvus* has a broad host range, but literature does not indicate that *Moringa* is a host (Scalenet, 2005; Williams & Watson, 1988). The single interception and lack of association with *Moringa* suggest that *P. parvus* was a probably a biological contaminant on *Moringa,* and not a true pest; therefore, it was considered unlikely to follow the pathway.
[12]*Maruca vitrata* is almost exclusively a pest of legumes (CABI, 2005), unrelated to plants in the Moringaceae family (Order Fabales vs. Order Caparales) (Mabberley, 1987). Only one interception record identifies Moringa as a host of *Maruca vitrata* (PIN 309, 2005). This interception record may be a mistake or an unusually rare event; therefore, it is unlikely that *M. vitrata* will regularly follow the pathway on fresh Moringa fruit from Hawaii. If port inspectors intercept additional individuals on Moringa fruit, then a risk analysis should be required.

2.5 Quarantine Pests that are Likely to Follow the Pathway

The quarantine pests of *Moringa oleifera,* that are reasonably expected to follow the pathway on fruit, are further analyzed in this risk assessment (Table 4). Other organisms included on the pest list (Table 3) were not chosen for further scrutiny because of one or more of the following reasons: they are well-established and widespread in the United States; they are associated mainly with plant parts other than the commodity; they may be associated with the commodity, but it was not considered reasonable to expect these pests to remain with the commodity during processing; or they have been intercepted on rare occasions as biological contaminants by APHIS-PPQ Officers during commodity inspections and would not be expected to be common to commercial shipments. Although organisms listed in Table 3 (at the genus level) are quarantine pests, they were not considered for further analysis because their identity was not clearly defined (IPPC, 2004).

Table 4. Quarantine Pests Likely to Follow the Pathway and Selected for Further Analysis

Aleurodicus dispersus Russell (Hemiptera: Aleyrodidae)
Aonidiella inornata (McKenzie) (Hemiptera: Diaspididae)
Bactrocera cucurbitae (Coquillett) (Diptera: Tephritidae)
Bactrocera dorsalis (Hendel) (Diptera: Tephritidae)
Ceratitis capitata (Wiedemann) (Diptera: Tephritidae)
Coccus viridis (Green) (Hemiptera: Coccidae)
Pseudococcus cryptus Hempel (Hemiptera: Pseudococcidae)

2.6 Consequences of Introduction—Economic/Environmental Importance

Potential Consequences of Introduction are rated using five Risk Elements: Climate-Host Interaction, Host Range, Dispersal Potential, Economic Impact, and Environmental Impact. These elements reflect the biology, host ranges, and climatic/geographic distributions of the pests. For each Risk Element, pests are assigned a rating of Low (1 point), Medium (2 points), or High (3 points) (USDA, 2002). A Cumulative Risk Rating is then calculated by summing all Risk Element values. Table 5 summarizes the values for the Consequences of Introduction for each pest.

Consequences of Introduction: *Aleurodicus dispersus* Russell (Hemiptera: Aleyrodidae)	**Risk Value**
Risk Element #1: Climate-Host Interaction *Aleurodicus dispersus* is native to tropical Americas. It occurs in tropical and subtropical Central and South America, the Caribbean, Africa, Asia, and Oceania (Akinlosotu *et al*., 1993). Its distribution corresponds to U.S. Hardiness Zones 8-11 (USDA ARS, 1990). One or more of its potential hosts occur in these Zones (USDA NRCS, 2006).	Medium (2)
Risk Element #2: Host Range *Aleurodicus dispersus* is a highly polyphagous species. Primary host species include Arecaceae (*Cocos nucifera*), Rutaceae (*Citrus* spp.), Papilionoideae (*Glycine max*), Euphorbiaceae (*Manihot esculenta*), Musaceae (*Musa x paradisiacal*), Lauraceae (*Persea Americana*), Rosaceae (*Prunus* spp.), and Myrtaceae (*Psidium guajava*) (CABI, 2003). Other host species include Moraceae (*Artocarpus* spp., *Ficus* spp., *Morus* spp.), Fabaceae (*Acacia* spp., *Arachis hypogaea*, *Pongamia pinnata*, *Bauhinia* spp., *Cassia* spp., *Phaseolus* spp., *Vigna* spp.), Nyctaginaceae (*Bougainvillea* spp.), Asteraceae (*Chrysanthemum* spp., *Dahlia pinnata*, *Lactuca sativa*), Lauraceae (*Cinnamomum camphora*), Cucurbitaceae (*Cucumis melo*, *Luffa aegyptiaca*, *Cucumis* spp.), Lamiaceae (*Coleus* spp., *Salvia* spp.), Euphorbiaceae (*Euphorbia pulcherrima*, *Acalypha* spp., *Euphorbia* spp., *Ricinus communis*), Myrtaceae (*Eugenia* spp.), Araliaceae (*Hedera* spp.), Oleaceae (*Jasminum* spp., *Osmanthus fragrans*), Convolvulaceae (*Ipomoea batatas*, *Ipomoea* spp.), Araceae (*Monstera deliciosa*, *Colocasia esculenta*), Ericaceae (*Rhododendron* spp.), Brassicaceae (*Rorippa indica*), Anacardiaceae (*Schinus terebinthifolius*, *Mangifera indica*), Solanaceae (*Solanum melongena*, *Cestrum* spp., *Capsicum* spp., *Lycopersicon esculentum*, *Physalis* spp., *Solanum* spp.), Poaceae (*Sorghum bicolor*), Strelitziaceae (*Strelitzia* spp.), Zingiberaceae (*Zingiber zerumbet*), Agavaceae (*Agave americana*), Amaranthaceae (*Amaranthus* spp.), Annonaceae (*Annona squamosa*), Arecaceae (*Areca catechu*, *Chrysalidocarpus lutescens*), Begoniaceae (*Begonia* spp.), Ulmaceae (*Celtis* spp.), Caricaceae (*Carica papaya*), Cannaceae (*Cannas* pp.), Rubiaceae (*Coffea* spp.), Malvaceae (*Hibiscus* spp.), Proteaceae (*Macadamia* spp.), Sapotaceae (*Manilkara zapota*), Musaceae (*Musa* spp.), Apocynaceae (*Plumeria* spp.), Rosaceae (*Rosa* spp., *Rubus* spp.), and Combretaceae (*Terminalia catappa*) (CABI, 2004; Martin-Kessing & Mau, 1993; EPPO, 2004).	High (3)
Risk Element #3: Dispersal Potential The female lays her eggs within the day of emergence, and continues to lay eggs throughout her lifetime (Martin-Kessing & Mau, 1993). Each female lays 14-26 eggs in a loose spiral on the underside of leaves (CABI, 2004). The eggs hatch in 7-11 days (Martin-Kessing & Mau, 1993; CABI, 2004). There are four larval stages (Martin-Kessing & Mau, 1993). The first instar lasts for 6-7 days; the second instar, 4 days; the third instar, 5-13 days; and the fourth (pupae), 5-16 days (CABI, 2004; Martin-Kessing & Mau, 1993). Adults live for about two weeks (CABI, 2004); thus, there are several generations per year. During the immature stages, the first instar is the only stage capable of active movement (Martin-Kessing & Mau, 1993). The adult disperses beyond the leaf by flying, and is most active in the morning hours (Martin-Kessing & Mau, 1993). Long distance dissemination is via infested plants and fruits (EPPO, 2004).	Medium (2)

Consequences of Introduction: ***Aleurodicus dispersus*** **Russell (Hemiptera: Aleyrodidae)**	**Risk Value**
Risk Element #4: Economic Impact *Aleurodicus dispersus* is a serious pest of tropical and subtropical crops (EPPO, 2004). This whitefly has a high potential to have major economic impact due to its polyphagous nature. *Aleurodicus dispersus* causes several types of economic damage: direct feeding damage to leaves; excreted honeydew encourages the development of sooty molds; and it vectors plant disease (CABI, 2004; Martin-Kessing & Mau, 1993). Whiteflies cause over 40 worldwide plant diseases of vegetables and crops (Martin-Kessing & Mau, 1993). *Aleurodicus dispersus* is a vector of the lethal yellowing virus of coconut palms in Florida (Akinolosotu *et al*., 1993). Depending on the crop, season, and prevalence, *A. dispersus* is capable of damaging from 20 to 100 percent of crops (Martin-Kessing & Mau, 1993). In Florida, it feeds on avocados, citrus, guavas, and palms (CABI, 2004). *Aleurodicus dispersus* is a quarantine pest for French Polynesia, Korea, New Zealand, and eastern and southern Africa (EPPO, 2004; PRF, 2004).	High (3)
Risk Element #5: Environmental Impact In addition to the Threatened and Endangered species, *A. dispersus* may already be affecting south Florida and Puerto Rico. If it established outside of Florida, it could affect Threatened and Endangered, including *Manihot walkerae* (Endangered species in TX), *Rorippa gambellii* (Endangered species in CA), *Solanum drymophilum* (Endangered species in PR), *Agave arizonica* (Endangered species in AZ), and *Amaranthus pumilus* (Threatened species in DE, MA, MD, NC, NJ, NY, RI, SC, VA). Further spread of *A. dispersus* in the continental United States would stimulate chemical or biological control programs. Successful biological control have been established in Hawaii (CABI, 2004; Martin-Kessing & Mau, 1993).	High (3)

Consequences of Introduction: ***Aonidiella inornata*** **McKenzie (Hemiptera: Diaspididae)**	**Risk Value**
Risk Element #1: Climate-Host Interaction *Aonidiella inornata* occurs in Hawaii and Texas (ScaleNet, 2005). Distribution also includes Australia, Dominican Republic, Ecuador, Puerto Rico, India, Philippines, Taiwan, Thailand, China, and Japan (ScaleNet, 2005). Its distribution corresponds to U.S. Hardiness Zones 9-11 (USDA ARS, 1990). One or more of its potential hosts occurs in these Zones (USDA NRCS, 2006).	Medium (2)
Risk Element #2: Host Range The papaya red scale, *A. inornata*, is a polyphagous species. Host species include Agavaceae (*Cordyline terminalis*), Anacardiaceae (*Campnosperma brevipetiolata, Mangifera indica*), Apocynaceae (*Allemanda, Nerium oleander, Ochrosia, Plumeria acuminate, P. rubra*), Barringtoniaceae (*Barringtonia*), Bischofiaceae (*Bischofia javanica*), Caricaceae (*Carica papaya*), Casuarinaceae (*Casuarina*), Cycadaceae (*Cycas*), Euphorbiaceae (*Annesijoa, Euphorbia*), Hippocrateaceae (*Salacea*), Leguminosae (*Cassia*), Moraceae (*Artocarpus alticis*), Musaceae (*Musa*), Myrtaceae (*Melaleuca*), Oleaceae (*Jasminum sambac*), Palmae (*Areca catechu, Cocos nucifera, Nipa fruitcans*), Pandanaceae (*Pandanus odoratissimus*), Piperaceae (*Piper, Piper aduncum, P. betle, P. methysticum*), Polygonaceae (*Polygonum*), Potaliaceae (*Fagraea cambageana*), Rhizophoraceae (*Rhizophora mucronata*), Rubiaceae (*Hedyotis ocutangulus, Platanocephalus morindaefolius*), Rutaceae (*Astronia, Citrus, Citrus paradise, C. reticulata*), Vitaceae (*Vitis vinifera*), and Zingiberaceae (*Elettaria cardamomum*) (ScaleNet, 2005).	High (3)

Consequences of Introduction: *Aonidiella inornata* McKenzie (Hemiptera: Diaspididae)	**Risk Value**
Risk Element #3: Dispersal Potential Little information is available on the biology of *A. inornata.* Other species within the same genus have an average of three to four generations per year (CABI, 2004). On average, the life-cycle of scales within the genus *Aonidiella* is about 65 days (CABI, 2004). During the immature stages, the first instar, or crawler, is the only stage capable of active movement (CABI, 2004). Long distance dissemination is via wind-blown crawlers and animals; adults are readily moved on infested plants and fruits (CABI, 2004).	Medium (2)
Risk Element #4: Economic Impact *Aonidiella inornata* is pest of papaya in Taiwan, and of mango in the Philippines and Puerto Rico (ScaleNet, 2005). Because this scale is polyphagous, and it can infest citrus, there is a high potential that it will cause economic damage. There is no scientific literature that describes *A. inornata* as causing serious damage to crops.	High (3)
Risk Element #5: Environmental Impact *Aonidiella inornata* has the potential to damage Threatened and Endangered species that are listed in Title 50, Part 17, Section 12 of the United States Code of Federal Regulations (50 CFR §17.12), such as *Euphorbia telephioides* (threatened species in FL), *Piperia yadonii* (endangered species in CA), and *Polygonum hickmanii* (endangered in CA) (USFWS, 2005). Because it may have a potentially high economic impact, it would stimulate chemical control.	High (3)

Consequences of Introduction: *Bactrocera cucurbitae* Coquillett (Diptera: Tephritidae)	**Risk Value**
Risk Element #1: Climate – Host Interaction *Bactrocera cucurbitae* is native to Asia and distributed throughout Asia. It is also found in several African countries and Hawaii. Its distribution corresponds to U.S. Plant Hardiness Zones 9-11 (USDA ARS, 1990). One or more of its potential hosts occurs in these Zones (USDA NRCS, 2006).	Medium (2)
Risk Element #2: Host Range *Bactrocera cucurbitae* is a serious pest of cucurbit crops (CABI, 2004). Its primary host is Cucurbitaceae (*Cucumis melo*, *Cucurbita maxima*, *Cucurbita pepo*, *Trichosanthes cucumerina var. anguinea*) (CABI, 2004). Other host species include Cucurbitaceae (*Cucumis sativus*, *Benincasa hispida*, *Citrullus colocynthis*, *Citrullus lanatus*, *Cucumis auguria*, *Cucurbita moschata*, *Lagenaria siceraria*, *Luffa acutangula*, *Luffa aegyptiaca*, *Momordica balsamina*, *Momordica charantia*, *Sechium edule*, *Trichosanthes cucumerina*), Moraceae (*Artocarpus heterophyllus*, *Ficus carica*), Malvaceae (*Abelmoschus moschatus*), Caricaceae (*Carica papaya*), Rutaceae (*Citrus maxima*, *Citrus sinensis*), Rosaceae (*Cydonia oblonga*, *Prunus persica*), Solanaceae (*Cyphomandra betacea*, *Lycopersicon esculentum*), Anacardiaceae (*Mangifera indica*), Sapotaceae (*Manilkara zapota*), Passifloraceae (*Passiflora* spp., *Passiflora edulis*), Lauraceae (*Persea americana*), Fabaceae (*Phaseolus vulgaris*, *Sesbania grandiflora*, *Vigna unguiculata*), Myrtaceae (*Psidium guajava*, *Syzygium samarangense*), and Rhamnaceae (*Ziziphus jujube*) (CABI, 2004).	High (3)

Consequences of Introduction: *Bactrocera cucurbitae* Coquillett (Diptera: Tephritidae)	**Risk Value**
Risk Element #3: Dispersal Potential Females can lay up to 40 eggs below the fruit skin; the total fecundity per female is more than 1000 eggs (CABI, 2004). Eggs hatch within 1-2 days; larval stages last for 4-17 days, depending on the thickness of fruit skin (CABI, 2004). Pupation takes place in the soil under the host plants for 7-13 days (CABI, 2004). Adults begin to mate after 10-12 days, and may live from 5 to 15 months (CABI, 2004); thus, there are multiple generations per year. Many *Bactrocera* species can fly 50-100 km. *Bactrocera cucurbitae* can be dispersed by infected plant materials, such as fruits and flowers (CABI, 2004).	High (3)
Risk Element #4: Economic Impact *Bactrocera cucurbitae* can attack cucurbit crops (CABI, 2004). Up to 100 percent of unprotected crops can be damaged (CABI, 2004). This pest has the potential to cause serious losses in other economically important crops, such as mango, avocado, and tomato (CABI, 2004).	High (3)
Risk Element #5: Environmental Impact *Bactrocera cucurbitae* has a high potential to damage Threatened and Endangered species listed in Title 50, Part 17, Section 12 of the United States Code of Federal Regulations (50 CFR §17.12). Threatened and Endangered species likely to be damaged include *Cucurbita okeechobeensis* spp. *okeechobeensis* (Endangered species in FL), *Prunus geniculata* (Endangered species in FL), and *Ziziphus celaata* (Endangered species in FL) (USFWS, 2005). The establishment and introduction of *B. cucurbitae* could stimulate biological and chemical control programs in the continental United States.	High (3)

Consequences of Introduction: *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae)	**Risk Value**
Risk Element #1: Climate-Host Interaction Except for adventive populations in Guam and Hawaii, *B. dorsalis* is restricted to subtropical and tropical Asia (White & Elson-Harris, 1992). It is estimated that this species could establish in the continental United States in areas corresponding to Plant Hardiness Zones 9-11. One or more of its potential hosts occurs in these Zones (USDA NRCS, 2006).	Medium (2)
Risk Element #2: Host Range This species is extremely polyphagous. Recorded hosts include Rubiaceae (*Coffea* sp.), Moraceae (*Ficus* sp.), Rosaceae (*Prunus* spp.), Myrtaceae (*Eugenia uniflora*), Anacardiaceae (*Mangifera* spp.), Rutaceae (*Citrus* spp.), Arecaceae (*Areca catechu*), Sapotaceae (*Chrysophyllum cainito*), Cucurbitaceae (*Cucumis* spp.), Sapindaceae (*Dimocarpus longan*), Ebenaceae (*Diospyros kaki*), Flacourtiaceae (*Flacourtia indica*), Punicaceae (*Punica granatum*), Rhamnaceae (*Ziziphus* spp.), Annonaceae (*Annona* spp.), Oxalidaceae (*Averrhoa carambola*), Caricaceae (*Carica papaya*), Malpighiaceae (*Malpighia glabra*), Elaeocarpaceae (*Muntingia calabura*), Lauraceae (*Persea americana*), Combretaceae (*Terminalia catappa*), Musaceae (*Musa* x *paradisiaca*) (CPC, 2004); Passifloraceae (*Passiflora mollissima*), Juglandaceae (*Juglans hindsii*), Simaroubaceae (*Quassia simarouba*), Solanaceae (*Solanum seaforthianum*), and Rutaceae (*Clausena lansium*) (White & Elson-Harris, 1992).	High (3)
Risk Element #3: Dispersal Potential Females deposit 3-30 eggs per host fruit; total fecundity per female may exceed 1000 eggs (Fletcher, 1989a). There are several generations per year. Adult flight is capable of flying distances up to 65 km (Fletcher, 1989b); the transport of infested fruit are the major means of movement and dispersal to previously uninfested areas (CABI, 2004). Like other dacine	High (3)

Consequences of Introduction: *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae)	Risk Value
tephritids, *B. dorsata* exhibits high reproductive and dispersal potentials.	
Risk Element #4: Economic Impact There are three kinds of economic losses that result from this pest (Harris, 1989): downgrading of fruit quality, which is caused by oviposition "stings" that spoil the fruits' appearance, including those unfavorable for larval survival; fruit spoilage caused by larval tunneling and the entry of organisms that cause decay; and indirect damage in the form of lost markets resulting from the imposition of quarantine restrictions. In Hawaii, annual losses in major fruit crops caused by *B. dorsalis* may exceed 13 percent, or $3 million (Culliney, 2002).	High (3)
Risk Element #5: Environmental Impact Because of its extremely broad host range, *B. dorsalis* is a potential threat to Threatened or Endangered plants in Title 50, Part 17, Section 12 of the United States Code of Federal Regulations (50 CFR §17.12), and those hosts occurring in the southern regions of the United States (*e.g*., *Prunus geniculata*, *Ziziphus celata*). As the species is a pest of numerous crops of economic significance in the continental United States (*e.g*., apple, peach, pear, citrus), its entry and establishment could stimulate the initiation of chemical or biological control programs, as has occurred in Hawaii.	High (3)

Consequences of Introduction: *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae)	Risk Value
Risk Element #1: Climate-Host Interaction *Ceratitis capitata* is found in southern Europe and west Asia, Africa, South and Central America (CABI, 2004), and northern Australia (Hassan, 1977). This species has the capacity to tolerate colder climates better than most other fruit fly species (Weems, 1981). It is estimated that *C. capitata* could establish in areas of the U.S. corresponding to Plant Hardiness Zones 8-11. One or more of its potential hosts occurs in these Zones (USDA NRCS, 2006).	High (3)
Risk Element #2: Host Range This pest has been recorded from a wide variety of host plants in several families, including Rubiaceae (*Coffea* sp.), Solanaceae (*Capsicum annuum*), Rutaceae (*Citrus* spp.), Rosaceae (*Malus pumila*, *Prunus* spp.), Moraceae (*Ficus carica*), Myrtaceae (*Psidium guajava*), Sterculiaceae (*Theobroma cacao*), Arecaceae (*Phoenix dactylifera*), and Anacardiaceae (*Mangifera indica*) (CABI, 2004). CABI (2004) list dozens of other hosts.	High (3)
Risk Element #3: Dispersal Potential Females deposit as many as 800 eggs in a lifetime, although 300 is the more typical number (Weems, 1981). Eggs are inserted into host fruit in small batches of one to 10. Breeding is continuous throughout the year, with several overlapping generations (Hassan, 1977). Adult flight (with a range of 20 km or more), and the transport of infested fruit, are the major means of movement and dispersal to previously uninfested areas (CABI, 2004).	High (3)
Risk Element #4: Economic Impact *Ceratitis capitata* is an important pest in Africa, spreading nearly worldwide to become the single most important pest species in its family. In Mediterranean countries, it is particularly damaging to citrus and peach crops. It may transmit fruit-rotting fungi (CABI, 2004). The species is of quarantine significance worldwide, especially in Japan and the United States. Its presence, even as temporary adventive populations, can lead to severe additional constraints for the export of fruits to uninfested areas in other parts of the world. In this respect, *C. capitata* is one of the most significant quarantine pests for any tropical or warm temperate area in which it is not yet established (CABI, 2004).	High (3)

Consequences of Introduction: *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae)	**Risk Value**
Risk Element #5: Environmental Impact As it represents a significant threat to citrus and peach production, the establishment of *C. capitata* in the continental United States would undoubtedly trigger the initiation of chemical or biological control programs, as has occurred in California and Hawaii. This species is highly polyphagous and, thus, has the potential to attack plants listed as Threatened or Endangered (*e.g.*, *Opuntia treleasei*, *Prunus geniculata*) (50 CFR §17.12)	High (3)

Consequences of Introduction: *Coccus viridis* (Green) (Hemiptera: Coccidae)	**Risk Value**
Risk Element #1: Climate-Host Interaction *Coccus viridis* has a pantropical distribution, which includes southern Florida and Hawaii (CABI, 2005; Deckle & Fasulo, 2001). These areas correspond to U.S. Plant Hardiness Zones 9-11. Within these Zones, several of its hosts occur. It is estimated that *C. viridis* could establish in areas of the United States corresponding to these Zones, including southern Texas, Arizona, California and Puerto Rico. Survival outside of these areas would be limited to greenhouse or other artificial situations.	Medium (2)
Risk Element #2: Host Range *Coccus viridis* has a broad host range (CABI, 2005), including the following genera and families: Acanthaceae (*Jacobinia, Odontonema, Sanchezia*), Agavaceae (*Cordyline, Dracaena*), Amaranthaceae (*Gomphrena*), Anacardiaceae (*Campnosperma, Dodonaea, Mangifera*), Annonaceae (*Annona*), Apocynaceae (*Alstonia, Alyxia, Carissa, Nerium, Ochrosia, Plumeria, Rauwolfia, Thevetia*), Aquifoliaceae (*Ilex*), Araceae (*Caladium*), Araliaceae (*Aralia, Meryta, Polyscias, Schefflera*), Barringtoniaceae (*Barringtonia*), Bignoniaceae (*Tecomaria*), Boraginaceae (*Cordia, Ehretia*), Bromeliaceae (*Ananas*), Celastraceae (*Maytenus*), Combretaceae (*Terminalia*), Commelinaceae (*Commelina*), Compositae (*Arctotis, Fitchia, Gerbera, Pluchea, Senecio*), Crassulaceae (*Bryophyllum*), Cucurbitaceae (*Cucurbita*), Dioscoreaceae (*Dioscorea*), Euphorbiaceae (*Carissa, Codiaeum, Croton, Manihot*), Flacourtiaceae (*Doryalis*), Goodeniaceae (*Scaevola*), Guttiferae *Mammea*), Hydrangaceae (*Hydrangea*), Lauraceae (*Persea*), Leguminosae (*Cassia, Gliricidia, Inocarpus, Tipuana*), Loranthaceae (*Loranthus*), Lythraceae (*Lagerstroemia*), Malpighiaceae (*Hiptage*), Malvaceae (*Hibiscus*), Melastomataceae,. Meliaceae (*Melia*), Moraceae (*Ficus*), Myristicaceae (*Myristica*), Myrsinaceae (*Ardisia, Moesa*), Myrtaceae (*Eucalyptus, Eugenia, Melaleuca, Myricaria, Myrtella, Psidium*), Nyctaginaceae (*Ceodes*), Orchidaceae (*Broughtonia, Lissochilus*), Palmae (*Areca, Cocos*), Pandanaceae (*Pandanus*), Periplocaceae (*Cryptostegia*), Pittosporaceae (*Pittosporum*), Podocarpaceae (*Podocarpus*), Polygonaceae (*Coccoloba, Homalocladium, Muehlenbeckia, Polygonum*), Rubiaceae (*Bobea, Borreria Canthium, Chioccoca, Cinchona, Coffea, Faramea, Gardenia, Genipa, Ixora, Morinda, Platanocephalus, Psychotria, Randia, Timonius*), Rutaceae (*Aegle, Aeglopsis, Atalantia, Balsamocitrus, Boninia, Chaetospermum, Citropsis, Citrus, Clausena, Coffea, Feroniella, Hesperethusa, Lavanga, Microcitrus, Murraya, Poncirus, Triphasia*), Sapindaceae (*Dodonaea, Euphoria, Litchi, Melicoccus*), Sapotaceae *Achras, Chrysophyllum, Lucuma, Manilkara, Mimusops, Palaquium, Planchonella, Pouteria*), Solanaceae (*Brunfelsia, Cestrum*), Sterculiaceae (*Heritiera, Theobroma*), Stilaginaceae (*Antidesma*), Strychnaceae (*Strychnos*), Theaceae (*Camellia*), Umbelliferae (*Apium*), Verbenaceae (*Callicarpa, Clerodendron, Lantana, Verbena*),and Zingiberaceae (*Alpinia, Zingiber*) (ScaleNet, 2005).	High (3)

Consequences of Introduction: *Coccus viridis* (Green) (Hemiptera: Coccidae)	**Risk Value**
Risk Element #3: Dispersal Potential *Coccus viridis* is parthenogenetic and oviparous (Deckle & Fasulo, 2001). Females deposit up to 500 eggs, which begin hatching within minutes to several hours (CABI, 2005). There may be several generations per year (CABI, 2005). As with all scale insects, the crawlers, inherently do not move very far, often settling somewhere near their parent; however, crawlers can sometimes be transported by wind or animals, such as birds (Greathead, 1997). Because scales are relatively small and unnoticeable, particularly crawlers, they are readily transported in commercial trade. Since 1985, *C. viridis* has been intercepted 11,099 times by PPQ at ports-of-entry (PIN 309 query February 13, 2006). There is strong evidence that this species can, and has, quickly spread worldwide via the transport of infested plant materials.	Medium (2)
Risk Element #4: Economic Impact Although its economic impact is usually minor, *C. viridis* can be extremely devastating, depending on its location and crop host (CABI, 2005). *Coccus viridis* is a pest of coffee, citrus and other crops in several tropical regions. It is reported as a major pest of citrus in Bolivia (Ben-Dov, 1993), and of coffee in India (Krishnan, 1973). In Brazil, infestations of 50 scales per plant caused significant damage to coffee seedlings, reducing leaf area and plant growth rate (Silva and Parra, 1982). In India, *C. viridis* infestation on citrus fruit, followed by an overgrowth of a sooty mold, significantly lowered fruit quality in the following seasons when trees were recuperating from infestations (Haleem 1984). Based on this evidence, the wider *Coccus viridis'* establishment is in the United States, the more likely it would lead to a lower yield of host crops, a lower value of host crop commodities, and the loss of foreign or domestic markets.	High (3)
Risk Element #5: Environmental Impact Because *C. viridis* is polyphagous**,** it may affect additional federally Threatened and Endangered (T&E) species not present in southern Florida or Puerto Rico. T&E species that are congeners of current hosts include the following five (5) species: Asteraceae: *Senecio franciscanus*, *Senecio layneae*; Euphorbiaceae: *Manihot walkerae*; Polygonaceae: *Polygonum hickmanii*; and Verbenaceae: *Verbena californica* (USFWS, 2005). If the potential host range of United States' T&E plants is considered at the family level, then there may be additional native hosts that *C. viridis* may impact. The wider the establishment of *C. viridis* in U.S. areas where it is not present, the more likely it will have a negative impact on the citrus industry, such as those in Arizona and Texas, and stimulate the initiation of chemical or biological control programs impacting the environment.	High (3)

Consequences of Introduction: *Pseudococcus cryptus* Hempel (Hemiptera: Pseudococcidae)	**Risk Value**
Risk Element #1: Climate-Host Interaction *Pseudococcus cryptus* is widely distributed in southeast Asia, tropical Africa, the mideastern Mediterranean, and South America (ScaleNet, 2005). Its distribution corresponds to U.S. Plant Hardiness Zones 9-11 (USDA ARS, 1990). One or more of its potential hosts occurs in these Zones (USDA NRCS, 2006).	Medium (2)
Risk Element #2: Host Range Host species of *P. cryptus* include Anacardiaceae (*Mangifera indica*), Apocynaceae (*Plumeria* spp.), Compositae (*Dahlia* spp.), Dilleniaceae (*Dillenia indica*), Euphorbiaceae (*Hevea brasiliensis*), Guttiferae (*Calophyllum inophyllum*), Heliconiaceae (*Heliconia* spp.), Lauraceae (*Ocotea pedalifolia*, *Persea americana*), Leguminosae (*Erythrina* spp.), Liliaceae (*Crinum asiaticum*), Moraceae (*Artocarpus altilis*, *Artocarpus incisa*, *Artocarpus odoratissimus*), Musaceae (*Musa* spp.), Myrtaceae (*Osbornia ocdonta*, *Psidium guajava*), Palmae (*Cocos nucifera*, *Elaeis guineensis*), Pandanaceae (*Pandanus* spp., *Pandanus upoluensis*), Passifloraceae (*Passiflora foetida*), Piperaceae (*Piper methysticum*), Rubiaceae (*Coffea arabica*, *Coffea liberica*, *Gardenia* spp., *Ixora* spp.), Rutaceae (*Citrus* spp., *Citrus aurantifolia*, *Citrus aurantium*, *Citrus grandis*, *Citrus limon*, *Citrus paradisi*, *Citrus reticulata*, *Citrus sinensis*), and Selaginellaceae (*Selaginella* spp.) (ScaleNet, 2005).	High (3)
Risk Element #3: Dispersal Potential The number of eggs produced by females varies with the seasons; the greatest number of eggs produced in summer, and the smallest number in the winter. Females typically lay groups of 30-50 eggs, for a total of 200-500 eggs (Avidov & Harpaz, 1969). This mealybug is able to have six generations per year (Avidov & Harpaz, 1969). The insect is only capable of limited dispersal under its own power. Long distance dispersal could be accomplished via the movement of infected plant materials.	Medium (2)
Risk Element #4: Economic Impact *Pseudococcus cryptus* is considered a major pest of citrus (Hill, 1983). The insect produces copious quantities of honeydew, on which sooty molds develop, sometimes reaching a thickness of 5-8 mm (Avidov & Harpaz, 1969). In heavy infestations, entire trees may be contaminated, and leaves and fruit prematurely shed. High population densities on coconut palm may cause inflorescences to dry up and floral buttons to shed (Moore, 2001). In Israel, both biological and chemical controls have succeeded in maintaining populations below economically damaging densities (Avidov & Harpaz, 1969; Blumberg *et al*., 2001). Citrus are commercially produced in AZ, CA, FL, and TX in the continental United States, and are worth more than $2.3 billion (USDA NASS, 2004). This mealybug may have a high potential to damage the citrus industry in the continental United States.	High (3)
Risk Element #5: Environmental Impact *Pseudococcus cryptus* has the potential to damage Threatened and Endangered species listed in Title 50, Part 17, Section 12 of the United States Code of Federal Regulations (50 CFR §17.12), such as *Eugenia* and *Hibiscus* species (USFWS, 2005). In Israel, where *P. cryptus* was introduced, it is successfully controlled by its natural enemy, *Clausenia purpurea* (ScaleNet, 2005), in addition to chemical treatment. The introduction and establishment of this pest would stimulate biological and chemical controls in the continental United States.	High (3)

For each pest, the sum of the five Risk Elements gives a Cumulative Risk Rating. This Cumulative Risk Rating is a biological indicator of the potential of the pest to establish, spread, and cause economic and environmental impacts. Table 5 summarizes the summary of risk ratings for Consequences of Introduction.

Low: 5-8 points
Medium: 9-12 points
High: 13-15 points

Table 5. Risk Rating for Consequences of Introduction (*Moringa oleifera* from Hawaii).

Pest	Risk Element 1 Climate/ Host Interaction	Risk Element 2 Host Range	Risk Element 3 Dispersal Potential	Risk Element 4 Economic Impact	Risk Element 5 Environmental Impact	Cumulative Risk Rating
Aleurodicus dispersus Russell	Medium (2)	High (3)	Medium (2)	High (3)	High (3)	High (13)
Aonidiella inornata McKenzie	Medium (2)	High (3)	Medium (2)	High (3)	High (3)	High (13)
Bactrocera cucurbitae (Coquillett)	Medium (2)	High (3)	High (3)	High (3)	High (3)	High (14)
Bactrocera dorsalis (Hendel)	Medium (2)	High (3)	High (3)	High (3)	High (3)	High (14)
Ceratitis capitata (Wiedemann)	High (3)	High (3)	High (3)	High (3)	High (3)	High (15)
Coccus viridis (Green)	Medium (2)	High (3)	Medium (2)	High (3)	High (3)	High (13)
Pseudococcus cryptus Hempel	Medium (2)	High (3)	Medium (2)	High (3)	High (3)	High (13)

2.7 Likelihood of Introduction—Quantity Imported and Pest Opportunity

The Likelihood of Introduction is a function of both the quantity of the commodity imported annually, and the opportunity of the pest to follow the pathway. The pest opportunity component consists of five criteria that consider the potential for pest survival along different steps of the pathway (USDA, 2002) (Table 6).

Quantity imported annually
Small quantities (less than ten containers per year) of *M. oleifera* will be imported as a specialty ethnic commodity with irregular shipments (Liquido, 2005); therefore, the ranking for each pest will be Low (1).

Survive post-harvest treatment
The fruit flies *(Bactrocera cucurbitae*, *B. dorsalis* and *Ceratitis capitata)* are ranked High (3) due to their ability to survive minimal post-harvest treatment, such as washing and culling.

The Hemipteran pests (*Aleurodicus dispersus*, *Aonidiella inornata*, *Coccus viridis* and *Pseudococcus cryptus*) are rated Low (1) for their ability to survive post-harvest treatments, such as washing and culling. In contrast to the many host plants of these pests that have cracks and crevices for hiding and protection (Kosztarab, 1996), the smooth *Moringa* pods do not provide tight, protected areas for pests to escape during culling and inspection. Furthermore, the hard and fibrous nature of the pods allow a high-pressure wash to dislodge the waxy and smallest scale insects (most scales are less than 5 mm long) (Gullan & Kosztarab, 1997). Washing, followed by culling and inspection, are a commonly approved post-harvest quarantine procedures to mitigate pests.

Survive shipment
Moringa oleifera is stored between 8-10°C (Wall, 2005). Under such benign conditions, all of the pests are expected to have a High (3) probability of surviving shipment (because all species or representatives from each family have been intercepted at ports-of-entry (PIN 309, 2005)).

Not detected at port-of-entry
As with assessing the risk of pests surviving post-harvest treatment, estimating the risk that these pests will not be detected at a port-of-entry involves consideration of pest size, mobility, and degree of concealment. Internal feeders (*Bactrocera cucurbitae, B. dorsalis,* and *Ceratitis capitata*) have a High (3) potential to evade detection at the port-of-entry, as fruit fly-infested fruit commonly go unrecognized (White & Elson-Harris, 1992).

External feeders (*Aleurodicus dispersus*, *Aonidiella inornata*, *Coccus viridis* and *Pseudococcus cryptus*) are ranked Low (1). The smooth surface of the pods does not provide concealment for these hemipterous pests. Inspection is an approved component of post-harvest quarantine mitigation for these pests.

Moved to suitable habitat
All pests (*A. dispersus, A. inornata, B. cucurbitae, B. dorsalis, C. capitata*, *C. viridis* and *P. cryptus*) are rated Medium (2) due to their ability to survive subtropical or tropical conditions. In the continental United States, those regions are limited to the South and the West Coast, which comprise an estimated 10-12% of the total land area.

Contact with host material

Because *A. dispersus*, *B. cucurbitae*, *B. dorsalis* and *C. capitata* have winged-adult stages capable of long distance flight, and because these species are highly polyphagous, it is highly likely they will come into contact with suitable hosts in the continental United States, should they be introduced (USDA, 2003); consequently, these pests are rated High (3) for this sub-element. The sessile nature of *A. inornata*, *C. viridis* and *P. cryptus* severely limits their chances to locate suitable hosts (Miller, 1985; Gullan & Kosztarab, 1997). Successful establishment of these insects in a new environment is contingent on the likelihood of at least two necessary conditions occurring: close proximity of susceptible hosts and their presence on the imported fruit of crawlers or other mobile forms to transfer to new hosts. Since these circumstances are highly unlikely to co-occur (Miller, 1985), these particular pests receive a risk rating of Low (1).

Table 6 summarizes the ratings for Likelihood of Introduction.

Low: 6 – 9 points
Medium: 10 – 14 points
High: 15 – 18 points

Table 6. Risk Rating for Likelihood of Introduction (*Moringa oleifera* from Hawaii).

Pest	Quantity imported annually	Survive Post-harvest treatment	Survive shipment	Not detected at port-of-entry	Moved to suitable habitat	Contact with host material	Cumulative Risk Rating
Aleurodicus dispersus Russell	Low (1)	Low (1)	High (3)	Low (1)	Medium (2)	High (3)	Medium (11)
Aonidiella inornata (McKenzie)	Low (1)	Low (1)	High (3)	Low (1)	Medium (2)	Low (1)	Medium (9)
Bactrocera cucurbitae (Coquillett)	Low (1)	High (3)	High (3)	High (3)	Medium (2)	High (3)	High (15)
Bactrocera dorsalis (Hendel)	Low (1)	High (3)	High (3)	High (3)	Medium (2)	High (3)	High (15)
Ceratitis capitata (Wiedemann)	Low (1)	High (3)	High (3)	High (3)	Medium (2)	High (3)	High (15)
Coccus viridis (Green)	Low (1)	Low (1)	High (3)	Low (1)	Medium (2)	Low (1)	Medium (9)
Pseudococcus cryptus Hempel	Low (1)	Low (1)	High (3)	Low (1)	Medium (2)	Low (1)	Medium (9)

2.8 Conclusion—Pest Risk Potential, Pests Requiring Phytosanitary Measures, and Risk Mitigation Options

The summation of the values for the Consequences of Introduction and the Likelihood of Introduction yield Pest Risk Potential values (USDA, 2002) (Table 7). This is an estimate of the risks associated with importation.

Pest Risk Potential Values:
Low: 11 – 18 points
Medium: 19 – 26 points
High: 27 – 33 points

Table 7. Pest Risk Potential.

Pest	Consequences of Introduction	Likelihood of Introduction	Pest Risk Potential
Aleurodicus dispersus Russell	Medium (13)	Medium (11)	Medium (24)
Aonidiella inornata (McKenzie)	Medium (13)	Medium (9)	Medium (22)
Bactrocera cucurbitae (Coquillett)	High (14)	High (15)	High (29)
Bactrocera dorsalis (Hendel)	High (14)	High (15)	High (29)
Ceratitis capitata (Wiedemann)	High (15)	High (15)	High (30)
Coccus viridis (Green)	High (13)	Medium (9)	Medium (22)
Pseudococcus cryptus Hempel	High (13)	Medium (9)	Medium (22)

The PPQ Guidelines state that a High Pest Risk Potential means that specific phytosanitary measures are strongly recommended, and that port-of-entry inspection is not sufficient to provide phytosanitary security. Pests with a Medium Pest Risk Potential may require specific phytosanitary measures, whereas a value within the Low range does not require mitigation measures.

Based on the Pest Risk Potential of the quarantine significant pests that are likely to follow the movement of *Moringa* pods from Hawaii into the continenatal United States, the appropriate phytosanitary measures to mitigate the risks posed by these pests include the following:

1. Irradiation treatment at a dose of 400 Gy (7 CFR §305.31a) for all quarantine-significant insect pests.

2. Irradiation treatment at a dose of 150 Gy (7 CFR §305.31a) for *Bactrocera* spp. and *Ceratitis capitata*; warm, soapy water wash and brushing (T102-c, PPQ Treatment Manual) for *Aleurodicus dispersus, Aonidiella inornata, Coccus viridis,* and *Pseudococcus cryptus*.

3. Irradiation treatment at a dose of 150 Gy (7 CFR §305.31a) for *Bactrocera* spp and *Ceratitis capitata*; inspection for *Aleurodicus dispersus, Aonidiella inornata, Coccus viridis,* and *Pseudococcus cryptus*.

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