Importation of Fruit of 'Hass' Avocado, *Persea Americana*, from Peru into the Continental United States

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A Qualitative, Pathway-Initiated Risk Assessment

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Executive Summary

This assessment examines the risks associated with the importation of 'Hass' avocado, *Persea americana* Miller., fruit from Peru into the United States. Among the pests found affecting avocado in Peru were seven quarantine pests—six insects and one viroid—that may be associated with fresh avocado fruit from Peru as a pathway for introduction into the United States. These pests are as follows:

Insects
Anastrepha fraterculus Wiedemann (Diptera: Tephritidae)
Anastrepha striata Schiner (Diptera: Tephritidae)
Ceratitis capitata Wiedemann (Diptera: Tephritidae)
Coccus viridis (Green) (Hemiptera: Coccidae)
Ferrisia malvastra (McDaniel) (Hemiptera: Pseudococcidae)
Stenoma catenifer Walsingham (Lepidoptera: Oecophoridae)

Viroid
Potato spindle tuber viroid

We qualitatively analyzed these quarantine pests using the methodology described in the USDA-APHIS Guidelines Ver. 5.02, which examines pest biology in the context of the Consequences of Introduction and Likelihood of Introduction, and estimates overall Pest Risk Potentials. Scale insects, *Coccus viridis* and *Ferrisia malvastra*, received Medium ratings for Pest Risk Potential. All three fruit flies—*Anastrepha fraterculus*, *A. striata*, and *Ceratitis capitata*—and the seed moth, *Stenoma catenifer*, were rated High risk. Although the viroid was rated High in the risk assessment, an additional analysis for the Likelihood of Establishment of the pathogen entering on avocados for consumption estimated the probability to be Low (Appendix B). Therefore, no mitigation measures are required against potato spindle tuber viroid. Specific phytosanitary measures may be necessary for pests with a baseline Pest Risk Potential of Medium. Port-of-entry inspections are insufficient to safeguard U.S. agriculture from pests that are rated High and mitigation measures are suggested to provide phytosanitary security.

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1. Introduction

The Animal and Plant Health Inspection Service (APHIS) of the United States Department of Agriculture (USDA) prepared this pest risk assessment to examine plant pest risks associated with the importation of fresh 'Hass' avocado, *Persea americana* fruits from Peru into the continental United States. This is a qualitative pest risk assessment. Estimates of risk are expressed in qualitative terms of high, medium, or low, rather than in numerical terms, such as probabilities or frequencies. The details of methodology and rating criteria are in the Guidelines for Pathway-Initiated Pest Risk Assessment, version 5.0 (PPQ, 2000).

International plant protection organizations, such as the North American Plant Protection Organization (NAPPO) and the International Plant Protection Convention (IPPC) provide guidance for conducting pest risk analyses. The methods used to initiate, conduct, and report this pest risk assessment are consistent with the guidelines provided by NAPPO and IPPC. The use of biological and phytosanitary terms conforms to the Glossary of Phytosanitary Terms (IPPC, 2007: ISPM #5).

Avocado is part of the Lauraceae plant family, which has about 50 genera (Ploetz et al., 1994). Most members of the family have aromatic foliage and include bays, camphor, cinnamon, and sassafras. Three races of avocado are generally recognized: Mexican, West Indian and Guatemalan; these races vary in their sensitivity to cold and fruit characteristics. Hass, of the Guatemalan race, is the leading variety produced in California. Hass has the advantages of year round production and excellent storage life and fruit quality. In 1987, Peru ranked 18th in annual production of avocado with 24,000 metric tons compared to Mexico's 357,000 metrics tons (Ploetz et al., 1994). Peruvian avocados for export are currently produced in Lima (20,180 Metric Tons in 1999), Ica (2,656) and Moquega (2,632) (Fig. 1, SENASA, 2002A).

2. Risk Assessment

2.1. Initiating Event: Proposed Action

This assessment was initiated in response to an official request for USDA authorization to allow imports under 7 CFR §319.56, the regulation which provides authority to USDA for restricting or prohibiting the importation of fruits and vegetables based on the risk of introducing harmful exotic plant pests into the United States. The PRA request was made by G.A. Ball, Import Specialist, Riverdale, MD, on October 31, 2001. Importing "Hass' avocados (*Persea americana)* from Peru into the United States is a potential pathway for the introduction of pests. This pest risk assessment is commodity-based and therefore pathway-initiated.

2.1.1. Correspondence with Peru

- December 29, 2000. Facsimile (2725) from Ing. Alicia de la Rosa Brachowicz, General Director Plant Health, SENASA to Dr Lou Vanechos, Area Director APHIS-IS, Chile. The letter included a request to export *Persea americana* fruit to the United States and contained the enclosed document "The Phytosanitary Status of the avocado (*Persea americana* Miller) in Peru."

- January, 11, 2002. Facsimile from Robert V. Flanders, Risk Assessment Branch Chief, APHIS to Ing. Alicia de la Rosa Brachowicz, General Director Plant Health, SENASA to Dr Lou Vanechos, Area Director APHIS-IS, Chile. The letter indicated that APHIS has a backlog of PRAs. SENASA was offered the chance to conduct the PRA as a way to expedite the risk assessment process.
- January, 14, 2002. Letter from Ing. Alicia de la Rosa Brachowicz, General Director Plant Health, SENASA to Dr Lou Vanechos, Area Director APHIS-IS, Chile. It indicated that Annabella Reszcynski was compiling information on the cultivation of Avocado in Peru.
- March 27, 2002. Letter from Alan S. Green (USDA/APHIS) to Dra. Elsa Carbonell Tores, SENASA. The letter acknowledged receipt of the report "The Phytosanitary Status of the avocado (Persea americana Miller) in Peru." The letter requested additional information relating to the harvest, packaging, shipment and export of avocados from Peru.

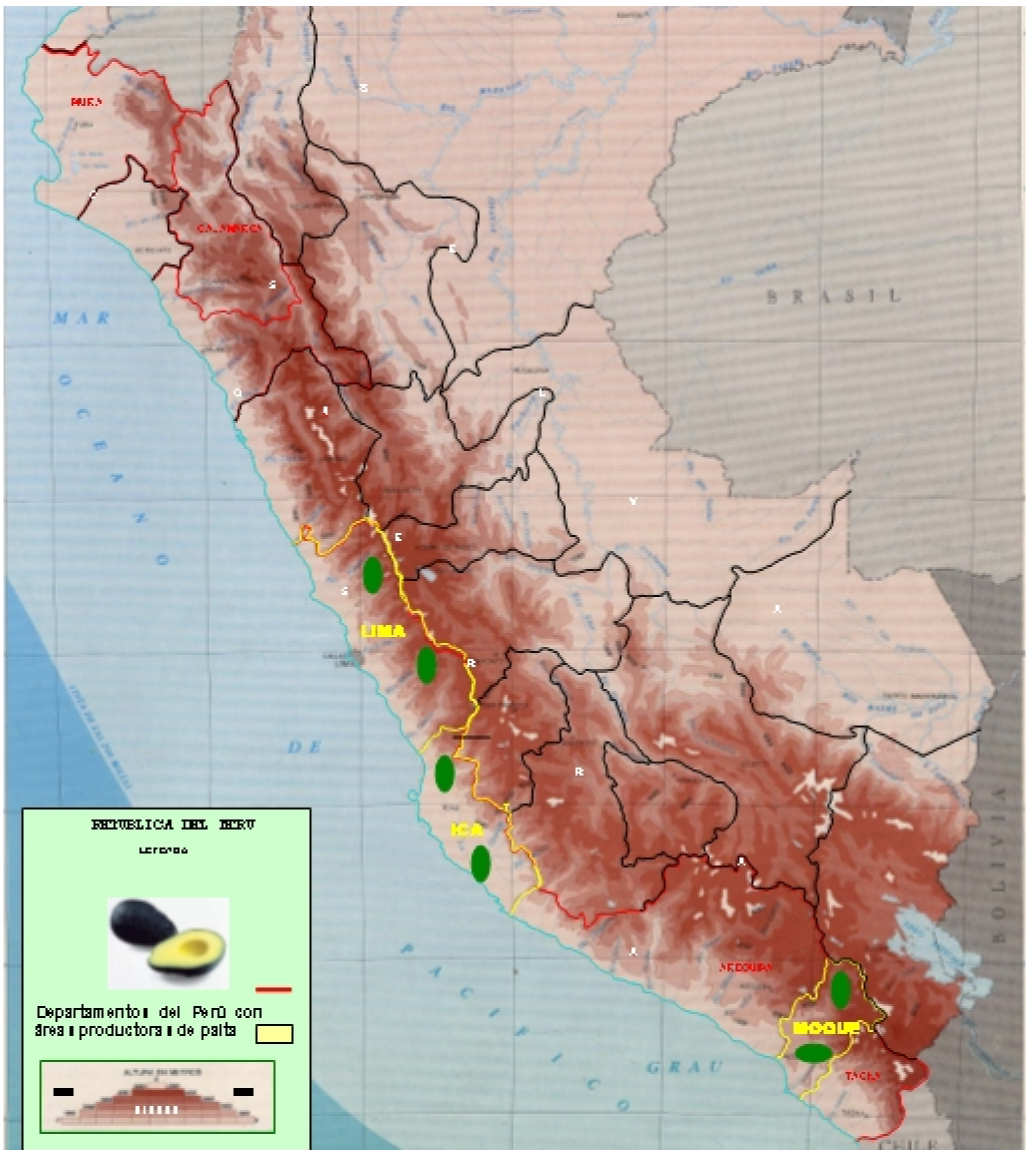

Figure 1. Avocado production in Peru (SENASA, 2002A).

- June 14, 2002. Letter (1653-2002-AG-SENASA-DGSV-DDF) from Ing. Alicia de la Rosa Brachowicz, General Director Plant Health, SENASA to Dr Lou Vanechos, Area Director APHIS-IS, Chile. The letter listed helpful reference material for the PRA process.
- July 11, 2002. Letter (1867-2002-AG-SENASA-DGSV-DDF) from Ing. Alicia de la Rosa Brachowicz, General Director Plant Health, SENASA to Dr Lou Vanechos, Area Director APHIS-IS, Chile. The letter provided the additional information requested by Alan S. Green on March, 27 2002.
- June 17, 2003. Letter from Ing. Alicia de la Rosa Brachowicz, General Director Plant Health, SENASA to Dr Lou Vanechos, Area Director APHIS-IS, Chile. The letter indicated that only the "Hass" variety of avocado should be considered for export.

2.1.2. Documents Supplied by Peru

1. "The Phytosanitary Status of the avocado (Persea americana Miller) in Peru." December, 2002. DGSV-DVF/DDF, 12 pp.
2. Information about the phytosanitary condition of the avocado (Persea americana Miller) In Peru. October, 2001
3. Draft proposal for the application of pest risk mitigation measures in the exportation of avocado (Persea americana) to the United States from Peruvian sites where the avocado seed moth (Stenoma catenifer) is not known to occur. SENASA, August, 2002.
4. "Importation of avocado fruit (Persea Americana) from Peru. A Pest Risk Assessment." SENASA, Dec 2002.

2.2. Assessment of Weediness Potential of *Persea americana* (avocado).

The weediness assessment is presented below (Table 1).

Table 1. Assessment of weediness potential of avocado

Phase 1: *Persea americana* is widely cultivated in California and Florida; (Ploetz et al., 1994; NRCS, 2003); avocadoes are also grown in Texas (Vines, 1960).

Phase 2: Is the species listed in:

NO	*Geographical 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)
NO	Weed Science Society of America list (WSSA, 2007)
NO	Is there any literature reference indicating weediness (e.g., *AGRICOLA, CAB, Biological Abstracts, AGRIS*; search on "species name" combined with "weed").

Phase 3: Conclusion: *Persea americana* is not considered to be an economically important weed.

2.3. Previous Risk Assessments, Current Status, and Pest Interceptions

2.3.1. Decision History

For avocado *(Persea americana)* fruit (limited to the last 30 years for South America) included one record: 1969 - Peru, avocado: Entry was denied for lack of effective treatments for *Ceratitis capitata*, *Anastrepha fraterculus*, *A. serpentina* and *Stenoma catenifer*.

Avocado importation requests from other South American countries were denied in the following years due to lack of effective treatments for *S. catenifer* and/or *Anastrepha* sp.:

1961 - Columbia
1970 - Columbia
1974 - Brazil, Columbia
1977 - Chile
1991 - Argentina
1994 - Ecuador

2.3.2. Current status

USDA does not currently authorize the importation of avocado from South America except for from Chile (PPQ, 2004). Importation of avocado from Peru is currently not authorized. A list of actionable and non-actionable pests (with the exception of non-reportable) intercepted on avocado from Peru is presented below (Table 2).

2.3.3. Pest interceptions

We listed pest interceptions for selected South American countries below (Appendix A). All interceptions were in baggage, quarters, and stores.

2.4. Pest List: Pests Associated with avocado in Peru

We listed the pests associated with avocado below (Table 3). The table was compiled from scientific and regulatory reports, including pest lists provided by Peruvian officials. Information sources consulted included bibliographic databases, such as AGRICOLA and CAB Abstracts; CAB International Crop Pest Compendium (CABI, 2002); previous risk assessments relevant to the proposed commodity; PPQ's Catalog of Intercepted Pests and interception records [Pest Identification Database]; Commonwealth Institute of Entomology (CIE) and Commonwealth Mycology Institute (CMI) Distribution Maps and/or Descriptions of plant pests; PPQ data sheets on Pests Not Known to Occur in the United States (PNKTO) and Insects Not Known to Occur in the United States (INKTO); standard texts; and published and unpublished scientific and regulatory reports. For each pest, Table 3 summarizes information on the presence or absence in the United States, commodity association (i.e., the generally attacked/infected plant parts), quarantine status in the United States, and the likelihood that the pest could move with the commodity in commerce (i.e. follow the pathway).

Table 2. Pest interceptions (recorded as events) on avocado, *Persea americana*, fruit from Peru, 1985 to 2008 (PestID, 2008).

Pest	**Interceptions (no.)**
Abgrallaspis sp.	1
Anastrepha sp. (Tephritidae)	2
Cladosporium sp.	1
Chrysomphalus pinnulifer (Diaspididae)	4
Curculionidae, species of	2
Diaspididae, species of	9
Fiorinia sp. (Diaspididae)	1
Heilipus sp. (Curculionidae)	2
Hemiberlesia diffinis	1
Oecophoridae, species of	2
Pentatomidae, species of	1
Phomopsis sp.	1
Phycitinae (Pyralidae)	
Pinnaspis sp. (Diaspididae)	5
Pseudaonidia trilobitiformis (Diaspididae)	11
Pseudococcidae, species of	3
Sphaceloma sp.	1
Stenoma catenifer (Oecophoridae)	11
Total	**58**

Table 3. Pests reported on avocado in any country and present in Peru on any host.

Scientific Name, Classification	**Distribution[1]**	**Plant part affected[2]**	**Quarantine pest[3]**	**Follow pathway[3]**	**References**
ARTHROPODS					
ACARI					
Tarsonemidae					
Polyphagotarsonemus latus Banks	PE, US	L, S, F, I	No	Yes	CABI, 2002
Tetranychidae					
Oligonychus mangiferus (Rahman and Sapra)	PE	L	Yes	No	Bolland et al., 1998; Hill, 1983

[1] Distribution: CA = California, FL= Florida, GA = Georgia, NY = New York, PE = Peru, USA = United States of America, TX = Texas.
[2] Plant part affected: F = fruit, I = flower or inflorescence, L = leaves, S = stem, R = roots, Sd = seed, Pd = Pod, U = unknown
[3] Quarantine Pest: U = Unknown. Brackets indicate that the species, although not fitting the definition of a quarantine pest (IPPC, 2002), is considered actionable (APHIS, PPQ, National Identification Services)

Scientific Name, Classification	Distribu-tion[1]	Plant part affected[2]	Quaran-tine pest[3]	Follow pathway[3]	References
Oligonychus peruvianus (McGregor)	PE, US	L	No	No	Bolland et al., 1998; CABI, 2003
Oligonychus punicae (Hirst)	PE, US	L	No	No	Bolland et al., 1998; Hofshi, 2005
Oligonychus yothersi (McGregor)	PE, US	L	No	No	Bolland et al., 1998
Panonychus citrii (McGregor)	PE, US	L	No	No	Bolland et al., 1998; Wolfe et al., 1969; Wysoki et al., 2002
Tetranychus mexicanus (McGregor)	PE, US	L	No	No	Bolland et al., 1998
Tetranychus neocaledonicus André	PE, US	L	No	No	Bolland et al., 1998
Tetranychus sp.	PE	L	Yes	No	Alata Condor, 1973
Tetranychus urticae Koch	PE, US	L	No	No	Bolland et al., 1998; Wolfe et al., 1969;
INSECTA					
COLEOPTERA					
Cerambycidae					
Derobrachus asperatus Bates	PE	S	Yes	No	Alata Condor, 1973; Hovore, 2003
Oncideres poecilla Bates	PE	S	Yes	No	Alata Condor, 1973; Wolfe et al., 1969; Wysocki et al., 2002
Oncideres sp.	PE, US	S	Yes	No	Alata Condor, 1973; CABI, 2003
Curculionoidae					
Copturomimus sp. L.	PE	S	Yes	No	Alata Condor, 1973; Wysoki et al., 2002;
Heilipus empiricus (Pascoe)	PE	F, S[4]	Yes	No[5]	Alata Condor, 1973;
Heilipus sp.	PE, US (FL)	F, Sd, R	Yes	No[6]	Laurencao et al., 2003; Pena (2003); PestID, 2008; Wolfenbarger (1948)
Pantomorus cervinus Boheman	PE, US	L, F, S, R	No	Yes	CABI, 2002
Rhynchophorus palmarum L.	PE	R, S, F[7]	[Yes]	No[8]	CABI, 2005

[4] Based on biology of *Heilipus catagraphus* (Wysoki et al., 2002).

[5] *H. empiricus* is only mentioned in the literature once by Alata Condor (1973). We found no other information about this species. According to SENASA (2005), this species is very rare in Peru and does not pose any economic threat. *Heilipus* sp. were intercepted twice on avocado in the passenger luggage from Peru (PestID, 2008), but this was insufficient evidence of its ability to follow the pathway. Thus, we did not further analyze this species. However, we reserve the right to add to the pathway any species of *Heilipus* if these insects are intercepted on avocados from Peru, because *H. empiricus* might be a misidentification by Alta Condor (1973) of some other species from the genus *Heilipus*.

[6] We listed *Heilipus* sp. based on two interceptions in a passenger baggage, but that is not sufficient evidence to conclude that it will follow the pathway. However, as stated above, we reserve the right to add any species of *Heilipus* to the pathway in the future should they be intercepted in commercial avocados from Peru. Also, see Conclusion section for more information.

[7] Predominantly a pest of palms; When reported on other plants, *R. palmarum* was feeding on ripe fruits but not causing

Scientific Name, Classification	Distribution[1]	Plant part affected[2]	Quarantine pest[3]	Follow pathway[3]	References
Languriidae					
Toramus sp.	PE, US	Sd, Pd	No[9]	Yes	Alata Condor, 1973
Histeridae					
Acritus sp.	PE, US	U	No[9]	U	Alata Condor, 1973; Anonymous, 2006a
Nitulidae					
Carpophilus sp.	PE, US	F	No[9]	Yes	Alata Condor, 1973
Scarabeidae					
Pelidnota chlorana Er.	PE	I, L	Yes	No	Arellano Cruz, 1998
Scolytidae					
Pagiocerus frontalis Fabricus	PE, US	S	No	No	Alata Condor, 1973
DIPTERA					
Agromyzidae					
Liriomyza trifolii Burgess in Comstock	PE, US	L	No	No	CABI, 2003; NZPPO, 1999
Cecidomyiidae					
Clinodiplosis sp.	PE, US	I, Sd, L	No[9]	Yes	Alata Condor, 1973
Lonchaeidae					
Neosilba pendula	PE	S, F	Yes	No[10]	Hofshi, 2005
Silba sp.	PE	S, F	Yes[6]	No[10]	Alata Condor, 1973; CABI, 2002; Katsoyannos, 1983
Muscidae					
Atherigona orientalis Schiner	PE, US	L, S, F	No	Yes	CABI, 2002
Tephritidae					
Anastrepha fraterculus Wiedemann	PE	F	Yes	Yes	CABI, 2002; Norrbom 2004; Ovruski et al., 2003; Putruele, 1996; White and Elson-Harris, 1992; Wille, 1952
Anastrepha obliqua (Macquart)	PE	F	Yes	No[11]	Aluha et al., 2004; CABI, 2004; Norrbom, 2004

economic damage (CABI, 2005). Avocado is a minor host of this species (CABI, 2005).

[8] Eggs are usually inserted into previously damaged tissue (CABI, 2005), but only mature, unripe avocado fruits will be imported. Furthermore, this is a large insect—larvae reach up to 4-6 cm in length, and adults are 4-5 cm—that is likely to be noticed during packing.

[9] Listed as 'Non-reportable' in Pest Identification database (PestID, 2008). Also, see Courneya (2003).

[10] These species are secondary pests that attack hosts previously damaged by primary invaders, particularly fruit flies (McAlpine and Steyskal, 1982; White and Elson-Harris, 1992). Culling damaged fruit and mitigating against fruit flies is likely to remove these pests from the pathway.

[11] Avocado is not a natural host for *A. obliqua* (Norrbom, 2004; Aluja et al. 2004.). Only one record exists, for Brazil, for *A. obliqua* on avocado where three "females" were "recovered from host fruit" of unspecified numbers and of unknown variety (Uramoto et al., 2001). This publication is only an abstract and reports "preliminary" results for a previously undocumented host for the fly. There is no specification as to whether the results were based on the adult or larval identifications. It is unknown whether the fruits were from the tree or ground, ripe or immature. No other records are listed

Scientific Name, Classification	Distribu-tion[1]	Plant part affected[2]	Quaran-tine pest[3]	Follow pathway[3]	References
Anastrepha serpentina (Wiedemann)	PE	F	Yes	No[12]	Bush, 1957; CABI, 2002
Anastrepha striata Schiner	PE	F	Yes	Yes	Ballou, 1936; CABI, 2002; Jiron et al., 1988; Uchôa et al., 2002; White & Elson-Harris, 1992
Ceratitis capitata Wiedemann	PE	F	Yes	Yes	CABI, 2002; Hofshi, 2005; Liquido et al., 1990, 1998; Metcalf & Metcalf, 1993; Putruele , 1996; Snell, 2006; White & Elson-Harris, 1992
Xanthaciura major Malloch	PE, US	I[13]	No	No	Alata Condor, 1973; Morin et al., 1997; Peña and Bennett, 1995
HEMIPTERA					
Aetalionidae					
Aetalion reticulatum L.	PE	F, S, I, L	Yes	No[14]	Alata Condor, 1973; Briceno, 1977, Dominguez Gil, 1978
Aleyrodidae					
Aleurodicus cocois Curtis	PE	L	Yes	No	Lopez and Kairo, 1999; Seguenas and Camara, 2002; Silva, 1978
Aleurodicus dispersus Russell	PE, US (FL)	L	[Yes[15]]	No	CABI, 2003
Aleurodicus pulvinatus (= *A. ridescens*)	PE	L	Yes	No	CABI, 2003
Aphididae					
Aphis gossypii (Glover)	PE, US	L, S, I	No	No	Blackman & Eastop, 2000; CABI, 2003
Aphis spiraecola Patch	PE, US	L, S, I	No	No	CABI, 2003
Myzus persicae Sulzer	PE, US	L, S	No	No	CABI, 2002
Toxoptera aurantii Boyer de Fonscolombe	PE, US	L, S, I	No	No	Blackman and Eastop, 2000; CABI, 2003

in the comprehensive *Anastrepha* species host database of Norrbom (2004). Based on the available information, we think the species is unlikely to follow the pathway in avocado fruit.

[12] Avocado is a poor host for *A. serpentina* (Bush, 1957; Aluja et al., 2004) therefore this pest is unlikely to follow the pathway.

[13] Based on biology of *Xanthaciura connexionis* (Morin et al., 1997).

[14] This insect is an external pest and affects fruit at the early stages of development by causing fruit darkening or premature drop (Dominguez Gil, 1978). Damaged fruit are likely to be eliminated during culling.

[15] Courneya (2004a)

Scientific Name, Classification	Distribution[1]	Plant part affected[2]	Quarantine pest[3]	Follow pathway[3]	References
Coccidae					
Ceroplastes cirripediformis Comstock	PE, US	L, S	No	No	Ebeling, 1959; Ben-Dov et al., 2003
Ceroplastes floridensis Comstock	PE, US	L, S[16]	No	No	Ebeling, 1959; Ben-Dov et al., 2003
Coccus hesperidum (L)	PE, US	L, S	No	No	CABI, 2003; Ben-Dov et al., 2003
Coccus viridis (Green)	PE, US (FL)	L, S, F	[Yes][17]	Yes	CABI, 2003; Courneya, 2004b, 2006; Ben-Dov et al., 2003
Parasaissetia nigra Nietner	PE, US	L, S	No	No	CABI, 2002
Parthenolecanium corni (Bouché)	PE, US	L, S	No	No	CABI, 2002; Swirski et al., 1997
Protopulvinaria pyriformis Cockerell	PE, US (FL)	L, F, S	No	Yes	Alata Condor, 1973; Ebeling, 1959; Wysoki et al., 2002
Saissetia coffeae Walker	PE, US	L, S	No	No	CABI, 2002
Saissetia oleae Oliver	PE, US	L, S	No	No	CABI, 2002
Diaspididae					
Acutaspis sp.	PE, US	L, S, F	Yes	Yes	Alata Condor, 1973; Peña et al., 2003
Acutaspis albopicta (Cockerell)	PE, US (TX, CA)	L, F	[Yes]	Yes[18]	Courneya, 2005; Ben-Dov et al., 2003
Acutaspis subnigra McKenzie	PE	L	Yes	No	Ben-Dov et al., 2003
Aspidiotus destructor	PE, US	L, F	No	Yes	CABI, 2002; Miller and Davidson, 2005
Chrysomphalus aonidum (L.)	PE, US	L, S, F	No	Yes	
Chrysomphalus dictyospermi Morgan	PE, US	L, S, F	No	Yes	CABI, 2003
Fiorinia fioriniae Targ.	PE, US	L, F	No	Yes	Alata Condor, 1973; Wysoki et al., 2002
Hemiberlesia cyanophyilli Signoret [Syn. *Abgrallaspis cyanophylli* (Signoret)]	PE, US	L, S, F[19]	No	Yes	Alata Condor, 1973; CABI, 2003
Hemiberlesia lataniae Signoret	PE, US	L, S, F	No	Yes	CABI, 2002; Nakahara, 1982
Hemiberlesia palmae (Cockerell)	PE, US (CA, FL)	L	No	No	Ben-Dov et al., 2003
Hemiberlesia rapax (Comstock)	PE, US	L, S, F	No	Yes	CABI, 2003; UCIPM, 2003
Howardia biclavis (Comstock)	PE, US	U	No	U	Ben-Dov et al., 2003

[16] Based on biology of C. *cirripediformis*
[17] Courneya (2004b)
[18] The armored scales *A. albopicta* and *P. trilobitiformis* may enter the United States on commercial fruit for consumption, but are unlikely to establish via this pathway. Please see discussion following the pest list for a detailed explanation.
[19] Based on biology of *Hemiberlesia lataniae* (CABI, 2003).

Scientific Name, Classification	**Distribution[1]**	**Plant part affected[2]**	**Quarantine pest[3]**	**Follow pathway[3]**	**References**
Lopholeucaspis cockerelli (Grandpré & Charmoy)	PE, US	U	No	U	Ben-Dov et al., 2003
Oceanaspidiotus spinosus (Comstock)	PE, US	L, Bark	No	No	Ben-Dov et al., 2003
Pinnaspis aspidistrae (Signoret)	PE, US	S, L, F	No	Yes	SENASA, 2002c; Ben-Dov et al., 2003
Pinnaspis sp.	PE, US	S, L, F	Yes	Yes	PestID, 2008
Pinnaspis strachani (Cooley)	PE, US	S, L, F	No	Yes	Ben-Dov et al., 2003
Pseudaonidia trilobitiformis Green	PE, US (FL)	F[20], L	[Yes]	Yes[18]	Anon., 1979; Coile and Dixon, 2000; Cavey, 2007; PestID, 2008
Selenaspidus articulatus Morgan	PE, US (CA)	L, S, F	No	Yes	CABI, 2002; Miller and Davidson, 2005; Wolfe et al., 1969; Wysoki et al., 2002
Unaspis citri Comstock	PE, US	L, F	No	Yes	Alata Condor, 1973; Ben-Dov et al., 2003; Wolfe et al., 1969; Wysoki et al., 2002
Margarodidae					
Icerya purchasi Maskell	PE, US	L, S	No	No	CABI, 2003; Mendel et al., 1992
Membracidae					
Tylopelta sp.	PE	S[21]	Yes[22]	No	Alata Condor, 1973
Pentatomidae					
Pentatomidae, species of	PE, US	L, F	Yes	No[23]	PestID, 2008
Pseudococcidae					
Dysmicoccus brevipes Cockerell	PE. US	L, S, R, F	No	Yes	CABI, 2003
Ferrisia malvastra (McDaniel)	PE, US (AZ, FL)	L, F, S[24]	[Yes]	Yes	Gullan et al., 2003; Miller et al., 2002; Ben-Dov et al., 2003
Ferrisia virgata Cock	PE, US	L, F, S	No	Yes	CABI, 2003
Nipaecoccus nipae Maskell	PE, US	L, S, F	No	Yes	CABI, 2003
Planococcus citri (Risso)	PE, US	L, S, F, R	No	Yes	CABI, 2003;
Pseudococcus longispinus Targioni	PE, US	S, F, L	No	Yes	CABI, 2002

[20] This scale species has been intercepted on fruit at U.S. ports-of-entry (PestID, 2008).
[21] Based on biology of the family Membracidae.
[22] Organisms listed at the level of genus (or family), although regarded as quarantine pests because of their uncertain identity, are not further analyzed due to the lack of evidence of the risks that they pose (see discussion after the pest list).
[23] Because of its size, biology, and mobility, this pest is not expected to stay on the commodity through harvest, and standard handling and processing. Pentatomidae (species of) has only been intercepted 5 times, all in baggage (not cargo) and only once on fruit. This indicates that insects in this family are unlikely to follow commercial export quality fruit.
[24] Based on biology of *Ferrisia virgata.*

Scientific Name, Classification	Distribution[1]	Plant part affected[2]	Quarantine pest[3]	Follow pathway[3]	References
Triozidae					
Trioza perseae Tuthill	PE	L	Yes	No	Alata Condor, 1973; Chavez et al., 1985; Hollis and Martin, 1997
HYMENOPTERA					
Formicidae					
Acromyrmex hispidus Santaschi	PE	L	Yes	No	Alata Condor, 1973; Arellano Cruz, 1998; San Juan, 2003
Atta cephalotes L.	PE	L	Yes	No	Alata Condor, 1973; CABI, 2003
Atta sexdens (L.)	PE	L	Yes	No	Arellano Cruz, 1998; Ebeling, 1959; Wolfe et al., 1969;
LEPIDOPTERA					
Geometridae					
Sabulodes caberata Gueneé	PE, US (CA)	L	No	No	Alata Condor, 1973; Condit, 1915; Robinson et al.,, 2004; Wolfe et al., 1969; Wysocki et al., 2002
Gracilariidae					
Phyllocnistis n. sp.	PE, US (FL)	L	Yes	No	CABI, 2002; Peña, 2003; Wolfe et al., 1969; Wysocki et al., 2002
Lymantriidae					
Eloria sp.	PE	L, S	Yes	No	Alata Condor, 1973; U.S. Congress, 1993
Noctuidae					
Chrysodeixis includens (Walker) [Syn. Pseudoplusia includens (Walker)]	PE, US	L, F, I	No	No[25]	CABI, 2003
Helicoverpa zea (Boddie)	PE, US	L, I, F, Sd	No	Yes	CABI, 2003; Robinson et al, 2004
Peridroma saucia Hübner	PE, US	L, S, F, I	No	No[25]	CABI, 2002
Spodoptera eridania Stoll	PE, US	L, F	No	No[25]	CABI, 2002
Oecophoridae					
Stenoma catenifer Walsingham	PE[26]	L, F, Sd	Yes	Yes	Alata Condor, 1973, CABI, 2002; Ebeling, 1959; Wolfe et al., 1969; Wysoki et al., 2002

[25] External feeder; damaged fruits are likely to be eliminated from packing by visual culling.
[26] The pest has a limited distribution in Peru (CABI, 2005).

Scientific Name, Classification	Distribution[1]	Plant part affected[2]	Quarantine pest[3]	Follow pathway[3]	References
Pyralidae					
Jocara zetila Druce	PE	L	Yes	No	Alata Condor, 1973; Arellano Cruz, 1998
Stericta albifasciata (Druce) [Syn. *Jocara ban* Dyar]	PE	L	Yes	No	CABI, 2002; Ebeling, 1959 Zhang, 1994
Psychidae					
Oiketicus kirbyi Guilding	PE	L	Yes	No	Alata Condor, 1973; Arce et al., 1987; Ponce et al., 1979; Rhainds et al., 1996
Sesiidae					
Aegeria sp.	PE, US	S (trunk)[27]	Yes	No	Alata Condor, 1973; BFW, 2004; Zhang, 1994
Tortricidae					
Platynota sp.	PE, US	L	Yes	No	Alata Condor, 1973
THYSANOPTERA					
Thripidae					
Heliothrips haemorrhoidalis Bouche	PE, US	L, F	No	Yes	CABI, 2002
Selenothrips rubrocinctus Giard	PE, US	L, F	No	Yes	CABI, 2002
VIRUSES					
Avocado sunblotch viroid	PE, US (CA, FL)	L, F, S, I	No	Yes	Ploetz, et al., 1994, Vargas, et al. 1991
Potato spindle tuber viroid	PE	L, F, S, I	Yes[28]	Yes	CABI 2003; Querci, et al. 1995
Algae					
Cephaleuros viriscens Künze (Trentepohliales, Trentepohliaceae)	PE, US (FL)	L, S	No[29]	No	Alfieri et al., 1993; Bazán de Segura, 1959; Brannen, 2004
BACTERIA					
Rhizobium radiobacter (Beijerinck & van Delden 1902) Young (Rhizobiaceae, Rhizobiales)	PE, US	R, S	No	No	CABI, 2002
FUNGI and CHROMISTANS					
Armillaria sp.[30] (Agaricales, Marasmiaceae)	PE	R, S	Yes [30]	No	CABI 2003; Gonzalez and Abad, 1975; Wellman, 1977

[27] The biology (plant part affected) is based on that of *Sesia* sp. of the same family Sessiidae. Larvae of this family are generally stem borers.
[28] Potato Spindle Tuber Viroid was declared absent from the United States (NAPPO, 2004a).
[29] Listed as non-reportable (PestID, 2008).
[30] Reported as *Armillaria mellea.* As currently accepted, *A. mellea* is a northern hemisphere species except for a single introduction into South Africa (Coetzee et al. 2001). Reports of its occurrence in South America are likely to be errors. A recent study (Coetzee and Wingfield 2003) identified *A. luteobubalina* and *A. novae-zelandiae* from Chile and Argentina. Both of these species occur in Australia and New Zealand, but not in the United States. It is uncertain which species of

Scientific Name, Classification	Distribution[1]	Plant part affected[2]	Quarantine pest[3]	Follow pathway[3]	References
Aspergillus niger Tiegh. (Anamorphic *Emericella*, Eurotiales, Trichocomaceae.)	PE, US	F, L, R, S, I	No	Yes	CABI 2003; Torres and Gamarra, 1988; Wellman, 1977
Botryodiplodia sp. *(*Anamorphic Ascomycetes*)*	PE, US	F, I, L, S	Yes[22]	Yes	Farr et al., 2004; Torres and Gamarra, 1988
Botryosphaeria dothidea (Moug.) Ces. & de Not. (=*Physolospora perseae* Doidge). (Anamorph: *Fusicoccum* sp. Dothideales, Botryosphaeriaceae.)	PE, US	F, L, S[31]	No	Yes	Bazán de Segura, 1959; CABI 2003; Farr et al., 2004, Kirk, et al. , 2001b; Ploetz et al., 1994.
Botrytis cinerea Pers.: Fr (Anamorphic Helotiales, Sclerotiniaceae)	PE, US	L, S, I, F, Sd	No	Yes	CABI 2003; Wellman, 1977
Ceratocystis fimbriata Ellis & Halst (Microascales, Ceratocystidaceae)	PE, US	F, L, R, S	No[29]	No[32]	CABI 2003; Farr et al., 2004;
Cercospora lingue Speg. (Anamorphic Mycosphaerellales, Mycosphaerellaceae)	PE	L, F	No[33]	Yes	Farr et al., 2004; Wellman, 1977
Cercospora perseae[34] Ell. & Mart. (Anamorphic Mycosphaerellales, Mycosphaerellaceae)	PE, US	L, F	No	Yes	Farr et al., 2004; Palm, pers. com. 2005; Wellman, 1977
Cladosporium sp. (Anamorphic Mycosphaerellales, Mycosphaerellaceae*)*	PE	R, S, F	Yes[22]	Yes	CABI, 2003; PestID, 2008
Corticium salmonicolor Berk. & Broome. (=*Erythricium salmonicolor* (Berk. & Broome) Burd. Polyporales, Phanerochaetaceae)	PE, US	L, S	No	No	CABI 2003; Farr et al., 2004; Wellman, 1977

Armillaria was detected in Peru, therefore the quarantine status is "Yes."

[31] These associations were based on the biology of *P. pyricola* Nose (*Botryosphaeria berengeriana* f.sp. *pyricola*).

[32] *Ceratocystis fimbriata* typically only causes stem and trunk cankers of its hosts but has been reported to cause superficial lesions on cocoa pods (CABI, 2005). The fungus produces sticky spores that are splash dispersed (Hodges, 2006) or moved by insects and pruning tools (CABI, 2005). Fruit infections of avocado have not been documented and the skin of the avocado, if it could be contaminated with the sticky spores, is highly unlikely to contact a fresh wound in a host plant in the United States. *Ceratocystis fimbriata* has not been intercepted at U.S. ports-of-entry on any commodity from any country (1985 to September, 2008; PestID, 2008). Standard post-harvest treatments and processing such as cleaning from dirt and dust and washing in low concentration of a bleach solution (see Risk Mitigation section: post-harvest procedures in the packing house) are likely to eliminate any spores from the surface**.**

[33] *Cercospora lingue* is listed in Wellman, 1977, but is not a recognized *Cercospora* fide (Chupp, 1953) and its status is unclear (Crous and Braun, 2003). Consequently, we did not further analyze it.

[34] *Cercospora persae* and *C. purpurea* are sometimes found together on the same leaf, however they are morphologically distinct species (Chupp, 1953).

Scientific Name, Classification	**Distribution[1]**	**Plant part affected[2]**	**Quarantine pest[3]**	**Follow pathway[3]**	**References**
Curvularia lunata (Wakk.) Boedijn. (= *Acrothecium lunatum* Wakk. Teleomorph: *Cochliobolus lunatus* R.R. Nelson & Haasis. Pleosporales, Pleosporaceae)	PE, US	L	No	No	CABI 2003; Wellman, 1977
Fusarium lateritium Nees. (Teleomorph *Gibberella baccata* (Wallr.) Sacc. Hypocreales, Nectriaceae)	PE, US	F, R, S, I,	No	Yes	CABI 2003; Icochea et al., 1994; Wellman, 1977
Fusarium roseum Link. (Teleomorph *Gibberella zea* (Schwein.) Petch. Hypocreales, Nectriaceae)	PE, US	F, R, S, L	No	Yes	CABI 2003; Icochea et al., 1994; Wellman, 1977
Fusarium oxysporum Schlecht. (Anamorphic *Gibberella*. Hypocreales, Nectriaceae)	PE, US	F, R, S, L	No	Yes	CABI 2003; Icochea et al., 1994; Wellman, 1977
Fusarium solani (Martius) Sacc. (Teleomorph *Nectria haematococca* (Wollenw.) Gerlach. Hypocreales, Nectriaceae*)*	PE, US	S, R	No	No	CABI 2003; Farr et al., 2004
Gibberella avenacea R.J. Cook (Anamorph *Fusarium avenaceum* (Fr.) Sacc. Hypocreales, Nectriaceae.)	PE, US	F, I, L, S	No	Yes	CABI, 2002
Glomerella cingulata (Stonem.) Spauld. & Schrenk (Incertae sedis, Glomerellaceae)	PE, US	F, L, S, I, Sd	No	Yes	CABI 2003; Farr et al., 2004
Lasiodiplodia theobromae (Pat.) Griffiths & Maubl. (anamorphic Botryosphaeriaceae)	PE, US	F, I, L, S	No	Yes	CABI 2003; Bazán de Segura, 1959
Macrophomina phaseolina (Tassi) Goid (Anamorphic Ascomycetes)	PE, US	F, I, L, R, S, Sd	No	Yes	CABI 2003; Farr et al., 2004
Mucor sp. (Mucorales, Mucoraceae)	PE	L, F	Yes[22]	Yes	Arce et al., 1974; Wellman, 1977
Mycena citricolor (Berk. & Curtis) Sacc. (Anamorph *Stilbella flavidum* (Cooke) Henn. Agaricales, Tricholomataceae).	PE, US (FL)[35]	L, F, S	Yes[35]	No[36]	CABI, 2002; Wellman, 1977

[35] *Mycena citricolor* is reported as present in Florida (CABI, 2002). However, Florida experts indicate that it has not been detected there since 1926 (Schubert, 2002).

Scientific Name, Classification	Distribution[1]	Plant part affected[2]	Quarantine pest[3]	Follow pathway[3]	References
Nectria rigidiuscula Berk. & Broome. (Anamorph *Fusarium rigidiusculum* W.B. Snyder & H.P. Hansen. Hypocreales, Nectriaceae)	PE, US	S, F	No	Yes	CABI, 2002
Nigrospora oryzae (Berk. & Broome) Petch. Teleomorph *Khuskia oryzae* H.J. Huds.. Trichosphaeriales, Taxonomic position of family uncertain.	PE, US	L, F	No	Yes	CABI, 2002; Vallejos and Mattos, 1990; Wellman, 1977
Oidium sp. (powdery mildew) (Anamorphic Erysiphales, Erysiphaceae)	PE	L	Yes	No	Alfieri, 1984; Bazán de Segura, 1959;
Pellicularia koleroga Cooke (=*Corticium koleroga* (Cooke) Höhn. Ceratobasidiales, Ceratobasidiaceae)	PE, US	S, L	No	No	CABI, 2002; Wellman, 1977
Pestalotiopsis guepinii (Desm.) Steyaert. (=*Pestalotia guepinii* Desm. Anamorphic *Pestalosphaeria*. Xylariales, Amphisphaeriaceae).	PE, US	L, F	No	Yes	Alfieri, 1984; Bazán de Segura, 1959
Pestalotia leprogena Speg. (Anamorphic *Broomella*. Xylariales, Amphisphaeriaceae).	PE, US	L	No	No	Farr et al., 2004; Wellman, 1977
Pestalotiopsis neglecta (Thüm.) Stayaert . (=*Pestalotia neglecta* Thüm). Anamorphic *Pestalosphaeria*. Xylariales, Amphisphaeriaceae)	PE, US	L, S, F	No	Yes	Farr et al., 2004; Wellman, 1977
Phomopsis sp. (Anamorphic *Diaporthe*. Diaporthales, Valsaceae)	PE	F, S	Yes[22]	Yes	Alfieri, 1984; PestID, 2008

[36] *Mycena citricolor* seems unlikely to follow the pathway, as we found no reference that it specifically attacks avocado fruit. For example, Mariau (2001) and Wellman (1977) report *M. citricolor* infects the fruit of coffee, but do not report that it infects avocado fruit. Most references refer to *M. citricolor* as a pest of coffee (Mariau, 2001; CABI, 2004; Thurston, 1989; Wellman, 1977). Avocado is not listed as any kind of host in CABI (2004). On coffee, the disease produces sub-circular spots on leaves, initially brown becoming pale-brown to straw-colored. Similar spots may be produced on stalks and berries. The main effect is to cause leaf fall with a consequent reduction in growth and yield of the coffee tree (CABI, 2004). Although it has been reported in Peru (Farr et al., 2004; CABI, 2004), it has not been intercepted on avocado fruit or any fruit from any country since at least 1985, the earliest APHIS computerized interception data available (PestID, 2008). Because *M. citricolor* is primarily a leaf spotting disease, primarily a disease of coffee (*Coffea* spp.), and has neither been reported on nor intercepted on avocado fruit, we did not consider it likely to follow the pathway.

Scientific Name, Classification	Distribution[1]	Plant part affected[2]	Quarantine pest[3]	Follow pathway[3]	References
Phytophthora cactorum (Lebert & Cohn) J. Schröt. (Pythiales, Pythiaceae)	PE, US	L, S, F, R	No	Yes	CABI, 2003
Phytophthora cinnamomi Rands. Pythiales, Pythiaceae	PE, US	L, S, R	No	No	Bazán de Segura, 1959; CABI, 2002; Ploetz, et al., 1994
Phytophthora citrophthora (R.H. Sm. & E. Sm.) Leonian. (Pythiales, Pythiaceae)	PE, US	F, L, R, S, Sd	No	Yes	CABI, 2003; Farr et al., 2004
Phytophthora nicotianae Breda de Haan var. *parasitica* (Dastur) G.M. Waterhouse (Pythiales, Pythiaceae)	PE, US	L, S, F, R	No	Yes	Alfieri, et al., 1984; Farr, et al., 1989; CMI, 1964; CABI, 2003
Phytophthora palmivora (E. J. Butler) E. J. Butler (Pythiales, Pythiaceae)	PE, US	L, S, F, R, I	No	Yes	CABI, 2003; Wellman, 1977
Polyporus hirsutus (Wulfen) Fr. (Polyporales, Polyporaceae)	PE, US	S	No	No	Farr et al., 2004; Wellman, 1977
Pseudocercospora purpurea (Cooke) Deighton (= Cercospora purpurea Cooke). Anamorphic Mycosphaerellales, Mycosphaerellaceae.	PE, US	F, L	No	Yes	Bazán de Segura, 1959; CABI 2003; Farr et al., 2004; Ploetz et al. 1994; Wellman, 1977
Pycnoporus sanguineus (L.) Murrill (=*Polyporus sanguineus* (L.) Fr. Polyporales, Polyporaceae.)	PE, US	S	No	No	Farr et al., 2004; Renjifo and Trujillo, 1992
Pythium ultimum Trow (Pythiales, Pythiaceae)	PE, US	R	No	No	CABI, 2003; Perez et al., 1994; Wellman, 1977
Rhizoctonia solani Kühn. (Teleomorph *Thanatephorus cucumeris* (Frank) Donk. Ceratobasidiales, Ceratobasidiaceae)	PE, US	L, S, F, R, I, Sd	No	Yes	CABI, 2003; Farr et al., 2004; Wellman, 1977
Rhizoctonia sp. (Anamorphic Ceratobasidiales, Ceratobasidiaceae)	PE	L, S, F, R, I, Sd	Yes[22]	Yes	Perez, 1999; Wellman, 1977
Rigidoporus microporus (Sw.) Overeem. Polyporales, Meripilaceae.	PE, US	R, S	No	No	CABI, 2003; Farr et al., 2004
Rosellinia bunodes (Berk. & Br.) Sacc. Xylariales, Xylariaceae.	PE	R, S	Yes	No	Menge and Ploetz, 2003; Ploetz, et al., 1994; Watson, 1971; CMI, 1985, CABI 2003; Farr et al., 2004

Scientific Name, Classification	Distribution[1]	Plant part affected[2]	Quarantine pest[3]	Follow pathway[3]	References
Sclerotinia sclerotiorum (Lib.) de Bary (Helotiales, Sclerotiniaceae)	PE, US	L, S, F, I, R	No	Yes	CABI, 2002
Sclerotium rolfsii Sacc. (Teleomorph *Athelia rolfsii* (Curzi) C.C. Tu & Kimbr. Polyporales, Atheliaceae)	PE, US	L, S, F, R, I, Sd	No	Yes	CABI, 2003; Wellman, 1977
Sphaceloma perseae Jenk. Anamorphic *Elsinöe*. Myriangiales, Elsinoaceae.	PE, US (FL, TX)	F, I, L	No	Yes	Alfieri, et al., 1984; CABI, 2002; Farr et al., 2004; Pernexny, 2000.
Sphaeropsis tumefaciens Hedges. (Anamorphic Ascomycetes.)	PE, US (FL)	S	No[29]	No	CABI, 2003; Timmer, 2003
Verticillium dahliae Kleb. (Anamorphic *Hypomyces*. Hypocreales, Hypocreaceae)	PE, US	L, S, F, R, I, Sd	No	Yes	CABI, 2003; Farr et al., 2004;
NEMATODES					
TYLENCHIDA					
Belonolaimidae					
Tylenchorhynchus sp.	PE	R	Yes	No	Torres, 1977; Wellman, 1977
Hoplolaimidae					
Helicotylenchus dihystera (Cobb) Sher	PE, US	R	No	No	CABI, 2003
Helicotylenchus multicinctus (Cobb) Golden	PE, US	R	No	No	CABI, 2003
Helicotylenchus sp.	PE	R	No	No	Torres, 1977; Wellman, 1977
Rotylenchulus reniformis Linford & Oliveira	PE, US	R	No	No	CABI, 2003
Heteroderidae					
Meloidogyne sp.	PE	R	Yes	No	Delgado and Rosas, 1977; Wellman, 1977
Pratylenchidae					
Pratylenchus brachyurus (Godfrey) Filipjev & Schuurmans Stekhoven	PE, US	R, S	No	No	CABI, 2003
Radopholus similis (Cobb) Thorne	PE, US	R, S	No	No	Anonymous, 1984; Anonymous, 1992; CABI, 2003; PestID, 2008; Ploetz, et al., 1994;
DORYLAIMIDA					
Xiphinematidae					
Xiphinema floridae Lamberti & Bleve-Zecheo	PE, US (FL)	R	No	No	Lamberti, et al. 1987; Lehman, 2002

Scientific Name, Classification	Distribu-tion[1]	Plant part affected[2]	Quaran-tine pest[3]	Follow pathway[3]	References
MOLLUSCA					
Helix aspersa Muller [=Sy. *Cornu aspersum* (Muller)]	PE, US	L, S, R, F, Sd	No[37]	No[38]	CABI, 2003

Table 4. Quarantine Pests Likely to be Associated with avocado imported from Peru

Type	Pests	Taxonomy
Arthropods	*Anastrepha fraterculus* Wiedemann	Diptera: Tephritidae
	Anastrepha striata Schiner	Diptera: Tephritidae
	Ceratitis capitata Wiedemann	Diptera: Tephritidae
	Coccus viridis (Green)	Hemiptera: Coccidae
	Ferrisia malvastra (McDaniel)	Hemiptera: Pseudococcidae
	Stenoma catenifer Walsingham	Lepidoptera: Oecophoridae
Viroid	Potato spindle tuber viroid	

2.4.1. General discussion

We listed the quarantine pests selected for further analysis above (Table 4). We only analyzed further those quarantine pests that can be reasonably expected to follow the pathway of commercial shipments of export avocado fruit. Other quarantine pests not included in this summary could be detrimental to U.S. agriculture, but were not further analyzed for a variety of reasons, as follows: the pest's primary association is with plant parts other than the commodity, such as *Aleurodicus cocois*, *Aleurodicus pulvinatus*, *Oligonychus mangiferus*, *Oncideres poecilla*, *Trioza perseae*, etc., which are associated with leaf or stem feeding (Bolland et al., 1998; CABI, 2003; Hollis and Martin, 1997; Lopez and Kairo, 1999); pests may be intercepted during inspection by Agricultural Officers as biological contaminants of the commodity (PestID, 2008), but biological contaminants are not expected to be present in every shipment.

Also, the biological hazard of organisms identified to the order, family or generic levels was not assessed; however, if pests identified to higher taxa are intercepted in the future, then a reevaluation of their risk may occur. In this risk assessment, this applies to the arthropods *Acutaspis* sp. and *Pinnaspis* sp., and the pathogens *Phomopsis* sp., *Cladosporium* sp., and *Oidium* sp. Generally, the biological hazard of organisms not identified to the species level is not assessed because there are many species within a genus, and it is not reasonable to assume that the biology of all organisms within a genus is identical. The lack of species' identification may indicate the limits of the current taxonomic knowledge, the life stage, or the quality of the specimen submitted for identification. By necessity, pest risk assessments focus on the organisms for which biological information is available. The lack of identification at a specific

[37] Action required to PR, FL, and AL (Courneya, 2004a).
[38] This large pest is unlikely to stay on the commodity through harvest and standard handling and processing.

level does not rule out the possibility that a high risk quarantine pest was intercepted or that the intercepted pest was not a quarantine pest. Conversely, development of detailed assessments for known pests that inhabit a variety of ecological niches, such as the surfaces and/or interiors of fruit, stems or roots, allow effective mitigation measures to eliminate the known organisms, as well as similar, but incompletely identified organisms that inhabit the same niche.

Other plant pests listed in Table 3 that were not chosen for further scrutiny may be potentially detrimental to the agricultural systems of the United States; however, there were a variety of reasons for not subjecting them to further analysis.

2.4.2. *Anastrepha* species discussion

In the past, *Anastrepha* species were one of the greatest concerns in allowing the importation of Mexican avocados. A review of the current literature, however, suggests that under most circumstances, Hass avocados do not serve as hosts for *Anastrepha* spp., as indicated by recent laboratory and field (Aluja et al. 2004) tests conducted in Mexico. The research prompted a re-evaluation of the potential of *Anastrepha* spp. to infest Hass avocado in Mexico. The re-evaluation concluded that uninjured, commercially produced Hass avocados in Mexico do not serve as hosts for the *Anastrepha ludens, A. serpentina, A. obliqua* and *A. striata*. Nevertheless, the current re-evaluation of '*Anastrepha* sp. - Hass avocado' relationships is based on experiments conducted in Mexico only, and, therefore, should be extrapolated to other regions of the world with caution, considering that Norrbom (2004) lists a field study by Wille (1952) that shows avocado is a host for some of the species in Peru. In addition, the Mexican studies indicated that Hass avocado could possibly be a host for species of *Anastrepha* under some environmental or tree stress circumstances (Aluja et al. 2004). Among *Anastrepha* species, *A. striata* is recorded to occasionally infest avocado in the field in Costa Rica and Brazil (Jiron et al., 1988; Uchôa et al., 2002). *Anastrepha fraterculus* is variable in its pest status in different regions, and isozyme and karyotype studies suggest that what has been considered *fraterculus* consists of several closely similar "sibling species" (Foote et al., 1993 and references therein). This species complex has not yet been studied in sufficient detail to permit a clear separation of the included species (White and Elson-Harris, 1992): thus, in Venezuela, Andean and lowland populations are distinct species, and populations from southern and north-eastern Brazil also have marked genetic differences. Also, "there is evidence that the Mexican morphotype differs significantly from South American morphotypes" (Aluja et al., 2004 and references therein) and this was one of the reasons why *A. fraterculus* was not investigated in Mexico by Aluja et al. (2004). Reliable research is very limited regarding actual host status of avocado for several *Anastrepha* species in different parts of the Western Hemisphere which leads to a high uncertainty level. Given available evidence, we believe that *A. fraterculus* could be considered a pest of avocado in Peru and *A. striata* could be considered an occasional pest (Jiron et al., 1988; White and Elson-Harris, 1992; Uchôa et al., 2002) while *A. obliqua* and *A. serpentina* are less likely to infest avocados (Bush, 1957; Uramoto et al., 2001; Norrbom, 2004; Aluja et al., 2004). Considering genetic diversity of *A. fraterculus* and limited research on *A. striata* in S. America, more data on the suitability of Hass avocado as a host for these fruit flies should be collected in Peru. This would be based on results of adult fly trappings in avocado groves, fruit cuttings for possible larval infestations, as well as further experiments designed to actually identify their status as pests of avocado.

2.4.3. Armored scales discussion

In the draft pest risk assessment for Hass avocados imported from Peru that was made available to the public for comment on May 25, 2006, we listed *Acutapsis albopicta* and *Pseudaonidia trilobitiformis* as quarantine pests and analyzed the risk associated with them. In this revised risk assessment however, these armored scales are not further analyzed because, although they may enter on commercial fruit for consumption, armored scales are not expected to become established, and therefore introduced, via this pathway (Miller, 1985; PERAL, 2007). A recent review of the literature, APHIS-PPQ operational data, and expert opinion concludes that, even assuming high quantities of imported fruit infested with armored scale species that could be parthenogenic, highly fecund, polyphagous, invasive, theoretically able to survive in most of the United States, and cause high level consequences, the specific pathway represented by commercially produced fruit shipped without leaves, stems or contaminants constitutes an extremely low risk (PERAL, 2007). This low risk is explained by poor ability of armored scales to disperse to new host plants from fruits for consumption, and consequently, by their low probability of establishment (PERAL, 2007). The following characteristics of armored scales contribute to their poor dispersal capabilities:

- Legs and wings are absent in females and in feeding immature forms. Males possess wings but are short-lived, do not feed, and tend to mate with nearby females.
- Self-dispersal of armored scales occurs by immature forms, or "crawlers". They are the most vulnerable life stage, survival of which decreases with long distance wind dispersal. Crawlers can be passively dispersed by wind from one plant to another only during a time period of approximately 24 hours. No further dispersal is possible after the crawlers start feeding as they lose their legs during the first molt and the mouth parts are deeply inserted in the host, anchoring them firmly to the substrate.
- Dispersal from fruit discarded in the environment is considered very unlikely because of low wind speeds at ground level and low survival rate of crawlers on the ground or on decaying fruit or fruit peel. There is a low probability of active dispersal of crawlers by walking from their natal host since they are not capable of rapid movement over bare soil or rough surfaces.

An additional reason for not analyzing the armored scales in this risk assessment is that commercially produced avocado fruit is expected to have a low infestation rate of armored scales due to requirements of industry quality standards. Processing, culling, and inspection of fruit infested with armored scales can further reduce the prevalence and survival of this group of pests.

2.5. Consequences of Introduction

The undesirable consequences that may occur from the introduction of quarantine pests is assessed in this section. For each quarantine pest, the potential Consequences of Introduction are rated in five areas called "Risk Elements": climate-host interaction, host range, dispersal potential, economic impact and environmental impact. The ratings are determined using the criteria in the risk assessment Guidelines, Version 5.02 (PPQ, 2000). A cumulative risk rating is then calculated by summing the values; we summarized these ratings below (Table 5).

The major sources of uncertainty present in this risk assessment are similar to those in other risk assessments: the use of a developing process (PPQ, 2000; Orr, et al., 1993), the approach used to combine risk elements (Bier, 1999; Morgan and Henrion, 1990), and the evaluation of risk by comparisons to lists of factors within the guidelines (Kaplan, 1992; Orr et al., 1993). To address this last source of uncertainty, the lists of factors are interpreted as illustrative and not exhaustive. Another traditionally recognized source of uncertainty is the quality of the biological information (Gallegos and Bonano, 1993), which includes uncertainty whenever biological information is lacking on the regional flora and fauna. Inherent biological variation within a population of organisms also introduces uncertainty (Morgan and Henrion, 1990).

Figure 2. Plant Hardiness Zones in Peru (source: http://www.backyardgardener.com/zone/sazone.html).

Anastrepha fraterculus Wiedemann (Diptera: Tephritidae)	Risk ratings
Risk Element #1: Climate-Host Interaction The *A. fraterculus* species complex is widely distributed in Central and South America, with restricted distribution in Mexico (CAB, 2001a; Weems, 2002a). This group occurs from the south of Texas to Argentina (Foote et al., 1993). A conservative estimate is that this insect can survive in Plant Hardiness Zones 7-10 of the Continental United States (USDA-NA, 2003).	High (3)
Risk Element #2: Host Range *Anastrepha fraterculus* is extremely polyphagous. Preferred hosts include Myrtaceae, *Eugenia* and *Syzygium* spp.and guava. Other hosts of this species are *Terminalia catappa* (Combretaceae), *Malus pumila* and *Prunus* spp. (Rosaceae), *Annona* spp. (Annonaceae), *Citrus* spp. (Rutaceae), *Coffea* spp. (Rubiaceae),	High (3)

Anastrepha fraterculus **Wiedemann (Diptera: Tephritidae)**	**Risk ratings**
Ficus carica (Moraceae), *Juglans* spp. (Juglandaceae), *Diospyros kaki* (Ebenaceae), *Manilkara zapota* (Sapotaceae), *Persea americana* (Lauraceae), *Solanum quitoense* (Solanaceae), *Theobroma cacao* (Sterculiaceae), *Olea europaea* (Oleaceae), and *Vitis vinifera* (Vitaceae) (CABI, 2003); *Passiflora* spp. (Passifloraceae) (Aguiar-Menezes et al., 2002).	
Risk Element #3: Dispersal Potential Females deposit 200-400 eggs in host fruits (White & Elson-Harris, 1992). Reproduction is continuous, as adults are present year-round (CABI, 2003). In international trade, the major means of dispersal to previously un-infested areas is the transport of fruit containing larvae. For most regions, the most important fruits liable to carry this species are mango and guava (CABI, 2003).	High (3)
Risk Element #4: Economic Impact *Anastrepha fraterculus* is the most economically important *Anastrepha* in Brazil and other South American countries because of its broad host range (Foote et al., 1993). In Brazil, where it causes severe yield losses in apple, the pest is of major concern to growers, and represents a significant constraint to fresh fruit export into countries with quarantine barriers (Sugayama et al., 1996). The insect is also an important pest of guava and mango, and to some extent *Citrus* and *Prunus* spp. (CABI, 2003). Introduction and establishment of this fruit fly will increase cost of production due to application of pesticides and initiation of monitoring programs. *Anastrepha fraterculus* is an important pest of quarantine significance and its establishment will lead to losses of foreign and domestic markets.	High (3)
Risk Element #5: Environmental Impact The extreme polyphagy of this species predisposes it to attack plants in the United States listed as Threatened or Endangered, such as *Prunus* (*P. geniculata*, FL) (USFWS, 2004). Its wider establishment in the United States would likely lead to the initiation of chemical or biological control programs.	High (3)

Anastrepha striata **Schiner (Diptera: Tephritidae)**	**Risk ratings**
Risk Element #1: Climate-Host Interaction *Anastrepha striata* is found throughout Central America, in South America down to Bolivia and Brazil, and the Netherlands Antilles (CABI, 2003). It is has not yet established in the United States (Foote et al., 1993; CABI, 2003). We estimated that this species could survive in Plant Hardiness Zones 9-10 of the Continental United States (USDA-NA, 2003).	Medium (2)
Risk Element #2: Host Range *Psidium guajava* (Myrtaceae) is the primary host (CABI, 2003). Secondary hosts include *Citrus sinensis* (Rutaceae); *Annona muricata* (Annonaceae); *Chrysophyllum cainito* (Sapotaceae); *Prunus persica* (Rosaceae); *Mangifera indica* (Anacardiaceae); *Persea americana* (Lauraceae); *Terminalia catappa* (Combretaceae) (CABI, 2003); *Manihot esculenta* (Euphorbiaceae) (White & Elson-Harris, 1992); *Solanum* sp. (Solanaceae) (Foote et al., 1993); and *Passiflora edulis* (Passifloraceae) (Silva et al., 1996).	High (3)

Anastrepha striata **Schiner (Diptera: Tephritidae)**	**Risk ratings**
Risk Element #3: Dispersal Potential We found little information on the biology of *A. striata*. Reproduction is continuous, adults occurring throughout the year (CABI, 2003). As in other *Anastrepha* species, long-distance dispersal occurs by the movement of immature stages present in consignments of infested fruit. The uncertainty involved in the dispersal potential of this species creates a high risk value.	High (3)
Risk Element #4: Economic Impact *Anastrepha striata* is not considered to be of primary economic importance, although it often is abundant and may be highly destructive to dooryard plantings of some tropical fruits. It is an important pest in the American tropics and subtropics, especially of guavas and other myrtaceous fruits, although it has also been reported to attack mango, mombins, orange, and peach. The main damage is caused by the larvae, which feed inside the fruit (Norrbom, 2001) which becomes unmarketable. *Anastrepha striata* is considered a significant quarantine pest by PPQ and many other regulatory agencies, and its introduction could lead to losses of foreign and domestic markets (Weems, 2002b). If introduced, eradication programs using insecticides will likely be used. If established, *A. striata* will be controlled with an insecticidal cover spray or a bait spray, which will increase cost of production (CABI, 2007).	High (3)
Risk Element #5: Environmental Impact Because of its broad host range, this species can attack vulnerable native plants in the United States, including *Prunus* (*P. geniculata*, FL), and *Manihot* (*M. walkerae*, TX) (USFWS, 2004). As a potential threat to the citrus and stone fruit industries, chemical or biological control programs will likely be used against it.	High (3)

Ceratitis capitata **(Diptera: Tephritidae)**	**Risk ratings**
Risk Element #1: Climate-Host Interaction *Ceratitis capitata* is found in Southern Europe and West Asia, throughout Africa, South and Central America, and in Northern Australia (CABI, 2002). We estimate this species could establish within Plant Hardiness Zones 7-10 of the continental United States (USDA-NA, 2003).	High (3)
Risk Element #2: Host Range This pest has been recorded on a wide variety of host plants in several families, including Rubiaceae (*Coffea* 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, 2002), Lauraceae (*Persea americana*) (Putruele, 1996).	High (3)
Risk Element #3: Dispersal Potential Eggs are deposited in host fruit in small batches of six to eight (Hassan, 1977), around 300 per female (Weems, 1981). In warm climates breeding is continuous throughout the year, as there are several overlapping generations (Hassan, 1977). Adults can fly 20 or more kilometers (CABI, 2002). Transport of infested fruits	High (3)

Ceratitis capitata (Diptera: Tephritidae)	Risk ratings
is the major means of movement and dispersal to previously un-infested areas (CABI, 2002).	
Risk Element #4: Economic Impact *Ceratitis capitata* is an important pest in Africa, and can be spread in suitable climates worldwide, making it the single most important pest species in its family (CABI, 2005). In Mediterranean countries, the pest is particularly damaging to citrus and peach crops increasing cost of production due to expenses related to control programs. It may also transmit fruit-rotting fungi (CABI, 2005). *Ceratitis capitata* is of quarantine significance worldwide, especially for Japan and the United States, where we spent considerable resources in order to prevent introduction of this fly (CABI, 2005). Its presence can lead to severe constraints for fruit export leading to losses of foreign and domestic markets (CABI, 2005).	High (3)
Risk Element #5: Environmental Impact The introduction and establishment of *C. capitata* in the United States will trigger the initiation of chemical control, particularly bait sprays. The species is highly polyphagous, and can attack the following species listed as Threatened or Endangered: *Prunus geniculata* (FL)*; Argemone pleiacantha* (NM)*; Asimina tetramera* (FL); *Berberis nevivii*, *B. pinnata*, *B. sonnei*, (CA); *Cucurbita okeechobeensis* (FL); *Echinocereus chisoensis*, *E. reichenbachii*, *E. iridiflorus* (TX); *E. fendleri* (NM); *E. triglochidiatus* (AZ); *Euphorbia telephioides* (FL); *Opuntia treleasei* (CA); *Ribes echinellum* (FL, SC); and *Ziziphus celata* (FL) (USFWS, 2006). As species of *Opuntia* are hosts, damage can disrupt critical habitats in the Southwest (Chavez-Ramirez et al., 1997).	High (3)

Coccus viridis (Green) (Hemiptera: Coccidae)	Risk ratings
Risk Element #1: Climate-Host Interaction This species is pantropical in distribution. It has been reported from India through Indo-China, Malaysia, the Philippines, Indonesia, Oceania and sub-Saharan Africa (CABI, 2003). In the New World, it is present in Florida, and ranges from Mexico and Central America to northern South America and the Caribbean (CABI, 2002). We estimate that *C. viridis* could establish in the continental United States throughout Plant Hardiness Zones 8-10 (USDA-NA, 2003).	Medium (2)
Risk Element #2: Host Range This species is polyphagous. Primary hosts include *Citrus* spp. (Rutaceae), *Coffea arabica* (Rubiaceae), *Artocarpus* sp. (Moraceae), *Camellia sinensis* (Theaceae), *Manihot esculenta* (Euphorbiaceae), *Mangifera indica* (Anacardiaceae), *Psidium guajava* (Myrtaceae), and *Theobroma cacao* (Sterculiaceae) (CABI, 2002). Other hosts include *Alpinia purpurata* (Zingiberaceae), *Chrysanthemum* sp. (Asteraceae), *Manilkara zapota* (Sapotaceae), and *Nerium oleander* (Apocynaceae) (CABI, 2002), *Persea americana* (Lauraceae) (Peña, 2003; Ben-Dov et al., 2003).	High (3)
Risk Element #3: Dispersal Potential Females may deposit up to 500 eggs (CABI, 2002); there may be several	High (3)

Coccus viridis **(Green) (Hemiptera: Coccidae)**	**Risk ratings**
generations per year (Kosztarab, 1997). In spite of the slow rate of natural dispersal (Tandon and Veeresh, 1988), the scale can quickly spread through the transport of infested plant materials. *Coccus viridis* has been intercepted numerous times by PPQ on many plants from many countries (PestID, 2008).	
Risk Element #4: Economic Impact *Coccus viridis* is a major pest of coffee in Haiti (Aitken-Soux, 1985) and India (Narasimham, 1987). 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). *Coccus viridis* is a major cause of yield loss in New Guinea coffee crop (Williams, 1986). In India, the infestation of *C. viridis* and the sooty mold (*Capnodium citri*) that accompanied it significantly altered the quality of citrus fruit (Haleem, 1984). This pest is mostly known to be a minor pest of tropical crops, particularly coffee. Most of these hosts are not grown in the United States or of minor economic importance. In Florida the preferred host is groundsel bush, *Baccharis halimifolia* L., a non-cultivated plant. Preferred cultivated hosts are gardenia and ixora. In Florida, the records include 174 host plants for the green scale (Dekle and Fasulo, 2001). This scale may occur on cultivated hosts in commercial nurseries and usually infestations are accompanied by sooty mold. Implementation of chemical control of the scale as well as the control of the ants protecting the scale from its natural enemies increases the cost of production (Dekle and Fasulo, 2001).	High (3)
Risk Element #5: Environmental Impact As a polyphagous organism, *C. viridis* is likely to attack native plants in the United States, some of which could be Threatened or Endangered (e.g., *Senecio layneae* – CA; *Cucurbita okeechobeensis* – FL; *Manihot walkerae* – TX; *Verbena californica* - CA) (USFWS, 2004). If this species were introduced to citrus production areas of California and Texas, it could have a negative impact and stimulate the initiation of additional biological control programs, such as release of predators (e.g., ladybird *Chilocorus*, caterpillars *Eublemma*, parasites *Coccophagus*, or the parasitic fungus *Cephalosporium lecanii)* (CABI, 2005). It is also possible, however, that native natural enemies in the new areas of scale introductions would be able to suppress populations of the pest. Thus, *C. viridis* is already present in Florida where several entomopathogenic fungi play an important role in the natural limitations of this scale on citrus (Peer Review, 2006). Chemical sprays that are already in place against other scale insects should be able to control *C. viridis*.	Medium (2)

Ferrisia malvastra **(McDaniel) (Hemiptera: Pseudococcidae)**	**Risk ratings**
Risk Element #1: Climate-Host Interaction The species is widely distributed in Africa (from South Africa to Israel), Americas (from Argentina to Mexico), Australia, Oceania, and India (Ben-Dov et al., 2003). It is estimated that it could establish in Plant Hardiness Zones 7-10 of the Continental United States (USDA-NA, 2003).	High (3)

Ferrisia malvastra **(McDaniel) (Hemiptera: Pseudococcidae)**	**Risk ratings**
Risk Element #2: Host Range This species is widely polyphagous. The most important host families include Cruciferae (*Brassica rapa*), Euphorbiaceae (*Euphorbia hirta*, *Manihot esculenta*), Lauraceae (*Persea Americana*), Fabaceae (*Arachis hypogaea*, *Phaseolus vulgaris*), Malvaceae (*Gossypium hirsutum*), Rutaceae (*Citrus paradise*), Solanaceae (*Lycopersicon esculentum*, *Solanum tuberosum*), Chenopodiaceae (*Suaeda monoica*), Compositae (*Erigeron*), Crassulaceae (*Sedum*) (Ben-Dov et al., 2003).	High (3)
Risk Element #3: Dispersal Potential *Note: We found no information about dispersal potential for this species. Consequently, we based our analysis on information for* F. virgata. In India, several overlapping generations occur per year, but only three generations occur in Egypt (CABI, 2003). Fecundity ranges from 109 to 185 eggs per generation, and may exceed 500 (CABI, 2003). The oviposition period is 20-29 days, while the incubation period is about 3-4 hours (CABI, 2003). Nymphs molted 3 (females) and 4 (males) times, and the development period varied from 26-47 and 31-57 days, respectively (CABI, 2003). Longevity of the adult female was 36-53 days and 1-3 days for the male (CABI, 2003). The primary dispersal stage is the first instar, which naturally disperses by wind and animals (CABI, 2003). The females are active and mobile until they start to produce an ovisac and lay eggs (CABI, 2003). All life stages may be carried on consignments of plant material and fruit (CABI, 2003). *Ferrisia malvastra* was intercepted three times and *Ferrisia* sp. 153 times, with 43 interceptions in commercial and permit cargo (PestID, 2008). We ranked this species High for this element.	High (3)
Risk Element #4: Economic Impact *Ferrisia malvastra* is a widespread, polyphagous species (USDA, 2003a). Although it is not commonly known to be a significant plant pest, it has been confused with *F. virgata* and prior to recognition of *F. malvastra* as distinct from *F. virgata*, *F. malvastra* may have been misidentified as *F. virgata* (Culik et al., 2006). It is considered to be a pest in the United States (Miller et al. 2002) and is of concern as a potential agricultural pest in Israel (Ben-Dov 2005). We found no good evidence that *F. malvastra* is a pest of economic significance, but it damages multiple species and is a vector of "swollen shoot", a virus disease of cacao in West Africa (Ben-Dov et al., 2003). Taking into account the pest's broad distribution, its polyphagy, and the ability to transmit a viral pathogen, we gave it a Medium rating for this risk factor.	Medium (2)
Risk Element #5: Environmental Impact As a polyphagous pest, *F. malvastra* is likely to attack native plants in the United States. Some of these could be Threatened or Endangered, such as *Euphorbia telephioides* (FL), *Manihot walkerae* (TX), *Suaeda californica*,(CA), *Erigeron* (*E. decumbens* – OR, *E. maguirei* – UT, *E. parishii* – CA, *E. rhizomatus* – NM), and *Sedum integrifolium* (MN, NY) (USFWS, 2004). Introduction of this species in areas where the related species, *F. virgata*, is already present and controlled, may not lead to the initiation of additional programs	Medium (2)

Potato Spindle Tuber Viroid (PSTVd)	**Risk ratings**
Risk Element #1: Climate-Host Interaction Climate is unlikely to limit the distribution of the viroid. PSTVd is found in a wide range of climates from temperate to tropical (CABI, 2004). Before being eradicated from the United States it was found in thirteen states from North Dakota to Mississippi, which corresponds to more than four hardiness zones.	High (3)
Risk Element #2: Host Range The primary natural host of PSTVd is potato, but the viroid also affects tomato and other *Solanum* spp. (Peters and Runia, 1985). The experimental host range of PSTVd includes a wide range of Solanaceous species, as well as species from other families (Singh, 1973). Sweet potatoes (*Ipomoea batatas*) (Convolvulaceae), avocados (*Persea americana*) (Lauraceae) and *Solanum muricatum* have recently been described as hosts, in addition to wild Solanum spp. hosts (Salazar, 1989; Owens et al., 1992; Querci et al., 1995; Behjatnia et al., 1996; Shamloul et al., 1997). The viroid attacks plant hosts from several families therefore the ranking is High.	High (3)
Risk Element #3: Dispersal Potential PSTVd may be spread by contact between infected and healthy plants (CABI, 2004). It may also be transmitted by pollen or aphid vectors (in association with PLRV) over short distances (CABI, 2004). The dispersal potential of the viroid in avocado fruit is unknown. In potato, tubers are the most important means of PSTVd dissemination over both long and short distances (Salazar, 1989). The increased use of true potato seed (TPS) for potato propagation is another potential avenue for spread of the disease if measures are not maintained to certify disease-free status (Singh and Crowley, 1985a; Salazar, 1989).	Medium (2)
Risk Element #4: Economic Impact PSTVd can cause up to a 90 percent yield reduction in avocado (Querci et al., 1995) Losses in potato vary from 3 to 64 percent (Le Clerg et al.,1944; Singh et al., 1971). However, the severe strain reduced the yield by up to 64 percent. Re-establishment of PSTV in the seed potato producing areas of the United States could lead to the losses of potential markets.	High (3)
Risk Element #5: Environmental Impact There are no known host plants that are listed as Threatened or Endangered in the continental United States (USFWS, 2004). The environmental impact of the pathogen is likely to be minimal since the disease used to be widely spread throughout North America (CABI, 2004).	Low (1)

***Stenoma catenifer* Walsingham (Lepidoptera: Oecophoridae)**	**Risk ratings**
Risk Element #1: Climate-Host Interaction This moth is distributed in the Western Hemisphere, from Mexico to Brazil (CABI, 2003). Suitable climatic conditions for this species in the Continental United States include Plant Hardiness Zones 9-10 (USDA-NA, 2003).	Medium (2)

Stenoma catenifer **Walsingham (Lepidoptera: Oecophoridae)**	**Risk ratings**
Risk Element #2: Host Range The seed moth infests species in several genera of Lauraceae: *Beilschmiedia*, *Chlorocardium rodiei* (greenheart tree), *Persea americana* (avocado), *P. schiedeana* (coyo) (CABI, 2003). We rated this factor Medium.	Medium (2)
Risk Element #3: Dispersal Potential Females lay eggs on the skin of the fruit, and the larvae bore into the pulp and seed; on *Persea* (in environmental chamber), there could be approximately 164 eggs laid per female, and up to 206 eggs per female on *Chlorocardium rodiei* (CABI, 2003). The average life cycle is 46 days with thee generations per year (FAO, 1999). In tropical regions, this pest is present throughout the year due to the availability of host plants with diverse flowering periods (CABI, 2003). *Stenoma catenifer* populations increase during the growing season, reaching the highest level before harvest (CABI, 2003). Because larvae are internal, *S. catenifer* can be spread worldwide via humans.	High (3)
Risk Element #4: Economic Impact *Stenoma catenifer* is a major pest of avocado in Latin America (CABI, 2003). The proportion of damaged fruit may reach 100 percent in Brazil (with total fruit loss), 80 percent in Venezuela, and 100 percent in Ecuador (CABI, 2003).	High (3)
Risk Element #5: Environmental Impact No plants in the genus *Persea* are listed as Threatened or Endangered (USFWS, 2004), but several states do. Thus, *P. borbonia* (L.) Spreng. is endangered in Maryland and *P. palustris* (Raf.) Sarg. is endangered in Arkansas. Species from the Lauraceae family are Federally listed as Threatened and Endangered (e.g., *Lindera melissifolia* (Walt.) Blume). Preference tests were not conducted for these species, but they could be hosts for *S. catenifer*. If *S. catenifer* was introduced, new spray programs will likely be initiated since current programs only target external lepidopteran avocado pests.(Bailey and Olsen, 1990a,b; Glenn et al., 2003). In Brazil, *S. catenifer* is currently controlled by organophosphates, carbamates, and pyrethroids (Ventura et al., 1999). In Mexico, insecticides have to be applied at least 12 times to be effective (Wysoki et al., 2002). New biological control programs could be developed based on the reports of the egg parasitism in natural populations. For example, in Brazil, natural egg infestations by *Trichogramma pretiosum* and *Trichogrammatoidea annulata* can reach 40 percent (Hohmann and Meneguim, 1993). One of these species (*T. annulata*) occurs in the United States where it has been released against the navel orange worm (Peer Review, 2006). Introduction of the new control programs could be detrimental to the beneficial fauna of the current pests, however, there is a high degree of uncertainty to the exact impact. We are erring on the side of caution and assigning High ranking for this risk factor.	High (3)

Table 5. Summary of the risk ratings for Consequences of Introduction

Pest	**Risk elements**					**Overall rating**[a]
	Climate / Host interaction	**Host Range**	**Dispersal potential**	**Economic impact**	**Environ. impact**	
Anastrepha fraterculus	High (3)	High (3)	High (3)	High (3)	High (3)	High (15)
Anastrepha striata	Med (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)
Coccus viridis	Med (2)	High (3)	High (3)	High (3)	Med (2)	High (13)
Ferrisia malvastra	High (3)	High (3)	High (3)	Med (2)	Med (2)	High (13)
Potato Spindle Tuber Viroid	High (3)	High (3)	Med (2)	High (3)	Low (1)	Medium (12)
Stenoma catenifer	Med (2)	Med (2)	High (3)	High (3)	High (3)	High (13)

[a] Low is 5-8 points, Medium is 9-12 points and High is 13-15 points

2.6. Likelihood of Introduction

The rating for the Likelihood of Introduction is the sum of the ratings values for the Quantity Imported Annually and the Pest Opportunity (Table 6). The likelihood that an exotic pest will be introduced depends on the amount of the potentially-infested commodity that is imported. The assessment of Pest Opportunity is based on the biological features exhibited by the pest's interaction with the commodity, and represent a series of independent events that must take place before a pest outbreak can occur. The five components are as follows: availability of postharvest treatments, whether the pest can survive through the interval of normal shipping procedures, whether the pest can be detected during a port-of-entry inspection, the interactions among factors that influence the rate of establishment, and the factors that influence the rate of population establishment.

2.6.1. Quantity imported annually

The amount reported by the country of proposed export, in standard units of 40-foot long shipping containers (Table 6), was 250 containers in 2003, 375 in 2004, and 500 in 2005 (SENASA, 2002b). This is greater than 100 containers, so the risk factor is High.

2.6.2. Survive Postharvest Treatment

We rated *Anastrepha fraterculus, A. striata, Ceratitis capitata,* and *Stenoma catenifer* High for this sub-element because the larvae are internal feeders that are not likely to be affected by a surface-cleansing postharvest treatment, such as washing and culling, especially if the extent of the damage is not very obvious.

We rated *Coccus viridis* and *Ferrisia malvastra* Medium because they are external feeders that are likely to be dislodged by a surface-cleansing postharvest treatment. Depending on their stage (egg, immature, adult) or instar, however, these insects might find shelter on fruit, particularly at the calyx end, on a bumpy surface or in packing materials. The Coccoidea have sessile stages that live firmly pressed to plant surfaces; this posture and their water-repellent, waxy cuticles can make them difficult to see or dislodge, especially if sheltered at the stem end of the fruit.

Potato Spindle Tuber Viroid (PSTVd), like other viruses or viroids, is expected to survive treatment, and we therefore rated it High risk.

2.6.3. Survive Shipment.

We rated all of the pests High risk for this sub-element. The internal feeders are protected from adverse environmental conditions by the plant part tissue, while other pests are expected to take shelter in rough or pitted areas on the plant part surface. Fruit can be shipped by airfreight, which makes delivery time short, and may or may not be refrigerated. The temperature conditions and time frames associated with un-refrigerated air or sea transport are insufficient to reduce population levels of these pests. Further evidence of the ability of numerous pests to survive with avocado fruit shipments is in the fact that, since 1985, officers at U.S. ports-of-entry have intercepted 17,402 pests on avocado fruit, including permit and general cargo, stores, quarters, mail, and passenger baggage (PestID, 2008). Interceptions from South America are presented below (Appendix A). PSTVd replicates autonomously and moves systemically within the plant. The viroid would be expected to survive shipment and is therefore ranked High.

2.6.4. Not Detected at the Port-of-Entry

We rated *Anastrepha fraterculus, A. striata, Ceratitis capitata,* and *Stenoma catenifer* High risk for this sub-element because these internal pests are only intercepted by destructive sampling. Depending on the age of infestation, the fruit fly pests can have a high probability of escaping detection at a port-of-entry; fruit fly-infested fruit can go unrecognized (White and Elson-Harris, 1992).

Staining of fruits by sooty molds and large, obvious infestations can lead to the easy detection of *Ferrisia malvastra* and *Coccus viridis*. Sparser populations of these relatively small insects (especially eggs and early instars), particularly if concealed at the stem end of fruits or in packing materials, would be more difficult to discover, despite the color differences with the plant part. Consequently, we rated these pests Medium.

PSTVd may not be detected upon entry. PSTVd has been found in potato seed (CABI, 2004). Some avocado fruits exhibit pronounced symptoms (Querci et al., 1995), but these fruits are unlikely to be packed. It is unclear if asymptomatic fruit contain viable inoculum quantities, so we ranked the pest Medium here.

2.6.5. Moved to a Suitable Habitat

Areas suitable for these pests to establish permanent populations include parts of the South and the West Coast of the continental United States, which comprises about 20 percent of the total land area. Domestic Hass avocado consumption indicates that states where avocados are grown—California and Florida—annually consume an average of about 36 percent of the total volume of avocados from all sources (Bellamore, 2006). If Hass avocados from Peru are allowed entry into the entire United States market, we expect a proportionately high share of the imports will go to California and Florida.

Based on their known distributions in warm temperate and tropical climates, we rated all of the arthropods Medium for this sub-element due to their need for specific temperature ranges.

PSTVd can establish in a broad range of climates so there is a High likelihood of it being moved to a suitable climate.

2.6.6. Contact with Host Material

This varies among the arthropods in their potential geographic range within the United States. Hosts of the polyphagous species *Anastrepha fraterculus*, *A. striata*, *Ceratitis capitata* (see above) should be available throughout the potential range. We rated these pests High for this sub-element.

Hosts of *Coccus viridis* are more limited in distribution in the United States, and are therefore less likely to be contacted. *Ferrisia malvastra* hosts include some temperate-zone or widely cultivated plants (NRCS, 2003), but Coccoidea biology reduces the likelihood of successful establishment in the United States. Specifically, their sessile nature greatly limits the chances of contacting hosts (Miller, 1985; Gullan and Kosztarab, 1997). Successful establishment of these insects in a new environment depends on at least two necessary conditions: close proximity of susceptible hosts, and 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), we rated all scale insects Low for this element.

PSTVd is unlikely to come into contact with hosts. In potato, natural spread of PSTVd is through seed or aphid transmission (CABI, 2004). PSTVd and a related viroid Avocado Sunblotch Viroid (ASBVd) are known to be transmitted through seed or pollen of infected plants (Desjardins et al., 1984; Fernow et al., 1970). Establishment would require infected seed or fruit tissue to come into contact with a host. This may require propagation of the seed rather than normal disposal; hence we rated the risk Low.

As mentioned above, *Stenoma catenifer* feeds on avocado and some other species from Lauraceae. We expect the host range to include species of native *Persea borbonia*, *P. humilis*, and *P. palustris*, grown in South and South East of the Continental United States. The territory with the available hosts comprises approximately of less than 20 percent of total Continental United States (NRCS, 2006).. For this reason, we rated it Medium for this factor.

Port-of-entry inspection will probably be inadequate to provide phytosanitary security for all quarantine pests that are likely to follow the pathway; therefore, the development of specific phytosanitary measures is recommended. Postharvest mitigation measures to reduce infestations of external and internal feeders are necessary and should be implemented for imports to be authorized.

Table 6. Summary of the ratings for the Quantity Imported Annually, the Pest Opportunity, and the rating for the overall Likelihood of Introduction

Pest	Quantity imported annually	Ratings for Pest Opportunity					Likelihood of Introduction rating[a]
		Survive postharvest treatment	Survive shipment	Not detected at port-of-entry	Moved to suitable habitat	Contact host material	
Anastrepha fraterculus	High (3)	High (3)	High (3)	High (3)	Med (2)	High (3)	High (17)
Anastrepha striata	High (3)	High (3)	High (3)	High (3)	Med (2)	High (3)	High (17)
Ceratitis capitata	High (3)	High (3)	High (3)	High (3)	Med (2)	High (3)	High (17)
Coccus viridis	High (3)	Med (2)	High (3)	Med (2)	Med (2)	Low (1)	Med (13)
Ferrisia malvastra	High (3)	Med (2)	High (3)	Med (2)	Med (2)	Low (1)	Med (13)
Potato Spindle Tuber Viroid	High (3)	High (3)	High (3)	Med (2)	High (3)	Low (1)	High (15)
Stenoma catenifer	High (3)	High (3)	High (3)	High (3)	Med (2)	Med (2)	High (16)

[a] Low: 6 - 9 points, Medium: 10 - 14 points, High: 15 - 18 point

2.7. Conclusion: Pest Risk Potential and Phytosanitary Measures

The sum of the values for Consequences of Introduction and Likelihood of Introduction gives values for Pest Risk Potential (Table 7). This is a baseline estimate of the risks associated with this importation, and the reduction of risk occurs through the use of mitigation measures.

Specific phytosanitary measures may be necessary for pests with a baseline Pest Risk Potential of Medium (*Coccus viridis, Ferrisia malvastra*). All the fruit fly pests in this risk assessment (*Anastrepha fraterculus*, *Anastrepha striata*, *Ceratitis capitata*) had analysis values within the High range for their Pest Risk Potential. The Guidelines (PPQ, 2000) state that a High Pest Risk Potential means that specific phytosanitary measures are strongly recommended, and that port-of-entry inspection is not considered sufficient to provide phytosanitary security.

Note that any species of *Heilipus* seed beetles may later be considered to follow the pathway if these insects are intercepted on avocados imported from Peru. We included *Heilipus* sp. in the pest list based on two interceptions on avocado from Peru in baggage but this was not sufficient evidence to indicate that the pest follows the pathway. We have a high degree of uncertainty associated with the *Heilipus* species based mostly on a lack of sufficient evidence about this genus in Peru and its economic importance there.

Likewise, uncertainty exists about whether or not other genera of seed weevils are associated with avocado in Peru. For example, *Conotrachelus* species were intercepted from Peru in permit and commercial cargo of different commodities, other than avocado (1985-2008; PestID, 2008). Despite this, we have no information on species of *Conotrachelus* that occur in Peru and may feed on avocado. We therefore did not include any species from this genus in the pest list. Species from the genus *Conotrachelus*, however, are well known pests of avocados (Wysoki et al., 2002) and one or more of these species might occur on avocados in Peru. Seed weevils from genera *Heilipus* and *Conotrachelus* are known to be in the pathway on avocados imported by the United States from other countries (7 CFR §319.56; PestID, 2008).

The conclusions from pest risk assessment are used to decide whether risk management is required and the strength of measures to be used (Stage 2 of PRA) (IPPC, 2007: ISPM #2). Pest risk management (Stage 3 of PRA) is the process of identifying ways to react to a perceived risk, evaluating the efficacy of these procedures, and recommending the most appropriate options (IPPC, 2007: ISPM #s 2 and 14). We described risk mitigation options below, with their efficacy and application.

Table 7. Pest Risk Potential

Pest	**Consequences of Introduction**	**Likelihood of Introduction**	**Pest Risk Potential**[a]
Anastrepha fraterculus	High (15)	High (17)	High (32)
Anastrepha striata	High (14)	High (17)	High (31)
Ceratitis capitata	High (15)	High (17)	High (32)
Coccus viridis	High (13)	Medium (13)	Medium (26)
Ferrisia malvastra	High (13)	Medium (13)	Medium (26)
Stenoma catenifer	High (13)	High (16)	High (29)
Potato Spindle Tuber Viroid	Medium (12)	High (15)	High (27)[b]

[a] Low = 11-18 points, Medium = 19-26 points and High = 27-33 points.
[b] Determined to be Low based on analysis in Appendix B.

3. Risk Mitigation

The appropriate level of protection associated with the risks of commodity importations can be achieved by the application of a single phytosanitary measure, such as inspection, quarantine treatment, or a combination of measures. Specific mitigations may be selected from a range of pre-harvest and post-harvest options (Table 8), and may include other safeguarding measures. Measures may be added or the strength of measures may be increased to compensate for uncertainty associated with evidence of a risk. At a minimum, for a measure to be considered for use in a systems approach, it must be: 1) clearly defined; 2) efficacious; 3) officially required (mandated); and 4) subject to monitoring and control by the responsible national plant protection organization (IPPC, 2007: ISPM #14).

A systems approach to mitigate risks involved with mature green ‘Hass’ avocado imports from Peru might combine a variety of measures: 1) certification of pest-free areas, pest-free places of production, or areas of low pest prevalence for certain quarantine pests; 2) programs to control pests within orchards (e.g., mechanical, chemical, cultural); 3) preclearance oversight by USDA-APHIS officials; 4) packinghouse procedures to eliminate external pests (e.g., washing, brushing, inspection of fruit); 5) quarantine treatments to disinfest fruit of internal and external pests; 6) consignments inspected and certified to be free of quarantine pests; 7) fruit traceable to origin, packing facility, grower, and field; 8) consignments subject to sampling and inspection after arrival in the United States; and 9) limits on distribution and transit within the United States.

3.1. Prior to Harvest

3.1.1. Pest-free Areas

Establishment of pest-free areas, pest-free places of production, and pest-free production sites, as well as areas of low pest prevalence, may be an effective alternative to post-harvest quarantine treatments or a component of systems approach (IPPC, 2007: ISPM #14). If used, pest-free areas or production sites should be established and maintained in compliance with relevant ISPMs (IPPC, 2007: ISPM #s 2, 10, and 22) and NAPPO Standard No. 17 (NAPPO 2004b). Export from Peru could be considered only from production areas that participate in the Integrated Fruit Fly Management program. Currently, this program includes trappings for fruit flies during the avocado growing season (SENASA, 2005). We that pre-harvest trapping programs are as important as monitoring population levels during the harvest season. Overall, the trapping schedules should satisfy the requirements of the appropriate international and regional standards, such as those mentioned above.

Fruit flies *Anastrepha fraterculus, Anastrepha striata* and *Ceratitis capitata*
Basic requirements for the trapping program for establishing fruit fly pest free areas (PFA) are found in NAPPO Standard No. 17 (NAPPO, 2004b). Specific trapping levels for *Anastrepha* spp. and *Ceratitis capitata* should be identified in the Workplan and are not discussed in this document. In addition to the trappings, an exclusion of untreated host fruit imports into PFA is required. Also, mandatory are treatments of all capture sites and strict increase of trapping levels at first capture, trapping in pueblos as well as in orchards, suspension of exports on second capture in 1 sq mile in the same life cycle. We suggest a periodic APHIS review of the program and possibly a pre-clearance of shipments.

Seed moth *Stenoma catenifer*
If used, establishing a pest-free area for this pest should be based on official sample prior to export season, orchard cleanliness, verification sampling and inspection of lots at harvest; certification of being harvested from pest free place of production.

The municipality should be surveyed at least annually and found to be free from the seed moth. The survey should cover a specific area (as stated in the Workplan) and include randomly selected portions of each registered orchard and areas with wild or backyard avocado trees. The survey should be conducted during the growing season and completed prior to the harvest of the avocados. Specifics for this survey could be similar to those approved for the importation of Hass avocados from Mexico into the United States as described in the Code of Federal Regulations (7 CFR § 319, 2003).

A second option is a pest-free place of production based on a higher level of official sampling, orchard cleanliness, and higher levels of verification samplings and inspections of lots at harvest as well as a phytosanitary certification of production in a pest free place.

Scales *Coccus viridis* and *Ferrisia malvastra*
Effective IPM programs achieving low pest prevalence of these scales combined with inspection is a possible mitigation option. Freedom from the scales could be verified by conducting an official survey or lot freedom based on inspection of shipping lot.

3.1.2. Control Program

Mechanical, cultural, or chemical means (e.g., orchard sanitation, pre-harvest insecticidal, fungicidal, and herbicidal sprays) could be used to control pests within the orchards routinely to achieve pest-free areas or pests-free production sites. Sanitation and pesticide applications, as essential components of best management practices, are mainstays of commercial fruit production (e.g., Kirk et al., 2001a).

3.1.3. Phytosanitary Certification Inspections

Fruit could be sampled and inspected periodically during the growing season and after harvest for quality control and as phytosanitary precautionary measures. Orchards could be surveyed periodically; at these times, a random sample of fruit per tree will be inspected to detect for presence of quarantine pests. Results of surveys must be negative for quarantine pests. Production areas also could be subject to scheduled audits and periodic, unannounced inspections by certified inspectors from PPQ and SENASA; these inspections will insure that production areas will meet stipulated requirements for the issuance of a phytosanitary certificate required for each consignment. This measure is useful for detecting pests present during the growing season that may be more difficult to detect post-harvest. Detection methods need to be combined with other measures to ensure the absence of pests of concern. Statistical procedures are available to verify, to a specified confidence level, the pest-free status of an area, given negative survey or trapping results (Barclay and Hargrove, 2005).

3.2. Post-harvest and Prior to Shipping

Removal of infected or infested plant material reduces the likelihood that quarantine organisms would be present with a shipment. Routine post-harvest and packing practices for avocados to be exported to the United States might include safeguards similar to those applied for avocados imported from Mexico (7 CFR § 319.56-2ff, 2003; now 7 CFR § 319.56-30, 2008). For example, removal and disposal of fallen avocado fruit from the orchard at least once every 7 days. Other safeguards might include placing fruit in containers or field boxes marked with an orchard registration number, protecting fruit from fruit flies with insect-proof screens or tarpaulins before they are moved, or moving fruit from the orchard to the packinghouse within 3 hours of harvest. Maintaining fruit identification from field boxes or containers to the shipping boxes would allow avocados to be traced back to the orchard of origin if pests are found at the packinghouse or during entry inspection in the United States.

In addition, the packinghouse might accept fruit only from orchards certified for participation in the avocado export program. To prevent insects from entering the packinghouse, all openings could be covered by screening or by some other barrier. The packinghouse could also have double doors at the entrance to the facility and at the interior entrance to the area where the avocados are packed.

Prior to the culling process, a sample of 300 avocados per shipment could be selected, cut, and inspected to be found free from quarantine pests.

Prior to being packed in boxes, each avocado fruit could be cleaned of all stems, leaves, and other portions of plants to remove external pests. Most avocado fruit can be cleaned by gently wiping the surface with a clean soft cotton cloth or gloves. It may be necessary to use a moist cloth if the dirt particles or surface stains are difficult to remove. The cloth should periodically be dipped in a mild solution of household bleach (150 ppm hypochlorous acid or household bleach) to minimize the spread of possible latent diseases. Larger-scale operations may choose to clean the avocados by hand- rubbing individual fruit dumped in a tank of sanitized water. The wash water should be sanitized with 150 ppm hypochlorous acid (household bleach) maintained at a pH of 6.5. This is equal to 2 oz of household bleach (such as Marvex) per 5 gallons of water, or .3 liters of bleach per 100 liters of water. Avocadoes can also be cleaned mechanically by passing the fruit over a series of roller brushes wetted from above with spray nozzles (GMC, 2006).

During the grading process, any damaged, diseased, or infested fruit could be removed and separated from the commodity destined for export. Each selected fruit should be labeled with a sticker that bears registration number of the packinghouse. Any avocados that have not been packed or loaded into a refrigerated truck or refrigerated container by the end of the work day must be kept in the screened packing area.

3.3. During Shipping and at U.S. Ports-of-entry

3.3.1. Shipping conditions

The boxes could be kept in a refrigerated truck or refrigerated container while in transit to the port of first arrival in the United States. Prior to leaving the packinghouse, the truck or container could be secured with a seal that will be broken when the truck or container is opened. Once sealed, the refrigerated truck or refrigerated container should remain unopened until it reaches the port of entry. Each shipment of avocados should be accompanied by a phytosanitary certificate issued by SENASA stating that all of the conditions of the Workplan have been met.

3.3.2. Limits on Distribution and Transit within the United States

Some imported commodities harboring exotic pests are authorized for shipment only to certain locations (e.g., Alaska or North Atlantic ports) or during a specific season (usually the one with the coldest temperatures). These additional measures limit the risk of establishment for many exotic pests. The importation of avocados into the United States is anticipated during the harvest season in Peru, which is during May – August, with the peak harvest during June and July. These months are warmest in the continental United States and could be very suitable for survival of exotic pests. Shortening the importation season to May only and confining shipments to Alaska and North Atlantic ports during these months could somewhat increase the level of protection.

3.3.3. Point-of-entry Sampling and Inspection

Inspect consignments upon arrival in the United States, paying particular attention to paperwork, to ensure that the chain of custody has remained intact. A random sample of fruit from each consignment might be inspected (depending on the Workplan conditions) to detect a pest infestation rate of 10 percent or greater (USDA, 2004).

3.3.4. Quarantine treatments

Fumigation and Refrigeration. Treatments of avocado against Mediterranean fruit fly, *Ceratitis capitata*, are governed by the rule 7 CFR § 305.2 (2008). Fumigation with methyl bromide at normal atmospheric pressure followed by refrigerated storage in accordance with the procedures described in this section of the CFR is effective against the above mentioned fruit fly but is not effective against other dangerous pests of avocado.

The fumigant is methyl bromide applied at normal atmospheric pressure with the dosage of two pounds per 1,000 cubic feet for 2½ hours at 70^{o} F or above. In addition, cold treatment T107-a is effective against *Ceratitis capitata* in avocado under 34^{o}F for 14 days or 36^{o} for 18 days. For avocados from Peru, these specific treatments should be effective only against *Ceratitis capitata*. We have no current data on the efficacy of this treatment against the fruit flies *Anastrepha* spp. and the moth *Stenoma catenifer* on avocado.

Many treatments are available, however, against *Anastrepha spp.* in other fruits and vegetables. For citrus, for example, the treatment is T101-j-2-1, which is fumigation with methyl bromide at NAP—chamber at 80—85^{o} F with the condition that the infestation level is less than 0.5 percent of the lot. Another option for citrus is to treat Anastrepha spp. with high-temperature forced air treatment (Treatment: T103-a-1). For mango, to treat against *Anastrepha* spp., available treatment is T102-a Hot water dip. Apples, grapes, apricots, tangerine and other fruits could be subject to different schedules of Cold treatment against *Anastrepha* spp. Specific efficacy data are needed to verify that any of the available treatments against *Anastrepha* spp. could be used for treating this group of pests in avocado.

Treatment T104-a-1 and T104-a-2 with methyl bromide at NAP–tarpaulin or chamber are approved by APHIS for scale insects (*Coccus viridis*) and mealybugs (*Ferrisia malvastra*) at 70° F or above (maximum dosage, 2 pounds/1,000 ft^3), for 0.5 or 2.0 hours, depending on concentration readings.

Irradiation. Recently approved irradiation treatment with the generic dose of 400 Gy for all pests of the phylum Arthropoda, excluding adults and pupae of the order Lepidoptera could be a valuable option for controlling external pests *Coccus viridis* and *Ferrisia malvastra* and fruit flies *Anastrepha* spp., and *Ceratitis capitata* (Treatments for Fruits and Vegetables, 2006). The treatment could be questionable against the moth *Stenoma catenifer* since not all of its larvae pupate outside the fruit, in the soil, as reported in CABI (2005). In some cases, larvae pupate inside the seed (Arrellano Cruz, 1998) and thus, irradiation could be ineffective against this pest. Irradiation dose of 150 Gy is effective treatment against fruit flies and could be used in combination with other measures to mitigate the rest of the pest complex. In spite of the effectiveness of the treatment against fruit fly pests, it appears that avocado fruit is sensitive to irradiation and even dose of 80 Gy causes loss of the fruit quality (Peer Review, 2006). It is the responsibility of exporting parties to decide regarding tradeoffs between efficacy of the treatment and its effect on the quality of the commodity.

3.4. Monitoring

3.4.1. Pre-shipment Programs

Inspection, treatment, or other mitigative measures performed in the field and packinghouse should be under the direct supervision of qualified APHIS and SENASA personnel, and in accordance with specified phytosanitary procedures. Such programs call for monitoring of all aspects of any required phytosanitary measures, in addition to identifying the shortcomings and opportunities for program modifications. Provisions should be made for the formal recognition of approved areas, sites, or producers, as well as the specification of conditions for revoking approvals or refusing certification for export to the United States.

3.4.2. Field Survey and Trapping

Survey procedures include visual inspection, fruit cutting, and field trapping. Surveys should be conducted at regular intervals during the growing season to determine the presence or absence of pests. Specific methodologies of trappings and surveys for each quarantine pest of concern should be outlined in the Workplan. Growers will receive or be denied certification for export on the basis of survey or trapping results.

3.4.3. Shipments Traceable to Place of Origin in Peru

A system of identification labels and record keeping is required for avocado indicating the specific place of origin to ensure traceability to each production site.

3.5. Conclusions

The number and diversity of pests that require mitigation make it unlikely that a single mitigative measure will be adequate to reduce risks of their introduction into the United States. For this reason, a combination of measures in a systems approach is most feasible. The system should include the following safeguards: monitoring of orchards and management programs to achieve and maintain area pest freedom; packinghouse inspection and post-harvest treatments; and maintenance of consignment security and traceability in transit.

This document does not purport to establish specific work plans or to evaluate the quality of a specific program or systems approach. It identifies risks and provides information regarding known mitigative measures. The specific implementation of measures, as would be present in an operational Workplan, is beyond the scope of this document.

Table 8. Summary of risk mitigation options for Avocado from Peru

Measure(s)	**Pest**	**Efficacy**
Pest-free areas or places of production	All	Satisfies requirements for appropriate level of protection
Control program, including mechanical, cultural, or chemical means, and monitoring	All	Research required to demonstrate efficacy
Fruit cutting samples combined with	*Anastrepha* spp.,	Adequate sampling size satisfies

Measure(s)	**Pest**	**Efficacy**
low pest prevalence	*Ceratitis capitata*, *Stenoma catenifer*	requirements for appropriate level of protection
Packinghouse procedures, including cleaning, brushing, washing and visual culling	External feeders *Coccus viridis* and *Ferrisia malvastra*	Research required to demonstrate efficacy on avocado. Washing with warm soapy water and brushing is used extensively against these pests in foliage and cut flowers.
Point-of-entry sampling and inspection including fruit cuttings combined with other treatments	Most of the external pests; most of the internal pests when fruit is cut	Certain small insects, such as scales demonstrate low rate of detection during routine visual inspections. Shaker-box technique and/or microscopic evaluations might be needed to reduce level of risk. For cut fruit, sample size should be adequate to detect infestation
Irradiation 150 Gy for fruit flies combined with low prevalence of other pests plus fruit cutting and inspection for *Stenoma catenifer*	All pests	Research required to demonstrate efficacy. Due to sensitivity of avocado to irradiation, data might be needed to identify a lower specific doze.
Methyl-Bromide fumigation (T104-a-1, schedule for mealybugs) combined with low pest prevalence	*Coccus viridis*	Approved by APHIS to treat surface pests such as scales on vegetables, including avocado.
Methyl-Bromide fumigation (T104-a-2, schedule for mealybugs) combined with low pest prevalence	*Ferrisia malvastra*	Approved by APHIS to treat mealybugs
Fumigation with Methyl-Bromide followed by cold treatment	*Ceratitis capitata*	Approved by APHIS to treat certain fruit flies in avocado.
Cold treatment	*Ceratitis capitata*	Approved by APHIS to treat *C. capitata* in avocado
Methyl-Bromide fumigation, or hot water dip, or high temperature forced air	*Anastrepha* spp.	Different schedules approved by APHIS for a number of fruits. Research required to demonstrate efficacy on avocado

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Appendix A. Pest interceptions from selected countries in South America (excluding Peru) from the pest identification database (PestID, 2008)[39]

Pest	Country[a]							Total
	ARG	BOL	BRA	CHI	COL	ECU	VEN	
Abgrallaspis sp. (Diaspididae)				1		1		2
Agrotis sp. (Noctuidae)				25		1		26
Aleyrodidae, species of						1		1
Anastrepha sp. (Tephritidae)					2	2	1	5
Apion sp. (Curculionidae)				1				1
Arhyssus tricostatus (Spinola) (Rhopalidae)				1				1
Ascochyta, species of						1		1
Athlia rustica erichson (Scarabaeidae)				1				1
Aulacaspis tubercularis newstead (Diaspididae)				1	1	1		3
Blapstinus punctulatus solier (Tenebrionidae)				3				3
Blapstinus sp. (Tenebrionidae)				1				1
Bruchidae, species of				1				1
Cerambycidae, species of				1				1
Ceratitis capitata (Wiedemann) (Tephritidae)			1					1
Cladosporium sp.						1	1	2
Coccotrypes sp. (Scolytidae)							1	1
Coelomycetes, species of			1					1
Conoderus rufangulus (Gyllenhal) (Elateridae)				1				1
Conotrachelus perseae							1	1
Conotrachelus sp. (Curculionidae)						3		3
Copitarsia sp. (Noctuidae)				18				18
Crambidae, species of				1				1
Chrysomphalus pinnulifer (Diaspididae)					1			1
Curculionidae, species of						1		1
Diaspididae, species of			1			1	2	4
Diaspis sp. (Diaspididae)				1				1
Elateridae, species of				1				1
Gelechiidae, species of		1		3	1			5

[39] Interceptions from Chile include commercial and permit cargo since Chile is the only country in South America from which commercial importations of avocados to the United States is authorized. All interceptions from other countries are from baggage, stores or holds due to the absence of trade in avocados from these countries.

Pest	Country[a]							Total
	ARG	BOL	BRA	CHI	COL	ECU	VEN	
Geometridae, species of				1				1
Grammophorus minor (Schwarz) (Elateridae)				1				1
Gryllus sp. (Gryllidae)				2				2
Hadeninae, species of (Noctuidae)				15				15
Heilipus sp. (Curculionidae)					1		1	2
Heliothinae, species of				1				1
Hemiberlesia diffinis (Newstead) (Diaspididae)						1		1
Homoptera, species of	1				1			2
Hoplosphyrum griseus (Philippi) (Gryllidae)				9				9
Hylurgus ligniperda (Fabricius) (Scolytidae)				1				1
Lepidoptera, species of				1				1
Lepidosaphes sp. (Diaspididae)				2				2
Ligyrus villosus burmeister (Scarabaeidae)				5				5
Lithraeus egenus (Blanchard) (Bruchidae)				2				2
Melanaspis sp. (Diaspididae)							1	1
Micrapate scabrata (Erichson) (Bostrichidae)				1				1
Microgryllus pallipes philippi (Gryllidae)				5				5
Microsphaeropsis sp.						1		1
Monochaetinula sp. (Coelomycetes)						1		1
Noctuidae, species of				3				3
Nomophila sp. (Pyralidae)				2				2
Nysius sp. (Lygaeidae)				2				2
Oecophoridae, species of				1				1
Palinaspis sp. (Diaspididae)						1		1
Phaeoseptoria sp.						1		1
Phoma sp.	1					1		2
Phomopsis sp.						3		3
Phyllosticta sp. (Coelomycetes)						1		1
Pseudaletia impuncta (Guenee) (Noctuidae)				3				3
Pseudaletia sp. (Noctuidae)				1				1
Pseudaonidia trilobitiformis (green) (Diaspididae)		1			2	5	1	9
Pseudococcidae, species of			1	141		2	3	146

Pest	**Country**[a]							**Total**
	ARG	**BOL**	**BRA**	**CHI**	**COL**	**ECU**	**VEN**	
Pseudococcus sp. (Pseudococcidae)				81				81
Pyraustinae, species of (Crambidae)				1				1
Rhyephenes sp. (Curculionidae)				1				1
Sitona sp. (Curculionidae)				1				1
Sphaceloma sp.			1					1
Stenoma catenifer Walsingham (Oecophoridae)			3	2	2	30	9	46
Syrphidae, species of						1		1
Tenebrionidae, species of				1				1
Tomarus villosus (Scarabaeidae)				6				6
Tortricinae, species of				2				2
Vinsonia stellifera (Coccidae)					1			1

[a] ARG – Argentina, BOL – Bolivia, BRA- Brazil, CHI – Chile, COL – Colombia, ECU – Ecuador, VEN – Venezuela.

Appendix B. Likelihood of Entry, Introduction, and Establishment of Potato Spindle Tuber Viroid (PSTVd) with Imported 'Hass' Avocado, *Persea americana*, Fruit from Peru.

Executive Summary

In the Peruvian Avocado PRA, the consequences of introduction and likelihood of introduction of PSTVd were analyzed and rated as medium for both measures. Here we evaluated the likelihood of establishment based on three pathways, commercial fruit disposal, residential disposal, and seed propagation, and found the overall likelihood of establishment of the pest to be Low.

Pathways for Establishment

In the PRA it was determined that PSTVd is unlikely to come into contact with hosts. In potato, natural spread of PSTVd is through seed or aphid transmission (CABI, 2004). PSTVd and a related viroid, Avocado Sun blotch Viroid (ASBVd), are known to be transmitted through seed or pollen of infected plants (Desjardins et al., 1984; Fernow et al., 1970). Establishment would require infected seed or fruit tissue to come into contact with a host. We evaluate the likelihood of establishment based on three pathways, commercial fruit disposal, residential disposal, and seed propagation. We did not evaluate the likelihood of an irrigation water pathway but this was considered less likely.

1. Warehouse disposal pathway: To illustrate the fate of exotic organisms on imported fresh produce we used a relevant study. Eight pathways were investigated by Gould et al. (2004) in a risk analysis that looked at fresh asparagus infested with lepidopteran eggs. The study examined disposal methods at 14 commercial import warehouses in the United States that represented 85 percent of the asparagus imports from Peru. That report concluded that of the discarded product (not initially sold for consumption): 76.0 percent went unbagged into dumpsters; 4.5 percent went bagged into dumpsters; 11.2 percent was compacted then placed in landfill; 7.3 percent went to soup kitchens (consumed); 0.5 percent was put in the garbage disposal (municipal sewage); 0 percent went as discounted produce (consumed); 0 percent was composted; 0 percent went for animal feed. Dumpsters leading to landfills are a dead-end pathway for insect pests in municipal waste, such as *Anoplophora glabripennis* (Auclair et al., 2005). We assume that the same is true with this pathogen. PSTVd only moves with plant material in the absence of a vector. If all plant material is accounted for in the dumpsters and landfills, the viroid is mitigated if all insect vectors are considered mitigated.

2. Residential disposal pathways: Consumers purchase fruit and take it home from supermarkets. A first discard scenario includes consuming fruit, but discarding stems and calyxes into a garbage disposal and finally into the waste water (sewage) system. In a second discard scenario, stems and calyxes are bagged and put into the trash destined for landfill. In the United States over 75 percent of the population is served by centralized waste water collection and treatment, the remaining population using other on-site systems to treat sewage and waste water (EPA 2004; Zipper, 2003). Waste water (sewage) treatment standards have been developed to reduce populations of pathogens harmful to humans, and this may reduce the viability of PSTVd (EPA, 2004; Zipper, 2003). There are no studies on the quantity of fruits and vegetables discarded in backyard compost in the U. S. One foreign study estimated that up to 0.5 percent of U. S. apples purchased in Japan ended up as compost (Roberts et al., 1998). Another study estimated that 5 percent of U. S. cherries purchased in New Zealand ended up as compost (Wearing et al., 2001). If it is assumed that 5 percent composting mirrors U. S. practices, then it is unlikely that the commodity would be discarded on compost piles. Although no studies have been done, it is assumed that all compost produced by consumers is used on home gardens or yards and not spread directly onto agricultural fields.

3. Seed Propagation pathway: Avocado seeds are frequently propagated in biology classes. Often students are allowed to take their plants home after completion of the class. There is no data available to determine the fate of these plants but some assumptions can be made. Most plants would probably remain indoors and die and be disposed under considerations discussed above. The only possible scenario would be for a propagated tree to be planted outside in proximity to other hosts such as potato or avocado. The avocado tree is relatively frost sensitive and would not survive in most of the United States (Scorza and Wiltbank, 1975). For these reasons, we consider this pathway to be Low risk.

Conclusions

In the PRA it was determined that there would be a high probability of introduction. We conclude, however, that the probability of establishment is Low and, consequently, the overall probability of the pest following the pathway is Low.

Table 1. Likelihood of PSTVd following pathway based on establishment and introduction

Event	**Likelihood**
Consequences of Introduction	**High** [a]
Likelihood of Introduction	**High** [a]
Likelihood of establishment:	
Warehouse disposal pathway	Low
Consumer disposal pathway	Low
Propagation pathway	Low
Overall risk of establishment	**Low**
Overall likelihood	**Low**

[a] From Risk Assessment above

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