Movement of Melon, *Cucumis melo* L., from Hawaii into the Continental United States

A Qualitative Pathway-Initiated Risk Assessment
September 11, 2006
Rev: Original

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Executive Summary

This risk assessment document examines the risks associated with the movement of melon, *Cucumis melo*, into the continental United States. Information on pests associated with melon in Hawaii revealed that four quarantine pests exist and could be introduced into the continental United States. The quarantine pests likely to follow the movement include four insects.

Insecta:
Bactrocera cucurbitae Coquillett (Diptera: Tephritidae)
Bactrocera dorsalis (Hendel) (Diptera: Tephritidae)
Ceratitis capitata Wiedemann (Diptera: Tephritidae)
Aleurodicus dispersus Russell (Hemiptera: Aleyrodidae)

These quarantine pests were qualitatively analyzed based on international principles and internal guidelines as described in the PPQ Guidelines for Pathway-Initiated Pest Risk Assessments, Version 5.02 (USDA APHIS, 2000). The following document examines pest biology in order to estimate the Pest Risk Potential. All six of these pests pose phytosanitary risks to the United States, and were given risk ratings of High or Medium. Port-of-entry inspections, as a sole mitigative measure, are considered insufficient to safeguard the U.S. from these pests; additional phytosanitary measures are necessary to reduce risks to acceptable levels.

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I. Introduction

The Plant Epidemiology and Risk Analysis Laboratory (PERAL) of the U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ), Center for Plant Health Science and Technology (CPHST) prepared this pest risk assessment to examine plant pest risks associated with the movement of melon, *Cucumis melo*, from Hawaii into the continental United States. This is a qualitative risk assessment, *i.e.*, estimates of risk are expressed in qualitative terms of High, Medium, and Low rather than probabilities or frequencies. Risk is characterized according to PPQ Guideline 5.02, which is available on the internet at http://www.aphis.usda.gov/ppq/commodity/cpraguide.pdf.

The International Plant Protection Convention (IPPC) of the United Nations, the Food and Agriculture Organization (FAO) provides guidance for conducting pest risk analyses. The methods used to initiate, conduct, and report pest risk assessments are consistent with standards provided by IPPC. The use of biological and phytosanitary terms conforms to the Glossary of Phytosanitary terms (IPPC, 1999). These guidelines describe three stages of pest risk analysis: Stage 1, Initiation, Stage 2, Risk Assessment, and Stage 3, Risk Management. This document satisfies the requirements of IPPC Stage 1 and 2.

II. Risk Assessment

2.1. Initiating Event: Proposed Action

This commodity-based, pathway-initiated assessment is in response to a request for USDA authorization to allow imports of a particular commodity presenting a potential plant pest risk. In this case, the movement of *Cucumis melo* grown in Hawaii is a potential pathway for the introduction of plant pests into the continental United States. Title 7 of the Code of Federal Regulations 318, Part 13 (7CFR § 318.13) provides regulatory authority for the importation of fruits and vegetables from Hawaii into the continental United States.

2.2. Assessment of Weediness Potential of *Cucumis melo*

This step is important to the initiation phase of the assessment process because, if the species considered for importation poses a risk as a weed pest, then a “pest-initiated” pest risk assessment may be prompted. If the species to be imported passes the weediness screening, the pathway-initiated pest risk assessment continues. The results of the weediness screening for *C. melo* did not prompt a pest-initiated risk assessment because it is not considered to be a weed in the continental United States (Table 1).

Table 1. Assessment of Weediness Potential of Cucumis melo

Commodity: Fruits of *Cucumis melo*

Phase 1: *Cucumis melo* is widely cultivated in the continental United States (USDA NRCS, 2005).

Phase 2: Answer Yes or No to the following questions:

Yes	Geographic Atlas of World Weeds (Holm *et al.*, 1979)
No	World's Worst Weeds (Holm *et al.*, 1977) or World Weeds: Natural Histories and Distribution (Holm *et al.*, 1997)
No	Report of the Technical committee to Evaluate Noxious Weeds: Exotic weeds for Federal Noxious Weed Act (Gunn & Ritchie, 1982).
No	Economically Important Foreign Weeds (Reed, 1977)
Yes	Weed Science Society of America List (WSSA, 1989)
Yes	Are there any literature references indicating weediness (*e.g.*, AGRICOLA, CAB, Biological Abstracts, AGRIS; search on "species name" combined with "weed")

Phase 3: Conclusion

Melon is listed as a "principal" weed in Colombia (it is one of the top five weeds of this particular crop) and is listed as a weed of unknown importance in Ghana, Polynesia and Sudan (Holm *et al.*, 1979). In the United States, *Cucumis melo* var. *dudaim* (L) Naudin is a weed (CDFA, 2005). This variety is a threat to melon production because it hybridizes with all varieties of melons, including commercial cultivars, causing them to yield undesirable fruits (CDFA, 2005). *C. melo* var. *dudaim* has not been reported to occur in Hawaii; thus, a pest-initiated risk assessment for this weed was unnecessary.

2.3. Previous Risk Assessment, Current Status and Pest Interceptions, and Decision History for *Cucumis melo* from the Hawaiian Islands

There is no record of a previous request to ship melon into the continental United States from Hawaii. Based on PIN 309 data, there are no previous interceptions of pests on *C. melo* (USDA APHIS PPQ, 2005); however, there have been pests detected on other *Cucumis* spp. (Table 2).

Table 2. Interceptions on *Cucumis* fruits from the islands of Hawaii, as reported in the PIN 309 database from 1985 to February, 2005.

Organism	Host	County	Imported As	Where Intercepted	Number of Interceptions
Bactrocera cucurbitae	*Cucumis sativus*	Hawaii	Fruit	Baggage	26
Bactrocera cucurbitae	*Cucumis* spp.	Hawaii	Fruit	Baggage	2
Dacus cucurbitae	*Cucumis sativus*	Hawaii	Fruit	Baggage	4
Dacus cucurbitae	*Cucumis sativus*	Hawaii	Fruit	Permit Cargo	1
Bactrocera dorsalis	*Cucumis sativus*	Hawaii	Fruit	Baggage	1
Bactrocera spp.	*Cucumis sativus*	Hawaii	Fruit	Baggage	1

Organism	Host	County	Imported As	Where Intercepted	Number of Interceptions
Bactrocera spp.	*Cucumis* spp.	Hawaii	Fruit	Baggage	1
Tephritidae	*Cucumis sativus*	Hawaii	Fruit	Baggage	13

2.4. Pest Categorization – Identification of Quarantine Pests and Quarantine Pests Likely to Follow the Pathway

PPQ adheres to the accepted international definition of a quarantine pest: *a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled* (IPPC, 1996; Hopper, 1996). The first step in identifying quarantine pests is to present a comprehensive pest list of potential quarantine pests known to occur in the country or region from which the commodity is to be exported. The list includes all pests in the exporting country associated with the parent species of the proposed export commodity. Because all pests on the list are associated with the plant species, they are considered to be "of potential economic importance" (IPPC, 1996). The listed pests may or may not occur in the United States.

There are two primary components to the definition of quarantine pest (IPPC, 1996; Hopper, 1996). First, a pest must be "of potential economic importance" to be included on the comprehensive list of potential quarantine pests. An organism is considered to be of potential economic importance if scientific evidence, as indicated in the literature, demonstrates that an organism has an association with the plant species being assessed; as a result, all of the listed organisms are potential quarantine pests. Second, to be considered a quarantine pest, an organism must satisfy geographic and regulatory criteria, specifically, the pest must be "not yet present there or present but not widely distributed and being officially controlled" (IPPC, 1996; Hopper, 1996).

The information collected in the risk assessment documents how each organism satisfies these criteria. Pertinent geographic and regulatory information, *i.e.*, with respect to the exporting country and the United States, is provided on the comprehensive pest list. If none of the potential quarantine pests satisfy the geographic and regulatory criteria as a quarantine pest, the PRA stops. Table 3 shows the pest list for *Cucumis melo* from Hawaii; this pest list identifies: (1) the presence or absence of these pests in the United States, (2) the generally affected plant part or parts, (3) the quarantine status of the pest with respect to the United States, (4) whether the pest is likely to follow the pathway to enter the United States on commercially exported litchi, and (5) pertinent citations for either the distribution or the biology of the pest. A pest is considered to follow the pathway if it is associated with the fruit.

2.5. Identify Quarantine Pest Likely to Follow the Pathway

Quarantine pests identified as likely to be associated with the potential export commodity are subject to steps 5-7. The biology and pest potential for these pests is documented as completely as possible. It is reasonable to assume quarantine pests will:

– Be present in the exporting country

– Be associated with the commodity at the time of harvest
– Remain with the commodity in viable form during harvesting, packing and shipping procedures

Because pests associated with the parent species are listed, there will be quarantine pests not expected to follow the pathway; for example, a pest may be associated only with plant parts other than the commodity, or a pest may not be reasonably expected to remain with the commodity during harvest and packing.

Pests not expected to follow the pathway are not further considered. Supporting information must be documented on the pest list or in the text. The decision to not further analyze a particular pest only applies to the current PRA; a pest may pose a different level of risk for the same commodity from a different country or from a different commodity from the same host plant species. Should any pests be intercepted in shipments of the commodity, quarantine action may be taken at the port-of-entry and additional risk analyses may be conducted.

Table 3. Pests in Hawaii associated with melon, *Cucumis melo*.

Pest Scientific Name	Geographic Distribution[1]	Plant Part Affected	Quarantine Pest	Follow Pathway	References
Arthropods					
Acari					
Tetranychus cinnabarinus (Boisduval) (Tetranychidae)	HI, CA, TX	leaf	No	No	CABI, 2004; UCIPM, 2002; Palumbo & Kerns, 1998
Tetranychus desertorum Banks (Tetranychidae)	HI, US	leaf	No	No	UCIPM, 2002
Tetranychus urticae Koch (Tetranychidae)	HI, US	leaf	No	No	UCIPM, 2002
Insecta					
Coleoptera					
Diabrotica barberi Smith & Lawrence (Krysan et al.) (Chrysomelidae)	HI, US	fruit, shoot, flower, root	No	No[2]	CABI, 2004; EPPO, 2005
Diabrotica undecimpunctata Mannerheim (Chrysomelidae)	HI, US	fruit, flower, leaf, root, stem	No	Yes	CABI, 2004; UCIPM, 2002
Carpophilus freemani Dobson (Nitidulidae)	HI, US	fruit	No	Yes	UCIPM, 2002

[1] HI = Hawaii, US = United States (specific states were listed only if the distribution was limited: CA = California; FL = Florida; TX = Texas)
[2] Large, mobile arthropods that typically feed externally (and only occasionally) on fruits were considered not likely to follow the pathway because minimal processing of the commodity would remove these pests prior to shipment.

Pest Scientific Name	**Geographic Distribution[1]**	**Plant Part Affected**	**Quarantine Pest**	**Follow Pathway**	**References**
Carpophilus hemipterus (Linnaeus) (Nitidulidae)	HI, US	fruit	No	Yes	UCIPM, 2002
Carpophilus mutilatus Erichson (Nitidulidae)	HI, US	fruit	No	Yes	UCIPM, 2002
Dermaptera					
Forficula auricularia Linnaeus (Forficulidae)	HI, US	fruit	No	Yes	UCIMP, 2002
Diptera					
Liriomyza huidobrensis (Blanchard) (Agromyzidae)	HI, CA	leaf	No	No	CABI, 2004
Liriomyza sativae Blanchard (Agromyzidae)	HI, US	leaf	No	No	CABI, 2004; UCIPM, 2002
Liriomyza trifolii Burgess in Comstock (Agromyzidae)	HI, US	leaf	No	No	CABI, 2004; Palumbo & Kerns, 1998; UCIPM, 2002
Delia platura (Meigen) (Anthomyiidae)	HI, US	germinating seed, seedling	No	No	Palumbo & Kerns, 1998;
Drosophila melanogaster Meigen (Drosophilidae)	HI, US	fruit	No	Yes	UCIPM, 2002
Atherigona orientalis Schiner (Muscidae)	HI, US	fruit, flower, leaf, root, stem	No	Yes	CABI, 2004
Bactrocera cucurbitae Coquillett (Tephritidae)	HI	fruit, flower, leaf, root, stem	Yes	Yes	CABI, 2004
Bactrocera dorsalis (Hendel) (Tephritidae)	HI, CA, FL	fruit	Yes	Yes	CABI, 2004
Ceratitis capitata Wiedemann (Tephritidae)	HI, CA	fruit	Yes	Yes	Liquido *et al.*, 1998; CABI, 2004
Hemiptera					
Aleurodicus dispersus Russell (Aleyrodidae)	HI, FL	leaf, fruit	Yes	Yes	CABI, 2004; EPPO, 2004; Martin Kessing & Mau, 1993
Aleyrodes spiraeoides Quaintance (Aleyrodidae)	HI, CA	leaf	Yes	No	UCIPM, 2002

Pest Scientific Name	**Geographic Distribution**[1]	**Plant Part Affected**	**Quarantine Pest**	**Follow Pathway**	**References**
Bemisia argentifolii (Gennadius) (Aleyrodidae)	HI, US	leaf	No	No	Palumbo & Kerns, 1998
Bemisia tabaci (Gennadius) (Aleyrodidae)	HI, US	leaf, vector of viruses	No	No	UCIPM, 2002
Trialeurodes vaporariorum Westwood (Aleyrodidae)	HI, US	fruit, flower, leaf, stem	No	No	CABI, 2004; UCIPM, 2002; Brown, 2003; Martin Kessing & Mau, 1991
Aphis fabae Scopoli (Aphididae)	HI, US	shoot, flower, leaf	No	No	CABI, 2004
Aphis gossypii Glover (Aphididae)	HI, US	vector of viruses, shoot, leaf, fruit	No	No	CABI, 2004; Palumbo & Kerns, 1998
Myzus persicae Sulzer (Aphididae)	HI, US	vector of viruses	No	No	Palumbo & Kerns, 1998
Pseudococcus jackbeardsleyi Gimpel and Miller (Pseudococcidae)	HI, FL, TX	fruit, leaf	No	Yes	CABI, 2004; USDA ARS SEL, 2005; Mau & Martin Messing, 1993
Lepidoptera					
Agrotis ipsilon (Hufnagel) (Noctuidae)	HI, US	seedling	No	No	Palumbo & Kerns, 1998
Chrysodeixis eriosoma Doubleday (Noctuidae)	HI	fruit, leaf	Yes	No[3]	CABI, 2004; EPPO, 2004; Mau & Kessing, 1991
Eudocima fullonia (Clerck) (Noctuidae)	HI	fruit	Yes	No[4]	CABI, 2004
Helicoverpa zea (Boddie) (Noctuidae)	HI, US	fruit, shoot, flower, leaf, seed	No	Yes	CABI, 2004
Peridroma saucia (Hübner) (Noctuidae)	HI, US	fruit, shoot, flower, leaf, seed, stem, seedling	No	Yes	CABI, 2004; Palumbo & Kerns, 1998

[3] *Chrysodeixis eriosoma* is unlikely to follow the pathway with melon fruits. Larvae are leaf feeders and may feed on young fruits. It is unlikely to be associated with mature fruits. *C. eriosoma* is a looper and a external mobile feeder; it is unlikly to remain on the melon fruits during the harvesting, sorting, and packing.
[4] Adult of *Eudocima fullonia* is a fruit-sucking, external-feedng insect. No record shows that larva of *E. fullonia* attacks melon; therefore, it is unlikely to follow the pathway.

Pest Scientific Name	Geographic Distribution[1]	Plant Part Affected	Quarantine Pest	Follow Pathway	References
Spodoptera exigua (Hübner) (Noctuidae)	HI, US	fruit, shoot, flower, leaf	No	Yes	CABI, 2004; Palumbo & Kerns, 1998; UCIPM, 2002
Trichoplusia ni (Hübner) (Noctuidae)	HI, US	leaf, seedling, fruit	No	Yes	CABI, 2004; Palumbo & Kerns, 1998; UCIPM, 2002
Thysanoptera					
Frankliniella occidentalis (Pergande) (Thripidae)	HI, US	flower, leaf, shoot	No	No	CABI, 2004; UCIPM, 2002
Thrips palmi Karny (Thripidae)	HI, FL	fruit, shoot, leaf	Yes	No[5]	CABI, 2004; Martin & Mau, 1992; Capinera, 2004
Thrips tabaci Lindeman (Thripidae)	HI, US	shoot, flower, leaf	No	No	CABI, 2004
Molluscs					
Stylommatophora					
Achatina fulica Bowdich (Achatinidae)	HI, FL	fruit, shoot, leaf, root, stem	Yes	No[6]	CABI, 2004
Nematodes					
Helicotylenchus multicinctus (Cobb) Golden (Hoplolaimidae)	HI, US	root	No	No	CABI, 2004
Rotylenchulus reniformis Linford & Oliveira (Hoplolaimidae)	HI, US	root	No	No	CABI, 2004; Zitter *et al.*, 1996
Meloidogyne arenaria (Neal) Chitwood (Meloidogynidae)	HI, US	root	No	No	Zitter *et al.*, 1996; CABI, 2004
Meloidogyne incognita (Kofoid & White) Chitwood (Meloidogynidae)	HI, US	root	No	No	UCIPM, 2002; Zitter *et al.*, 1996
Meloidogyne javanica (Treub.) Chitwood (Meloidogynidae)	HI, US	root	No	No	UCIPM, 2002; Zitter *et al.*, 1996
Plant Pathogens					

[5] Infestation by *Thrips palmi* occurs in young fruit and results in deformities and and consequent abortion. *Thrips palmi* is not likely to be associated with commercial grade commodity.
[6] Due to size of this snail, it is unlikely to remain on the fruits during harvesting, sorting, and packing and to follow the pathway with melon fruits.

Pest Scientific Name	**Geographic Distribution**[1]	**Plant Part Affected**	**Quarantine Pest**	**Follow Pathway**	**References**
Bacteria					
Erwinia carotovora subsp. *carotovora* (Jones) Bergey et al. (Enterobacteriale: Enterobacteriaceae)	HI, US	shoot, leaf, root, stem, fruit	No	Yes	CABI, 2004; Zitter *et al.*, 1996
Rhizobium radiobacter (Beijerinck & van Delden) Young et al. (Rhizobiales: Rhizobiaceae)	HI, US	fruit, root, stem	No	Yes	CABI, 2004
Rhizobium rhizogenes (Riker et al.) Young et al. (Rhizobiales: Rhizobiaceae)	HI, US	fruit, root, stem	No	No[7]	CABI, 2004
Fungi					
Alternaria alternata (Fr.:Fr.) Keissl. (Ascomycetes: Pleosporales)	HI, US	fruit	No	Yes	CABI, 2004; USDA ARS SBML, 2005; Nishijima, 1993; Zitter *et al.*, 1996
Alternaria brassicae (Berk.) Sacc. (Ascomycetes: Pleosporales)	HI, US	fruit, flower, leaf, seed, stem	No	Yes	CABI, 2004
Alternaria brassicicola (Schwein.) Wiltshire (Ascomycetes: Pleosporales)	HI, US	fruit, flower, leaf, seed, stem	No	Yes	CABI, 2004
Alternaria cucumerina (Ascomycetes: Pleosporales) Syn: *Macrosporium cucumerinum*	HI, US	leaf, fruit	No	Yes	CABI, 2004; USDA ARS SBML, 2005; Kucharek, 2000; Zitter *et al.*, 1996
Alternaria tenuissima (Kunze) Wiltshire (Ascomycetes: Pleosporales)	HI, US	leaf, stem, branch	No	No	USDA ARS SBML, 2005
Aspergillus niger Teigh. (Ascomycetes: Eurotiales)	HI, US	fruit, flower, leaf, root, seed, stem	No	Yes	CABI, 2004

[7] *Rhizobium rhizogenes* is not transferred with fruit and is mainly carried by growing medium, seedlings, roots, and stem (CABI, 2004).

Pest Scientific Name	**Geographic Distribution**[1]	**Plant Part Affected**	**Quarantine Pest**	**Follow Pathway**	**References**
Athelia rolfsii (Curzi) C. C. Tu & Kimbr. (Basidiomycetes: Polyporales) Syn: *Corticium rolfsii* Syn: *Pellicularia rolfsii* Syn: *Sclerotium rolfsii*	HI, US	root, fruit	No	Yes	USDA ARS SBML, 2005; Zitter *et al.*, 1996
Botryosphaeria ribis Grossenb. & Duggar (Ascomycetes: Dothideales)	HI, US	fruit, shoot, flower, leaf, stem	No	Yes	USDA ARS SBML, 2005
Botrytis cinerea Pers.:Fr. (Ascomycetes: Helotiales)	HI, US	leaf, stem, seed, fruit	No	Yes	USDA ARS SBML, 2005
Cercospora apii Fresen (Ascomycetes: Mycosphaerellales)	HI, US	leaf	No	No	USDA ARS SBML, 2005
Cercospora citrullina Cooke (Ascomycetes: Mycosphaerellales) Syn: *Cercospora cucurbitae*	HI, US	leaf, stem, fruit	No	No[8]	USDA ARS SBML, 2005; Zitter *et al.*, 1996
Chaetomium globosum Kunze:Fr. (Ascomycetes: Sordariales) Syn: *Chaetomium cochliodes*	HI, US	leaf, root	No	No	USDA ARS SBML, 2005; CABI, 2004
Chalara elegans Nag Raj & W.B. Kendr. (Ascomycetes) = *Thielaviopisis basicola*	HI, US	fruit, leaf, root	No	Yes	CABI, 2004; UCIPM, 2002
Choanephora cucurbitarum (Zygomycetes: Mucorales)	HI, US	flower, fruit	No	Yes	Zitter *et al.*, 1996; CABI, 2004
Cochliobolus lunatus R.R. Nelson & Haasis (Ascomycetes: Pleosporales)	HI, US	flower, leaf, seed	No	No	CABI, 2004

[8] Fruit size and quality are affected; no infection on fruit occurs.

Pest Scientific Name	**Geographic Distribution**[1]	**Plant Part Affected**	**Quarantine Pest**	**Follow Pathway**	**References**
Colletotrichum orbiculare (Berk. & Mont.) Arx (Ascomycetes: Phyllachorales) Syn: *Colletotrichum lagenarium* Syn: *Glomerella lagenarium*	HI, US	fruit, leaf, stem	No	Yes	CABI, 2004; USDA ARS SBML, 2005; UCIPM, 2002; Zitter *et al*., 1996
*Corynespora cassiicol*a (Berk. & M.A. Curtis) C.T. Wei (Ascomycetes: Pleosporales)	HI, US	leaf, fruit	No	Yes	USDA ARS SBML, 2005; AVRDC, 2001; Zitter *et al*., 1996
Didymella bryoniae (Auersw.) Rehm (Ascomycetes: Pleosporales) Syn: *Mycosphaerella citrullina* Syn: *Ascochyta cucumis* Ana: *Phoma cucurbitacearum*	HI, US	stem, fruit, leaf	No	Yes	CABI, 2004; USDA ARS SBML, 2005; Zitter *et al*., 1996
Epicoccum nigrum Link (Ascomycetes)	HI, US	fruit	No	Yes	CABI, 2004; Zitter *et al*., 1996
Erysiphe cichoracearum DC (Ascomycetes: Erysiphales)	HI, US	shoot, leaf, stem, petiole	No	No	USDA ARS SBML, 2005; UCIPM, 2002; Zitter *et al*., 1996
Erysiphe communis (Wallr.) Link (Ascomycetes: Erysiphales)	HI, US	fruit	No	Yes	USDA ARS SBML, 2005; CABI, 2004
Erysiphe polygoni DC. (Ascomycetes: Erysiphales)	HI, US	fruit, leave, stem, seed	No	Yes	USDA ARS SBML, 2005; CABI, 2004
Fusarium acuminatum Ellis & Everh. (Ascomycetes: Hypocreales) Syn: *Fusarium scirpi var. acuminatum*	HI, US	root, stem, fruit	No	Yes	USDA ARS SBML, 2005; Zitter *et al*., 1996
Fusarium chlamydosporum Wollenweb. & Reinking (Ascomycetes: Hypocreales)	HI, US	root	No	No	USDA ARS SBML, 2005

Pest Scientific Name	Geographic Distribution[1]	Plant Part Affected	Quarantine Pest	Follow Pathway	References
Fusarium culmorum (W.G. Sm.) Sacc. (Ascomycetes: Hypocreales)	HI, US	root, stem, fruit	No	Yes	USDA ARS SBML, 2005; Zitter *et al.*, 1996
Fusarium equiseti (Corda) Sacc. (Ascomycetes: Hypocreales) Syn: *Fusarium scirpi* Syn: *Fusarium scirpi var. compactum*	HI, US	root, fruit	No	Yes	USDA ARS SBML, 2005; Zitter *et al.*, 1996
Fusarium graminearum Schwabe (Ascomycetes: Hypocreales)	HI, US	fruit, leaf, root, stem, seed	No	Yes	USDA ARS SBML, 2005; Zitter *et al.*, 1996
Fusarium moniliforme J. Sheld. (Ascomycetes: Hypocreales)	HI, US	fruit, leaf, root, seed, stem	No	Yes	USDA ARS SBML, 2005; Zitter *et al.*, 1996
Fusarium moniliforme var. subglutinans Wollenweb. & Reinking (Ascomycetes: Hypocreales) Syn: *Fusarium subglutinans*	HI, US	seedling, root	No	No	USDA ARS SBML, 2005
Fusarium oxysporum f. sp. niveum (E.F.Sm.) Snyder & H.N. Hansen (Ascomycetes: Hypocreales) Syn: *Fusarium bulbigenum var. niveum* Basionym: *Fusarium niveum*	HI, US	fruit, leaf, root, stem, seed	No	Yes	USDA ARS SBML, 2005; Zitter *et al.*, 1996; Ferreira & Boley, 1991
Fusarium oxysporum f.sp. melonis W.C. Snyder & H.N. Hansen (Ascomycetes: Hypocreales)	HI, US	root, leaf, seeding, stem, fruit	No	Yes	CABI, 2004; USDA ARS SBML, 2005; UCIPM, 2002; Zitter *et al.*, 1996
Fusarium oxysporum f.sp. vasinfectum (G.F. Atk.) W.C. Snyder & H.N. Hansen (Ascomycetes: Hypocreales)	HI, US	leaf	No	No	USDA ARS SBML, 2005

Pest Scientific Name	Geographic Distribution[1]	Plant Part Affected	Quarantine Pest	Follow Pathway	References
Fusarium oxysporum Schlechtend.:Fr. (Ascomycetes: Hypocreales)	HI, US	leaf, fruit, root, stem, seed	No	Yes	USDA ARS SBML, 2005; CABI, 2004
Fusarium pallidoroseum (Cooke) Sacc. (Ascomycetes: Hypocreales)	HI?, US	fruit	No	Yes	CABI, 2004
Fusarium roseum Link:Fr. (Ascomycetes: Hypocreales)	HI, US	fruit	No	Yes	USDA ARS SBML, 2005; Carter, 1979
Fusarium semitectum Berk. & Ravenel (Ascomycetes: Hypocreales)	HI, US	fruit, stem, leaf	No	Yes	USDA ARS SBML, 2005; Zitter *et al*., 1996
Fusarium solani (Mart.) Sacc. (Ascomycetes: Hypocreales) = *Nectria haematococca*	HI, US	leaf, stem, root, fruit	No	Yes	USDA ARS SBML, 2005; CABI, 2004; Zitter *et al*., 1996
Fusarium solani f.sp. cucurbitae W.C. Snyder & H.N. Hansen (Ascomycetes: Hypocreales)	HI, US	root	No	No	USDA ARS SBML, 2005; CABI, 2004
Geotrichum candidum Link (Saccharomycetes: Saccharomycetales)	HI, US	root	No	No	CABI, 2004; USDA ARS SBML, 2005; Holmes and Clark, 2002
Glomerella cingulata (Stonem.) Spauld. & Schrenk (Ascomycetes)	HI, US	fruit, flower, leaf, stem	No	Yes	CABI, 2004; USDA ARS SBML, 2005
Hypocrea rufa (Pers.) Fr. (Ascomycetes: Hypocreales)	HI, US	wood	No	No	CABI, 2004
Lasiodiplodia theobromae (Ascomycetes: Dothideales) Syn: *Botryodiplodia theobromae* Syn: *Diplodia natalensis* Tele: *Physalospora rhodina*	HI, US	fruit, shoot, flower, leaf, root, seed, stem	No	Yes	CABI, 2004; USDA ARS SBML, 2005; Zitter *et al*., 1996

Pest Scientific Name	Geographic Distribution[1]	Plant Part Affected	Quarantine Pest	Follow Pathway	References
Leveillula taurica (Lév.) G. Arnaud (Ascomycetes: Erysiphales)	HI, US	shoot, leaf, stem	No	No	CABI, 2004; USDA ARS SBML, 2005
Macrophomina phaseolina (Tassi) Goidanich (Ascomycetes) Syn: *Macrophomina phaseoli*	HI, US	leaf, root, seed, stem, fruit	No	Yes	CABI, 2004; USDA ARS SBML, 2005; UCIPM, 2002; Zitter *et al*., 1996
Microdochium tabacium (J.F.H. Beyma) Arx (Ascomycetes: Xylariales)	HI, US	stem, fruit, leaf	No	Yes	Zitter *et al*., 1996; USDA ARS SBML, 2005
Monilia sitophila (Mont.) Sacc. (Ascomycetes: Helotiales)	HI, US	stem	No	No	USDA ARS SBML, 2005; CABI, 2004
Monosporascus cannonballus Pollack & Uecker (Ascomycetes: Sordariales)	HI, US	root	No	No	Ferreira and Boley, 1992
Myrothecium roridum Tode (Ascomycetes: Hypocreales)	HI, US	leaf, petiole, fruit, stem	No	Yes	CABI, 2004; USDA ARS SBML, 2005; Zitter *et al*., 1996
Penicillium digitatum (Pers.: Fr.) Sacc. (Ascomycetes: Eurotiales)	HI, US	fruit	No	Yes	USDA ARS SBML, 2005; Zitter *et al*., 1996
Penicillium viridicatum Westling (Ascomycetes: Eurotiales)	HI, US	fruit	No	Yes	CABI, 2004; Zitter *et al*., 1996
Peronospora parasitica (Pers.) Fr. (Oomycetes: Peronosporales)	HI, US	fruit, flower, leaf, stem, seed	No	Yes	USDA ARS SBML, 2005; CABI, 2004
Phoma eupyrena Sacc. (Ascomycetes: Pleosporales)	HI, US	seedling	No	No	CABI, 2004
Phytophthora capsici Leonian (Oomycetes: Pythiales)	HI, US	root, stem, fruit	No	Yes	USDA ARS SBML, 2005; Zitter *et al*., 1996
Phytophthora citrophthora (R.E. Sm. & E.H. Sm.) Leonian (Oomycetes: Pythiales)	HI, US	fruit, leaf, root, stem	No	Yes	USDA ARS SBML, 2005; Zitter *et al*., 1996

Pest Scientific Name	**Geographic Distribution[1]**	**Plant Part Affected**	**Quarantine Pest**	**Follow Pathway**	**References**
Phytophthora cryptogea Pethybr. & Laff (Oomycetes: Pythiales)	HI, US	leaf, root, stem, fruit	No	Yes	CABI, 2004; Zitter *et al*., 1996
Phytophthora drechsleri Tucker (Oomycetes: Pythiales)	HI, US	root, fruit	No	Yes	CABI, 2004; USDA ARS SBML, 2005; Zitter *et al*., 1996
Phytophthora nicotianae var. parasitica (Dastur) G.M. Waterhouse (Oomycetes: Pythiales) Basionym: *Phytophthora parasitica*	HI, US	fruit, shoot, leaf, root, stem	No	Yes	USDA ARS SBML, 2005; Zitter *et al*., 1996
Plectosporium tabacinum (J.F.H. Beyma) M.E. Palm, W. Gams & Nirenberg (Ascomycetes: Phyllachorales)	HI, US	stem, leaf, fruit	No	Yes	USDA ARS SBML, 2005; Hansen, 2000
Pleospora herbarum Pers.:Fr.) Rabenh. (Ascomycetes: Pleosporales)	HI, US	leaf	No	No	USDA ARS SBML, 2005; CABI, 2004
Podosphaera fuliginea (Schltdl.) U. Braun & S. Takam. (Ascomycetes: Erysiphales)	HI, US	flower, leaf, stem	No	No	CABI, 2004
Pseudoperonospora cubensis (Berk. & M.A. Curtis) Rostovtzev (Oomycetes: Peronosporales) Syn: *Peronoplasmopara cubensis* Syn: *Peronospora cubensis*	HI, US	leaf, flower, fruit	No	No[9]	CABI, 2004; USDA ARS SBML, 2005; UCIPM, 2002; Zitter *et al*., 1996
Pyrenochaeta terrestris (Hansen) Gorenz, Walker & Larson (Ascomycetes: Pleosporales) Syn: *Phoma terrestris*	HI, US	root	No	No	USDA ARS SBML, 2005; Zitter *et al*., 1996

[9] Flower and fruits are rarely affected.

Pest Scientific Name	**Geographic Distribution**[1]	**Plant Part Affected**	**Quarantine Pest**	**Follow Pathway**	**References**
Pythium anandrum Drechsler (Oomycetes: Pythiales)	HI, US	root, fruit, seedling	No	Yes	Zitter et al., 1996; USDA ARS SBML, 2005
Pythium aphanidermatum (Edson) Fitzp. (Oomycetes: Pythiales) Syn: *Pythium butleri*	HI, US	root, leaf, fruit	No	Yes	USDA ARS SBML, 2005; CABI, 2004; Zitter *et al*., 1996
Pythium debaryanum Hesse (Oomycetes: Pythiales)	HI, US	root, leaf	No	No	USDA ARS SBML, 2005; Zitter *et al*., 1996
Pythium irregulare Buisman (Oomycetes: Pythiales)	HI, US	root, stem, leaf	No	No	USDA ARS SBML, 2005; Zitter *et al*., 1996
Pythium myriotylum Drechsler (Oomycetes: Pythiales)	HI, US	root, fruit	No	Yes	Zitter *et al*., 1996; USDA ARS SBML, 2005
Pythium oligandrum Drechsler (Oomycetes: Pythiales)	HI, US	fruit	No	Yes	Zitter *et al*., 1996 USDA ARS SBML, 2005
Pythium periplocum Dastur (Oomycetes: Pythiales)	HI, US	fruit, leaf, root	No	Yes	USDA ARS SBML, 2005; Zitter *et al*., 1996
Pythium spinosum Sawada (Oomycetes: Pythiales)	HI, US	root, leaf	No	No	USDA ARS SBML, 2005; Zitter *et al*., 1996
Pythium ultimum Trow (Oomycetes: Pythiales)	HI, US	root, leaf, fruit	No	Yes	USDA ARS SBML, 2005; Zitter *et al*., 1996
Rhizoctonia solani Kuhn (Basidiomycetes: Polyporales)	HI, US	fruit, shoot, flower, leaf, root, seed, stem	No	Yes	USDA ARS SBML, 2005; Zitter *et al*., 1996
Rhizopus stolonifer (Ehrenb.:Fr.) Vuill. (Zygomycetes: Mucorales) Syn: *Rhizopus nigricans*	HI, US	fruit	No	Yes	CABI, 2004; USDA ARS SBML, 2005; Zitter *et al*., 1996
Rhizopus tritici Saito (Zygomycetes: Mucorales)	HI, US	fruit	No	Yes	USDA ARS SBML, 2005
Sclerotinia sclerotiorum (Lib.) de Bary (Ascomycetes: Helotiales)	HI, US	fruit, flower, leaf, root, seed, stem	No	Yes	CABI, 2004; USDA ARS SBML, 2005; Zitter *et al*., 1996

Pest Scientific Name	**Geographic Distribution**[1]	**Plant Part Affected**	**Quarantine Pest**	**Follow Pathway**	**References**
Sphaerotheca fuliginea (Schltdl.) Pollacci (Ascomycetes: Erysiphales)	HI, US	stem, leaf, petiole	No	No	USDA ARS SBML, 2005; UCIPM, 2002; Zitter *et al*., 1996
Trichoderma viride Pers.:fr. (Ascomycetes: Hypocreales)	HI, US	control agent[10]	No	No	USDA ARS SBML, 2005; CABI, 2004;
Trichothecium roseum (Pers.:Fr.) Link (Ascomycetes) Syn: *Cephalothecium roseum*	HI, US	fruit, flower, leaf root stem, seed	No	Yes	USDA ARS SBML, 2005
Verticillium albo-atrum Reinke & Berthier (Ascomycetes: Hypocreales)	HI, US	leaf, root, seed, stem, fruit	No	Yes	USDA ARS SBML, 2005
Verticillium dahliae Kleb. (Ascomycetes: Hypocreales)	HI, US	leaf, stem, root	No	No	CABI, 2004; USDA ARS SBML, 2005; UCIPM, 2002; Zitter *et al*., 1996
Viruses					
Cucumber mosaic virus (Bromoviridae)	HI, US	fruit, leaf	No	Yes	CABI, 2004; UCIPM, 2002; Zitter *et al*., 1996
Papaya ringspot virus (Potyviridae)	HI, US	leaf, fruit	No	Yes	UCIPM, 2002; Zitter *et al*., 1996
Squash mosaic virus	HI, US	leaf, fruit, seed	No	Yes	Zitter *et al*., 1996; CABI, 2004; Brunt, et al., 2005; UCIPM, 2002;
Watermelon mosaic virus (Bunyaviridae)	HI, US	fruit, leaf	No	Yes	CABI, 2004; UCIPM, 2002; Zitter *et al*., 1996
Zucchini yellow mosaic virus	HI, US	fruit, flower, leaf, stem	No	Yes	CABI, 2004; UCIPM, 2002; Zitter *et al*., 1996

Quarantine pests that were expected to follow the pathway, *i.e.*, be included in commercial shipments of *Cucumis melo* fruit, were analyzed in detail (Step 5-7, USDA APHIS, 2000). Other plant pests not chosen for further scrutiny may be potentially detrimental to the United States agricultural production systems; however, there were a variety of reasons for not subjecting them to further analysis. For example, these pests were mainly associated with plant parts other than

[10] *Trichoderma viride* is used as a biological control agent (CABI, 2004; Georgakopoulos *et al*., 2002; Koch, 1999).

the commodity; they were associated with the commodity, but it was not considered reasonable to expect these pests to remain with the commodity during processing; or they were intercepted as biological contaminants of these commodities during inspection by Plant Protection and Quarantine Officers, but would not be expected to be present with every shipment. In addition, the biological hazard of organisms identified only to the generic level is not assessed due to the lack of adequate biological taxonomic information. The lack of biological information on any given insect or pathogen should not be equated with Low risk. By necessity, pest assessments focus on those organisms for which biological information is available. By developing detailed assessments for known pests that inhabit a variety of niches on the parent species, *e.g.*, on the surface of or within the bark/wood, on the foliage, *etc.*, effective mitigation measures may be developed to eliminate the known organism and any similar unknown ones that inhabit the same niches.

The quarantine pests that are likely to follow the pathway of importation on melon, *C. melo*, from Hawaii, that are further analyzed in this risk assessment, are summarized in Table 4.

Table 4. Quarantine Pests Likely to be Associated with Melon Imported from Hawaii

Arthropoda:
Bactrocera cucurbitae Coquillett (Diptera: Tephritidae)
Bactrocera dorsalis (Hendel) (Diptera: Tephritidae)
Ceratitis capitata Wiedemann (Diptera: Tephritidae)
Aleurodicus dispersus Russell (Hemiptera: Aleyrodidae)

2.6 Consequences of Introduction

After identifying those quarantine pests that could reasonably be expected to follow the pathway (Table 2), the assessment of risk continues by considering the Consequences of Introduction (Table 3). For each of these quarantine pests, the potential Consequences of Introduction are rated using five Risk Elements; these elements reflect the biology, host range and climatic/geographic distribution of the pests. For each Risk Element, pests are assigned a rating of Low (1 point), Medium (2 points), or High (3 points). A Cumulative Risk Rating is then calculated by summing all Risk Element values. The values determined for the Consequences of Introduction for each pest are summarized in Table 5.

Risk Element #1: Climate – Host Interaction

When introduced to new areas, pests can be expected to behave as they do in their native areas if host plants and climates are similar. Ecological zonation and the interactions of pests with their biotic and abiotic environments are considered in this element. Estimates are based on the availability of host material and suitable climate conditions. To rate this Risk Element, the U.S. "Plant Hardiness Zones," created by U.S. Department of Agriculture (USDA ARS, 1990), is used (Figure 1). Due to the availability of both suitable host plants and suitable climate, the pest has the potential to establish a breeding colony:

Low (1): In a single plant hardiness zone.
Medium (2): In two or three plant hardiness zones.
High (3): In four or more plant hardiness zones.

If none of the quarantine pests are capable of becoming established in the PRA area because of the absence of suitable climates or hosts, the PRA stops.

Risk Element #2: Host Range

The risk posed by a plant pest depends on its ability to establish a viable, reproductive population, and its potential for causing plant damage. For arthropods, risk is assumed to be positively correlated with host range. For pathogens, risk is more complex and is assumed to depend on host range, aggressiveness, virulence and pathogenicity; for simplicity, risk is rated as a function of host range.

Low (1): Pest attacks a single species or multiple species within a single genus.
Medium (2): Pest attacks multiple species within a single plant family.
High (3): Pest attacks multiple species among multiple plant families.

Risk Element #3: Dispersal Potential

A pest may disperse after introduction to a new area. The following items are considered: reproductive patterns of the pest (*e.g.*, voltinism, biotic potential); inherent powers of movement; factors facilitating dispersal, wind, water, presence of vectors, human, *etc*.

Low (1): Pest has neither high reproductive potential nor rapid dispersal capability.
Medium (2): Pest has either high reproductive potential OR the species is capable of rapid dispersal.
High (3): Pest has high biotic potential, *e.g.*, many generations per year, many offspring per reproduction ("r-selected" species), AND evidence exists that the pest is capable of rapid dispersal, *e.g.*, over 10 km/year under its own power, via natural forces, wind, water, vectors, *etc.*, or human-assistance.

Risk Element #4: Economic Impact

Introduced pests are capable of causing a variety of direct and indirect economic impacts. These impacts are divided into three primary categories (other types of impacts may occur): lower yield of the host crop, *e.g.*, by causing plant mortality, or by acting as a disease vector; lower value of the commodity, *e.g.*, by increasing costs of production, lowering market price, or a combination; loss of foreign or domestic markets due to the presence of a new quarantine pest.

Low (1): Pest causes any one or none of the above impacts.
Medium (2): Pest causes any two of the above impacts.
High (3): Pest causes all three of the above impacts.

Risk Element #5: Environmental Impact

The potential of each pest to cause environmental damage (IPPC, 1996) proceeds by considering the introduction of the pest as it is expected to cause significant, direct environmental impacts, *e.g.*, ecological disruptions, reduced biodiversity. Those damages are categorized into four groups. (1) When used within the context of the National Environmental Policy Act (NEPA) (7CFR §372), significance is qualitative and encompasses the likelihood and severity of an environmental impact; (2) a pest that is expected to have a direct impact on other existing species is listed by federal agencies as endangered or threatened (50CFR §17.11 and §17.12), by infesting/infecting a list plant. If the pest attacks other species within the genus or other genera within the family, and preference/no preference tests have not been conducted with the listed plant and the pest, then the plant is assumed to be a host; (3) the pest is expected to have an indirect impact on the species listed by federal agencies as endangered or threatened by disrupting the sensitive, critical habitats; (4) the introduction of such a pest would stimulate chemical or biological control programs.

Low (1): None of the above would occur. It is assumed that the introduction of a nonindigenous pest will have some environmental impact (by definition, introduction of a nonindigenous species affects biodiversity).
Medium (2): One of the above would occur.
High (3): Two or more of the above would occur.

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 much of subtropical and tropical Asia. It is also reported as present in Eastern and Western Africa, and the Pacific Islands (CABI, 2004). 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, 2005).	Medium (2)
Risk Element #2: Host Range *Bactrocera cucurbitae* is a serious pest of cucurbit crops (CABI, 2004). Primary hosts are 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 americanaunlikely*), Fabaceae (*Phaseolus vulgaris*, *Sesbania grandiflora*, *Vigna unguiculata*), Myrtaceae (*Psidium guajava*, *Syzygium samarangense*), and Rhamnaceae (*Ziziphus jujube*) (CABI, 2004). Wild hosts of *B. cucurbitae* include wild species of Cucurbitaceae and fruits of the following other families: Cucurbitaceae: *Cucumis trigonus* (White and Elson-Harris, 1992), *Diplocyclos palmatus, Gymnopetalum integrifolium, Melothria wallichii, Mukia maderaspatana* (CABI, 2004), *Trichosanthes ovigera*, *T. tricuspidata*, *T. wallichiana* and *T. wawraei* (Allwood *et al*., 1999; CABI, 2004). Agavaceae: *Dracaena curtissi* (Allwood *et al*., 1999); *Capparidaceae: Capparis sepiaria*, *C. thorellii* and *Maerua siamensis* (Allwood *et al*., 1999); Moraceae:	High (3)

Ficus chartacea (Allwood *et al*., 1999); Rutaceae*: Citrus hystrix* (Allwood *et al*., 1999); Solanaceae: *Solanum trilobatum* (Allwood *et al.*, 1999); and Vitaceae: *Tetrastigma lanceolarium* (Allwood *et al*., 1999).	
Risk Element #3: Dispersal Potential Females lay up to 40 eggs below the fruit skin or in vegetative parts of plants. Females may produce 800-1000 eggs over their life span (Capinera, 2001; CABI, 2004; Weems, 1964). Reproduction is continuous, and adults occur throughout the year. Under warm conditions, the development from egg to adult requires 12-28 days (Weems, 1964). Eggs hatch within 1-2 days, and larval stages last for 4-17 days, depending on the thickness of the fruit's skin (CABI, 2004). Pupation takes place in the soil under the host plant(s) for 7-13 days (CABI, 2004). Adults start mating after 10-12 days and may live 5-15 months (CABI, 2004). The fruit fly may naturally disperse by flight. Fletcher (1989) reports that many Bactrocera species can fly 50-100 km. Additionally, *B. cucurbitae* can be dispersed by infected plant materials, such as fruits and flowers (CABI, 2004). In commodities originating from Hawaii alone, it has been intercepted at ports-of-entry over 150 times (USDA APHIS PPQ, 2005).	High (3)
Risk Element #4: Economic Impact *Bactrocera cucurbitae* has been considered the most destructive pest of cucurbits in the Indo-Malayan region (Weems 1964; USDA 1983), reducing the production of melons, cucumbers, tomatoes, and similar vegetables in Hawaii (Weems 1964; USDA 1983). Around 1915, *B. cucurbitae* caused a loss of nearly $1 million in Hawaii (in terms of destroyed crops). For example, more than 95% of the pumpkin crop was destroyed. Damage levels have been reported to be anything up to 100% of unprotected fruit (CABI, 2002). If *B. cucurbitae* were introduced into the continental United States, an eradication program would be implemented to eliminate the pest before widespread damage. Similar eradication programs for other Tephritidae fruit flies (*i.e., B. dorsalis* and *Ceratitis capitata)* have cost an average of $10 million per introduction. EPPO (2004c) records this as an A1 pest; thus, should this species become established in the United States, there would likely be a loss of export markets. Losses in export revenue of fruit fly susceptible hosts could amount to over $300 million annually (Vo & Miller, 1989).	High (3)
Risk Element #5: Environmental Impact *Bactrocera cucurbitae* has a high 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). Threatened and endangered species, such as *Cucurbita okeechobeensis* spp. *okeechobeensis* (endangered species in FL), *Prunus geniculata* (endangered species in FL), and *Ziziphus celaata* (endangered species in FL), are likely to be damaged by *B. cucurbitae* (USFWS, 2002). Since this fruit fly represents an important economic threat, the establishment and introduction of *B. cucurbitae* in the continental United States would trigger the initiation of eradication programs using biological and chemical methods.	High (3)

Cumulative Risk Rating: 14/15

Consequences of Introduction: ***Bactrocera dorsalis*** **(Hendel) (Diptera: Tephritidae)**	**Risk Value**
Risk Element #1: Climate – Host Interaction Oriental fruit fly, *B. dorsalis*, exists in the tropical and subtropical regions of Asia, Guam, and Hawaii (CABI, 2004). Its distribution corresponds to U.S. Plant Hardiness Zones 9-11 (USDA ARS, 1990).	Medium (2)
Risk Element #2: Host Range *Bactrocera dorsalis* is a serious pest to a wide range of plant species (CABI, 2004). Its host species include Cucurbitaceae (*Cucumis melo, C. sativus, Momordica charantia*), Moraceae (*Artocarpus altilis, A. heterophyllus, Ficus racemosa*), Rutaceae (*Aegle marmelos, Citrus aurantiifolia, C. maxima, C. reticulata*), Anacardiaceae (*Anacardium occidentale, Mangifera foetida, Spondias purpurea, Mangifera indica*), Arecaceae (*Areca catechu*), Rubiaceae (*Coffea Arabica*), Sapotaceae (*Chrysophyllum cainito, Mimusops elengi, Manilkara zapota*), Sapindaceae (*Dimocarpus longan, Nephelium lappaceum, Litchi chinensis*), Ebenaceae (*Diospyros kaki*), Flacourtiaceae (*Flacourtia indica*), Rosaceae (*Prunus avium*, *P. cerasus, P. mume, P. persica, P. armeniaca*, *P. domestica*, *Malus pumila*, *Pyrus communis*), Punicaceae (*Punica granatum*), Myrtaceae (*Psidium guajava, Syzygium aromaticum, S. cumini, S. aqueum, S. jambos*, *S. malaccense*, *S. samarangense*), Rhamnaceae (*Ziziphus jujuba*, *Z. mauritiana*), Annonaceae (*Annona reticulata*, *A. squamosa*), Oxalidaceae (*Averrhoa carambola*), Caricaceae (*Carica papaya*), Solanaceae (*Capsicum annuum*), Malpighiaceae (*Malpighia glabra*), Musaceae (*Musa* spp.), Tiliaceae (*Muntingia calabura*), Lauraceae (*Persea americana*), and Combretaceae (*Terminalia catappa*) (CABI, 2004).	High (3)
Risk Element #3: Dispersal Potential The life-cycle of *B. dorsalis* varies with seasons and locations (CABI, 2004); however, it completes one generation in about 30 days (Capinera, 2001). In Hawaii, the average life-cycle takes about 16 days (Mau & Martin, 1992). Females deposit eggs under the skin of fruit in clusters of 10-50 eggs; the total fecundity per female is approximately 1200-1500 eggs, but may be greater than 3000 eggs under optimum conditions (Mau & Martin, 1992). Eggs hatch within a day (CABI, 2004; Mau & Martin, 1992), and the larva stage typically lasts 11-15 days in Hawaii (Mau & Martin, 1992). Pupation is in the soil occurs between 10-12 days (CABI, 2004; Mau & Martin, 1992). The major means of dispersal is through the transportation of infested fruits (CABI, 2004); the oriental fruit fly can fly distances of up to 65 km (Fletcher, 1989).	High (3)

Risk Element #4: Economic Impact	
Risk Element #4: Economic Impact *Bactrocera dorsalis* is a serious pest of a wide range of fruits and vegetables. This pest can damage up to 100% of fruits and vegetables if the plants are not protected (CABI, 2004). Economic losses resulting from the attack by this pest are of three kinds (Harris, 1989): 1) downgrading of quality caused by oviposition "stings," which spoil the appearance of fruits, including those unfavorable for larval survival; 2) fruit spoilage caused by larval tunneling and the entry of organisms of decay; and 3) indirect damage in the form of lost markets resulting from the imposition of quarantine restrictions. In Hawaii, papaya is the primary host for oriental fruit fly (Mau & Martin, 1992). In 2003, papaya production in Hawaii was more than $13 million (USDA NASS, 2004a).	High (3)
Risk Element #5: Environmental Impact Because of a wide host range, *B. dorsalis* has a high potential to harm threatened or/and endangered species. In particular, the endangered species, Scrub plum (*Prunus geniculata*) and Florida ziziphus (*Ziziphus celata*), can both be attacked by *B. dorsalis* (USFWS, 2002). Because the oriental fruit fly is a major pest of numerous crops of economic significance in the United States, the introduction and establishment of this pest could stimulate the initiation of chemical or biological control programs.	High (3)

Cumulative Risk Rating: 14/15

Consequences of Introduction: *Ceratitis capitata* Wiedemann (Diptera: Tephritidae)	Risk Value
Risk Element #1: Climate – Host Interaction *Ceratitis capitata* is found in Africa, southern Europe, west Asia, South and Central America, and northern Australia (CABI, 2004). Its distribution corresponds to USDA Plant Hardiness Zones 8-11, which exist in CA, TX, FL, and HI (USDA ARS, 1990).	High (3)
Risk Element #2: Host Range This pest attacks over 400 different species (Capinera, 2001), including Rubiaceae (*Coffee* spp.), 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).	High (3)
Risk Element #3: Dispersal Potential Eggs are deposited on fruits in clusters of 3-9 eggs, with an average of 300 eggs laid per female (Capinera, 2001). Under ideal conditions, a generation is completed in 18 days, but 30-40 days is more common. Up to 15 generations can be observed per year (Bedford *et al*., 1998). In the adult stage, *C. capitata* is highly mobile and can fly at least 20 km (CABI, 2004). The transportation of infested fruits is a major means of movement and dispersal to previously un-infested areas (CABI, 2004).	High (3)

Risk Element #4: Economic Impact	
Risk Element #4: Economic Impact This species is a serious pest of *Prunus* and *Citrus*. In 2002, CA, TX, and FL produced over $2.3 billion worth of *Citrus* and $333 million worth of *Prunus* (USDA NASS, 2004b; USDA NASS, 2004a). In Mediterranean countries, it is particularly damaging to citrus and peach crops (CABI, 2004). *Ceratitis capitata* is one of the most significant quarantine pests for any tropical or warm temperate zones in which it is not yet established (CABI, 2004). Bedford *et al.* (1998) stated that susceptible deciduous fruits crops can suffer losses up to 80% when control measures are not applied. *Ceratitis capitata* may also transmit fruit-rotting fungi (CABI, 2004). This species is of quarantine significance throughout the world, particularly for 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 worldwide; as a result, *C. capitata* is one of the most significant quarantine pests for any tropical or warm temperate regions in which it is not yet established (CABI, 2004).	High (3)
Risk Element #5: Environmental Impact The introduction and establishment of *C. capitata* would stimulate chemical or biological control programs. *Ceratitis capitata* has the potential to damage endangered and threatened species, such as *Prunus genuclata* (FL), *Argemone pleiacantha* (NM), *Asimina tetramera* (FL), *Berberis nevivii* (CA), *B. pinnata* (CA), *B. sonnei* (CA), *Cucurbita okeechobeensis* (FL), *Echinocereus chisoensis* (TX), *E. reichenbachii* (TX), *E iridiflorus* (TX), *E. fendleri* (NM), *E. triglochidiatus* (AZ), *E. telephioides* (FL), *Opuntia treleasei* (CA), *Solanum drymophilum* (PR), *Ribes echinellum* (FL, SC), and *Ziziphus celata* (FL) (USFWS, 2002).	High (3)

Cumulative Risk Rating: 15/15

FL – Florida; NM – New Mexico; CA – California; TX – Texas; AZ – Arizona; SC – South Carolina

Consequences of Introduction: *Aleurodicus dispersus* Russell (Hemiptera: Aleyrodidae)	**Risk Value**
Risk Element #1: Climate – Host Interaction Spiraling whitefly, *A. dispersus* is native to the tropical Americas, occurring in Central and South America, the Caribbean, Africa, Asia, and Oceania (Akinlosotu *et al*., 1993). Its distribution corresponds to U.S. Hardiness Zones 9-11 (USDA ARS, 1990).	Medium (2)

Risk Element #2: Host Range	
Aleurodicus dispersus is a highly polyphagous species. It has been recorded on 38 genera of plants belonging to 27 plant families and more than 100 species (Akinlosotu *et al*., 1993; Martin Kessing & Mau, 1993). 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, 2004). 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, Cucumis* spp., *Luffa aegyptiaca*), Lamiaceae (*Coleus* spp., *Salvia* spp.), Euphorbiaceae (*Euphorbia pulcherrima*, *Euphorbia* spp., *Acalypha* 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*, *Solanum* spp., *Cestrum* spp., *Capsicum* spp., *Lycopersicon esculentum*, *Physalis* 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, 2004a). In Florida, *A. dispersus* has been reported on avocados, citrus, guavas and palms (CABI, 2004).	High (3)
Risk Element #3: Dispersal Potential Females begin laying eggs within a day of emergence and continue to lay eggs throughout their lives (Martin Kessing & Mau, 1993). Females lay about 14-26 eggs in a loose spiral on the underside of leaves (CABI, 2004). 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 4-5; the third instar for 5-13 days; and the fourth (pupae) 5-16 days (CABI, 2004; Martin Kessing & Mau, 1993). Adults live for about two weeks (CABI, 2004). The first instar is the only immature stage capable of active movement (Martin Kessing & Mau, 1993). Adults disperse by flying and are most active in the morning (Martin Kessing & Mau, 1993). Long distance dissemination is via infested plants and fruits (EPPO, 2004).	Medium (2)

Risk Element #4: Economic Impact *Aleurodicus dispersus* is polyphagous and a serious pest of tropical and subtropical crops (EPPO, 2004a). *Aleurodicus dispersus* causes at least three kinds of economic damage: (1) direct feeding damages on leaves, (2) indirect damages to excreted honeydew that encourages the development of sooty moulds, and (3) a vector of plant diseases (CABI, 2004; Martin Kessing & Mau, 1993). Whiteflies cause over 40 plant diseases of vegetables and crops worldwide (Martin Kessing & Mau, 1993). *Aleurodicus dispersus* is a vector of the lethal yellowing virus of coconut palms in Florida (Akinlosotu, et al., 1993). *Aleurodicus dispersus* damages on crops can vary from 20-100%, depending on the crop, season, and prevalence (Martin Kessing & Mau, 1993). In Florida, *A. dispersus* has been reported on avocados, citrus, guavas and palms (CABI, 2004).	Medium (2)
Risk Element #5: Environmental Impact *Aleurodicus dispersus* could damage threatened and endangered species, such as the endangered *Manihot walkerae* (TX), *Prunus geniculata* (FL), *Eugenia haematocarpa* (PR), *E. woodburyana* (PR), *Rhododendron chapmanii* (FL), *Rorippa gambellii* (CA), *Solanum drymophilum* (PR), and *Agave arizonica* (AZ), and the threatened *Euphorbia telephioides* (FL) and *Amaranthus pumilus* (DE, MA, MD, NC, NJ, NY, RI, SC, VA) (USFWS, 2002). The introduction and establishment of *A. dispersus* in the continental U.S. could stimulate chemical or biological control programs. Successful biological control has been established in Hawaii (CABI, 2004; Martin Kessing & Mau, 1993).	High (3)

Cumulative Risk Rating: 12/15

TX – Texas; FL – Florida; PR – Puerto Rico; CA – California; AZ – Arizona; DE – Delaware; MA – Massachusetts; MD – Maryland; NC – North Carolina; NJ – New Jersey; NY – New York; RI – Rhode Island; SC – South Carolina; VA – Virginia

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

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

Table 5. Risk Rating for Consequences of Introduction (*Cucumis melo*) from Hawaii

Pest	**Risk Elements**					**Cumulative Risk Rating**
	Climate-Host Interaction	**Host Range**	**Dispersal Potential**	**Economic Impact**	**Environ-mental Impact**	
Bactrocera cucurbitae	Medium (2)	High (3)	High (3)	High (3)	High (3)	**High (14)**
Bactrocera dorsalis	Medium (2)	High (3)	High (3)	High (3)	High (3)	**High (14)**

Ceratitis capitata	High (3)	High (3)	High (3)	High (3)	High (3)	**High (15)**
Aleurodicus dispersus	Medium (2)	High (3)	Medium (2)	Medium (2)	High (3)	**High (12)**

2.7. Introduction Potential

Each pest is rated with respect to its Likelihood of Introduction, which is based on two separate components. First, an estimate is made concerning the quality of the commodity likely to be imported (Risk Element #6). Second, pest opportunity (Risk Element #7) is estimated using five biological features. Details of these two Risk Elements and their rating criteria are provided in USDA APHIS (2000); the ratings and cumulative score for Risk Element #6 and #7, *i.e.*, the "Likelihood of Introduction Risk Rating," are shown in Table 5.

Risk Element #6: Pest Opportunity (Survival and Access to Suitable Habitats and Hosts)

For each pest, consider six sub-elements:

1. Quantity of commodity imported annually:
The likelihood that an exotic pest will be introduced depends on the amount of potentially-infested commodity imported. For qualitative pest risk assessments, the amount of commodity imported is rated by the annual number of standard 40-foot long shipping containers:

Low (1 point): < 10 containers/year
Medium (2 points): 10 – 100 containers/year
High (3 points): > 100 containers/year

If the quantity of a commodity imported is provided in terms of kilograms, pounds, or number of items, *etc*., we can convert the units into 40-foot shipping containers. Sea shipping containers that are 40-feet long hold approximately 40,000 pounds (20 U.S. tons), which is used to estimate the shipment volume (USDA FAS, 2003).

The amount of melon produced in Hawaii was unavailable. USDA NASS (2004c) reported that the annual production of melon and several other vegetables in Hawaii for 2003 was 16.3 million pounds. Sea shipping containers, which are 40-feet in length, and hold approximately 40,000 pounds (20 U.S. tons), are used for estimating various commodity shipments (USDA FAS, 2003); therefore, the anticipated volume of melon to be exported from Hawaii to the continental United States could be more than 100 containers per year (High).

2. Survive post-harvest treatment:
For this sub-element, post-harvest treatment refers to any manipulation, handling, or specific phytosanitary treatment to which the commodity is subjected. Examples of post-harvest treatments include culling, washing, chemical treatment, and cold storage. If no post-harvest treatments exist, the estimate of the likelihood for this sub-element is High.

Fruit flies (*Bactrocera cucurbitae*, *B. dorsalis*, *Ceratitis capitata*) have a High potential to survive post-harvest treatments, as they are internal feeders and are not likely affected, especially if the infestation of the fruit is not obvious.

Whitefly (*A. dispersus*) is an external feeder that can be controlled by post-harvest treatments; however, anticipated treatments for Hawaiian melon are unknown. Melons are hand picked and hand packed, and fruits with *A. dispersus* infestation can be easily culled at the field or packing house. Therefore, it is rated as Medium (2).

3. Survive Shipment
The means of transportation for melon from Hawaii are unknown. Typically, melons are stored at 0-5 ºC with a relative humidity of 90-95% during shipment (Zitter *et al*., 1996). All commercially important cucurbits are subject to chilling injury; this is time-temperature dependent, which means injuries are more severe at lower temperatures or longer periods (Zitter *et al*., 1996). Most insect pests can be effectively controlled at 0 ºC. Cold treatment at 0 ºC or below is used to mitigate fruit fries for several commodities (PPECB, 2002). Regulatory cold treatments are commodity specific (USDA APHIS, 1999).

All pests in Table 4 may survive standard shipping conditions. All species have been intercepted at ports-of-entry by PPQ officers (USDA APHIS PPQ, 2005) (Appendix A). All species have a High rating.

4. Not detected at the port-of-entry:
Unless specific protocols with special commodity inspections are in place, the standard inspection protocols for similar commodities are assumed. If no inspection is planned, this sub-element is estimated to be High.

Fruit flies, *Bactrocera cucurbitae*, *B. dorsalis*, and *Ceratitis capitata* were rated High as to their potential to escape detection at the port-of-entry. These feeders are not detected unless fruits are destructively sampled. White and Elson-Harris (1992) stated that fruit flies have a high probability of escaping detection at ports-of-entry, and infested fruit could go unrecognized.

Aleurodicus dispersus is rated Medium because it is an external feeder that is very small (adult size is about 2 mm). The eggs found on leaves and fruits are difficult to detect since they are only 0.3 mm wide (CABI, 2004).

5. Imported or subsequently moved to an area with an environment suitable for survival:
Fruit flies (*Bactrocera cucurbitae*, *B. dorsalis*, and *Ceratitis capitata*), and whitefly (*Aleurodicus dispersus*) have Medium potentials to move to environmentally suitable locations because they are limited to tropical and subtropical regions. In the continental U.S., tropical and subtropical climate zones only occur in the South and on the West Coast, which is only about 10-12 % of the total area of the continental United States.

6. Come into contact with host material suitable for reproduction:
Fruit flies, *Bactrocera cucurbitae*, *B. dorsalis*, and *Ceratitis capitata*, have a High potential to come into contact with suitable host material. These fruit flies have a wide range of tropical and

temperate host species. *Bactrocera dorsalis* and *Ceratitis capitata* already have established populations in the continental United States. Although these species have been officially eradicated, they are highly likely to come into contact with host material suitable for reproduction.

Whitefly (*Aleurodicus dispersus*) is rated as Medium (2). It is highly polyphagous species, and natural dispersal can be ensured by flying adults (EPPO, 2004a). However, it is a pest of tropical and subtropical crops (EPPO, 2006). Tropical and subtropical areas are limited in the continental United States.

The summary of the ratings for the Likelihood of Introduction is depicted in Table 6.

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

Table 6. Risk Ratings for Likelihood of Introduction

Pest	Quantity Imported Annually	Survive Post-harvest Treatment	Survive Shipment	Not Detected at Port-of-Entry	Move to Suitable Habitat	Contact with Host Material	Cumulative Risk Rating
Bactrocera cucurbitae	High (3)	High (3)	High (3)	High (3)	Medium (2)	High (3)	**High (17)**
Bactrocera dorsalis	High (3)	High (3)	High (3)	High (3)	Medium (2)	High (3)	**High (17)**
Ceratitis capitata	High (3)	High (3)	High (3)	High (3)	Medium (2)	High (3)	**High (17)**
Aleurodicus dispersus	High (3)	Medium (2)	High (3)	Medium (2)	Medium (2)	Medium (2)	**High (14)**

2.8. Conclusion – Pest Risk Potential and Pests Requiring Phytosanitary Measures

To estimate the Pest Risk Potential for each pest, the Cumulative Risk Rating for the Consequences of Introduction and the Likelihood of Introduction are summed in Table 7.

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	Risk Rating
Bactrocera cucurbitae	High (14)	High (17)	31	High
Bactrocera dorsalis	High (14)	High (17)	31	High

Ceratitis capitata	High (15)	High (17)	32	High
Aleurodicus dispersus	High (12)	High (14)	26	Medium

Following the assignment of the Pest Risk Potential for each pest, the risk assessor may briefly comment on risk management options associated with the requested commodity importations. The following guidelines are offered as an interpretation of the Low, Medium, and High Pest Risk Potential Ratings:

Low: Pest will typically not require specific mitigation measures; the port-of-entry inspection to which all imported commodities are subjected can be expected to provide sufficient phytosanitary security.
Medium: Specific phytosanitary measure may be necessary.
High: Specific phytosanitary measures are strongly recommended. Port-of-entry inspection is not considered sufficient to provide phytosanitary security.

Identification and selection of appropriate sanitary and phytosanitary measures to mitigate risk for pests with particular Pest Risk Potential ratings is undertaken as part of the risk management phase and is not discussed in this document. The appropriate risk management strategy for a particular pest depends on the risk posed by that pest. APHIS risk management programs are risk based and dependent on the availability of appropriate mitigation methods. Details of APHIS risk management program are published, primarily, in the Federal Register as quarantine notices.

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