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Importation of *Citrus maxima* for consumption from Vietnam into the United States and Territories

A Qualitative, Pathway-Initiated Pest Risk Assessment

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Executive Summary

The Animal and Plant Health Inspection Service (APHIS) of the United States Department of Agriculture (USDA) prepared this document to assess pest risks associated with importing commercially-produced fruit of pummelo, *Citrus maxima* (Rutaceae), for consumption from Vietnam into the United States and Territories. Based on the market access request submitted by Vietnam, we considered the pathway to include the following processes and conditions: hand-picked fresh fruit. The pest risk ratings depend upon the application of all conditions of the pathway as described. Fruit produced under different conditions was not evaluated and may have a different pest risk.

Using scientific literature, port-of-entry pest interception data, and information from the government of Vietnam, we developed a list of pests with quarantine significance for the United States that occur in Vietnam (on any host) and are associated with the commodity plant species (anywhere in the world).

We determined that the below listed pests are candidates for risk management. In the current risk assessment, the listed arthropods and fungi met the threshold to likely cause unacceptable consequences of introduction and have a reasonable likelihood of introduction. The pathogen *Xanthomonas citri* subsp. *citri* (citrus canker) has a limited distribution in the United States and is considered a quarantine pest. USDA-APHIS previously conducted pest risk assessments examining the likelihood that this pathogen will spread through the movement of commercial citrus fruit intended for consumption. USDA-APHIS has determined that asymptomatic or commercially packed fruit is not an epidemiologically significant pathway for the introduction and establishment of these pathogens into new areas. For the above reasons, it was not analyzed in the pest risk assessment; however, additional import requirements will be specified in the risk management document as a condition of entry for citrus fruit from Vietnam to the United States.

Pest type	**Taxonomy**	**Scientific name**	**Likelihood of Introduction overall rating**
Arthropod	Diptera: Tephritidae	*Bactrocera dorsalis* (Hendel)	High
		Zeugodacus cucurbitae (Coquillett)	Medium
	Lepidoptera: Yponomeutidae	*Prays endocarpa* Meyrick	Medium
Fungi	Diaporthales: Cryphonectriaceae	*Cylindrocarpon lichenicola* (C. Massal.) D. Hawksw	Medium
	Botryosphaeriales: Botryosphaeriaceae	*Phyllosticta citriasiana* Wulandari, Crous & Gruyter	Medium
Bacteria		*Xanthomonas citri* subsp. *citri* (ex Hasse) Gabriel et al.	Analyzed previously[a]

[a] Plant pests with limited distribution and under official control in the United States; therefore, additional import requirements may be required.

Detailed examination and choice of appropriate phytosanitary measures to mitigate pest risk are addressed separately from this document.

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1. Introduction

1.1. Background

The Plant Epidemiology and Risk Analysis Laboratory of the USDA Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ) prepared this document to assess the pest risk associated with the importation of commercially-produced fresh fruit of pummelo (*Citrus maxima* Merrill) for consumption from Vietnam (referred to as the export area) into the United States and Territories (referred to as the PRA area).

This is a qualitative risk assessment; the likelihood of pest introduction is expressed as a qualitative rating rather than in numerical terms. This methodology is consistent with guidelines provided by the International Plant Protection Convention (IPPC) in the International Standard for Phytosanitary Measures (ISPM) No. 11, "Pest Risk Analysis for Quarantine Pests" (IPPC, 2017b). The use of biological and phytosanitary terms is consistent with ISPM No. 5, "Glossary of Phytosanitary Terms" (IPPC, 2017a).

As defined in ISPM No. 11, this document comprises Stage 1 (Initiation) and Stage 2 (Risk Assessment) of risk analysis. Stage 3 (Risk Management) will be covered in a separate document.

1.2. Initiating event

The importation of fruits and vegetables for consumption into the United States is regulated under Title 7 of the Code of Federal Regulations, Part 319.56 (7 CFR §319.56). Under this regulation, the entry of pummelo fruit from Vietnam into the United States is not authorized. This commodity pest list was initiated due to a request by the Plant Protection Department of Vietnam to change the Federal regulation to allow entry (Vietnam Plant Protection, 2016).

1.3. Description of the pathway

A pathway is "any means that allows the entry or spread of a pest" (IPPC, 2017a). In the context of this document, the pathway is the commodity to be imported, together with all the processes the commodity undergoes (from production through importation and distribution) that may have an impact on pest presence. The following description of this pathway focuses on those relevant conditions and processes. The conclusions in this document are therefore contingent on the application of all components of the pathway as described.

1.4.1. Description of the commodity

The specific pathway of concern is the importation of fresh fruit of pummelo for consumption.

1.4.2. Summary of the production, harvest and post-harvest procedures, and shipping and storage conditions being considered.

The pummelo originates from the lowland tropics and is not grown commercially above elevations of 400 m. Vietnamese production is mostly in the southern part of the country, although some cultivars can be grown in the northern and central areas. Fruit color varies from yellow to green (Vietnam Plant Protection, 2016).

Orchards are monitored weekly for pests. When pest populations exceed the economic injury level, chemical pesticides are applied (Vietnam Plant Protection, 2016).

Pummelo is hand-harvested six to seven months after flowering on cool days without extreme sunlight, fog, or rain. After harvest, damaged fruits are culled, and the remaining fruits are dried, dipped into sodium hypochlorite one-percent solution, dried again, dipped in Citrashine solution, dried again, wrapped in mesh polystyrene, and placed into cold storage. The fruits are later packed into cartons for transport (Vietnam Plant Protection, 2016).

For the purposes of assessing risk in the document, post-harvest practices, shipping and storage conditions are not considered.

2. Pest List and Pest Categorization

The pest list is a compilation of plant pests with regulatory status for the United States. This includes pests that are both present in Vietnam (on any host) and are known to be associated with pummelo (anywhere in the world). Species on the pest list with a reasonable likelihood of being present on the commodity at the time of harvest could follow the pathway into the United States and are therefore analyzed to determine their pest risk potential. Pests are considered to be of quarantine significance if they are actionable at U.S. ports of entry. This includes known quarantine pests, regulated non-quarantine pests, pests under official control or considered for official control, and pests that require evaluation for regulatory action.

2.1. Pest list

In Table 1, we list the quarantine pests that occur in the export area on any host and are associated with the commodity species, whether in the export area or elsewhere. For each pest, we indicate 1) the part of the plant the pest is generally associated with and 2) whether the pest is likely to remain with the commodity in a viable form following harvesting from the field and prior to any post-harvest processing. We developed this pest list based on the scientific literature, port-of-entry pest interception data, and information provided by the government of Vietnam. Pests in shaded rows were selected for further evaluation, because they are likely to remain associated with the harvested commodity (Table 2); for these pests we also denote U.S. distribution as appropriate.

Table 1. Quarantine pests associated with pummelo (in any country) and present in Vietnam (on any host).

Pest name	Presence in Vietnam	Host association	Plant part(s) [1]	Considered further?
INSECTA				
COLEOPTERA				
Cerambycidae				

[1] The plant parts listed are those for the plant species under analysis. If the information has been extrapolated, such as from plant part association on other plant species, we note that.

Pest name	**Presence in Vietnam**	**Host association**	**Plant part(s)** [1]	**Considered further?**
Anoplophora chinensis (Forster)	Vietnam Plant Protection, 2016; Whittle, 1992	Vietnam Plant Protection, 2016	Stem (Vietnam Plant Protection, 2016)	No.
Nadezhdiella cantori (Hope)	Whittle, 1992	Wang et al., 2002	Stem (Wang et al., 2002)	No.
Chelidonium argentatum (Dalman)	Vietnam Plant Protection, 2016; Whittle, 1992	Vietnam Plant Protection, 2016	Stem (Vietnam Plant Protection, 2016)	No.
Chrysomelidae				
Clitea metallica Chen	Vietnam Plant Protection, 2016; Whittle, 1992	Vietnam Plant Protection, 2016	Leaf (Vietnam Plant Protection, 2016)	No.
Curculionidae				
Hypomeces squamosus Fabricius	Vietnam Plant Protection, 2016; Whittle, 1992	Vietnam Plant Protection, 2016	Leaf, root (Vietnam Plant Protection, 2016)	No.
DIPTERA				
Tephritidae				
Bactrocera dorsalis (Hendel)	Waterhouse, 1993a	Huang and Chi, 2014	Fruit (Huang and Chi, 2014)	Yes. Present in Hawaii (Vargas et al., 2010)
Zeugodacus cucurbitae (Coquillett) syn. *Bactrocera cucurbitae, Dacus cucurbitae*	Boontop et al., 2017	Tan and Lee, 1982	Fruit (Tan and Lee, 1982)	Yes. Present in Hawaii (Carey et al., 1985)
HEMIPTERA				
Aleyrodidae				
Aleurocanthus woglumi Ashby	Whittle, 1992	Pena et al., 2008	Leaf (Medina-Gaud et al., 1991)	No. Present in Hawaii (Culliney et al., 2003), Florida (Dowell et al., 1979; Hart et al., 1978), and Texas (Meagher and French, 2004)
Aleurocanthus spiniferus (Quaintance)	CABI, 2019	Rae et al., 2000	Leaf (Gyeltshen et al., 2005)	No. Present in Hawaii (Paulson and Kumashiro, 1985)
Aphididae				

Pest name	Presence in Vietnam	Host association	Plant part(s) [1]	Considered further?
Toxoptera citricidus (Kirkaldy) syn.: *T. citricada* (Kirkaldy)	Waterhouse, 1993b	Michaud, 1998	Newly expanded shoot, leaf, flower bud (Michaud, 1998)	No. Pummelo is a poor host of *T. citricada* (Ghosh et al., 2014). Present in Florida and Puerto Rico (Michaud, 1998)
Coccidae				
Ceroplastes rubens Maskell	Whittle, 1992	Williams and Watson, 1990	Twig, leaf (Krull and Basedow, 2005)	No. Present in Florida (Hamon and Williams, 1984) and Hawaii (Gimpel et al., 1974)
Pulvinaria aurantii Cockerell	Vietnam Plant Protection, 2016	Vietnam Plant Protection, 2016	Leaf (Vietnam Plant Protection, 2016)	No.
Psyllidae				
Diaphorina citri Kuwayama	Vietnam Plant Protection, 2016	Vietnam Plant Protection, 2016	Fruit, leaf (Vietnam Plant Protection, 2016)	No. Limited distribution in California (Bayles et al., 2017)
Pentatomidae				
Rhynchocoris poseidon Kirkaldy	Vietnam Plant Protection, 2016; Whittle, 1992	Vietnam Plant Protection, 2016	Leaf (Vietnam Plant Protection, 2016)	No.
Pseudococcidae				
Nipaecoccus viridis (Newstead)	Ben-Dov, 1994	Mani and Krishnamoorthy, 2008	Shoot, fruit, leaf, stem, flower (Mani and Krishnamoorthy, 2008)	No. See discussion in section 2.2. Present in Florida (Stocks, 2013)
Pseudococcus cryptus Hempel	Ben-Dov, 1994	Ben-Dov, 1994	Twig, fruit, leaf, (Blumberg et al., 1999)	No. See discussion in section 2.2. Present in Hawaii and the U.S. Virgin Islands (Ben-Dov, 1994)
LEPIDOPTERA				
Gracillariidae				
Phyllocnistis citrella Stainton	Vietnam Plant Protection, 2016	Vietnam Plant Protection, 2016	Leaf (Vietnam Plant Protection, 2016)	No. Present in Florida (Heppner, 1993)
Noctuidae				

Pest name	Presence in Vietnam	Host association	Plant part(s) [1]	Considered further?
Achaea janata (Linnaeus)	Waterhouse, 1993b	Ngampongsai et al., 2005	Fruit (Ngampongsai et al., 2005)	No. Fruit-piercing moths feed on fruit as adults by sucking juices (Sands and Liebregts, 2005) but would not remain with fruit through harvest
Eudocima phalonia (Clerck) syn.: *E. fullonia* (Clerck)	Waterhouse, 1993b	Denton et al., 1989	Fruit (Denton et al., 1989)	No. Fruit-piercing moths feed on fruit as adults by sucking juices (Sands and Liebregts, 2005) but would not remain with fruit through harvest
Papilionidae				
Papilio demoleus Linnaeus	Vietnam Plant Protection, 2016	Vietnam Plant Protection, 2016	Leaf (Vietnam Plant Protection, 2016)	No.
Papilio polytes Linnaeus	Vietnam Plant Protection, 2016	Vietnam Plant Protection, 2016	Leaf (Vietnam Plant Protection, 2016)	No.
Pyralidae				
Citripestis sagittiferella Moore	Vietnam Plant Protection, 2016; Whittle, 1992	Vietnam Plant Protection, 2016	Fruit (Vietnam Plant Protection, 2016)	No. Infestation causes fruit to rot and drop early (CABI, 2019), making it unlikely the insect would be harvested with the fruit. This is probably why the pest has never been intercepted on fruit entering the United States (PestID, 2019).
Tortricidae				
Adoxophyes privatana (Walker)	Vietnam Plant Protection, 2016	Vietnam Plant Protection, 2016	Leaf (Vietnam Plant Protection, 2016)	No.
Archips atrolucens Diakonoff	Dang et al., 2016	Vang et al., 2013	Leaf (Vang et al., 2013)	No.
Homona coffearia (Nietner)	Dang et al., 2016; Whittle, 1992	Whittle, 1992	Leaf (Vang et al., 2013)	No.

Pest name	**Presence in Vietnam**	**Host association**	**Plant part(s)** [1]	**Considered further?**
Yponomeutidae				
Prays citri Millière	Vang et al., 2011; Vietnam Plant Protection, 2016	Vang et al., 2011; Vietnam Plant Protection, 2016	Fruit (Vietnam Plant Protection, 2016), flowers, young shoots (Conti and Fisicaro, 2015)	No. Larvae feed on flowers, young shoots, and developing fruit, causing fruit to drop (Conti and Fisicaro, 2015).
Prays endocarpa Meyrick	Vang et al., 2011; Vietnam Plant Protection, 2016	Vang et al., 2011; Vietnam Plant Protection, 2016	Fruit (Vietnam Plant Protection, 2016)	Yes
NEMATODES				
Radopholus similis (Cobb) Thorne	Goodey et al., 1965; Nguyet et al., 2003	Goodey et al., 1965 (Affecting *C. grandis*, a synonym of *C. maxima*)	Root (Goodey et al., 1965)	No. Restricted distribution in the United States (Florida, Hawaii, Louisiana, Texas, Puerto Rico, and the U.S. Virgin Islands) (CABI, 2019; Oramas-Nival and Roman, 2006; Roman et al., 1974; UGA, 2018). Reportable / actionable (PestID, 2019).
FUNGI AND CHROMISTANS				
Capnodium citri Penz.	Vietnam Plant Protection, 2016; Whittle, 1992	French, 1989	Fruit, leaf, stem (Timmer et al., 2000)	No. Present in the continental United States (French, 1987), Puerto Rico, and the U.S. Virgin Islands (Stevenson, 1975). No evidence of presence in Hawaii.
Clitocybe tabescens (Scop.) Bres, syn.: *Armillariella tabescens* (Scop.) Singer	Vietnam Plant Protection, 2016	Alfieri et al., 1984	Root, stem (Timmer et al., 2000)	No. Present in the continental United States (Alfieri et al., 1984). No evidence of presence in Hawaii, Puerto Rico, or the U.S. Virgin Islands.

Pest name	Presence in Vietnam	Host association	Plant part(s) [1]	Considered further?
Cylindrocarpon lichenicola (C. Massal.) D. Hawksw syn.: *Fusarium lichenicola* C. Massal.	Amby et al., 2015	Amby et al., 2015	Fruit (Amby et al., 2015)	Yes. This species was reported as a human pathogen in the continental United States (Iwen et al., 2000; Summerbell and Schroers, 2002). No evidence of presence in Hawaii, Puerto Rico or the U.S. Virgin Islands.
Didymella citri	Vietnam Plant Protection, 2016	Vietnam Plant Protection, 2016	Stem (Vietnam Plant Protection, 2016)	No.
Erythricium salmonicolor (Berk. & Broome) Burds, syn.: *Corticium salmonicolor* Berk. & Broome	Mordue and Gibson, 1976	Peregrine and Bin Ahmad, 1982	Bark, limbs (Timmer et al., 2000)	No. Present in the continental United States (Alfieri et al., 1984), Puerto Rico, and the U.S. Virgin Islands (Stevenson, 1975). No evidence of presence in Hawaii.
Meliola citricola (Syd. & P. Syd.)	Whittle, 1992	Peregrine and Bin Ahmad, 1982	Fruit, leaf (Whittle, 1992)	No. See discussion in section 2.2.
Phyllosticta beltranii Penzig	Vietnam Plant Protection, 2016	Vietnam Plant Protection, 2016	Leaf (Vietnam Plant Protection, 2016)	No.
Phyllosticta citriasiana Wulandari, Crous & Gruyter	Wulandari et al., 2009	Wulandari et al., 2009	Fruit (Wulandari et al., 2009)	Yes.
Septobasidium albidum Pat.	Kiet, 1998	Farr and Rossman, 2019	Leaf (Kiet, 1998)	
BACTERIA AND PHYTOPLASMAS				
'*Candidatus* Liberibacter asiaticus' Jagoueix, Bové, & Garnier, 1994	Tomimura et al., 2009	Kumagai et al., 2013	Systemic (Puttamuk et al., 2014)	No. Present in the continental United States (Kumagai et al., 2013), Puerto Rico, and the U.S. Virgin Islands (CABI, 2019). No evidence of presence in Hawaii. See discussion in section 2.2.

Pest name	Presence in Vietnam	Host association	Plant part(s) [1]	Considered further?
Xanthomonas citri subsp. *citri* (ex Hasse) Gabriel et al. syn.: *X. axonopodis* pv. *citri* (Vauterin, et al.), *X. campestris* pv. *citri* (Hasse) Dye	Vietnam Plant Protection, 2016; Whittle, 1992	Timmer et al., 2000	Fruit, leaf, stem (Timmer et al., 2000)	No, analyzed previously. Restricted distribution in the United States (Florida, Louisiana, and Texas) (CABI, 2019) and under official control. The transportation of fruit is regulated by 7 CFR 301.75-7. No evidence of presence in Hawaii, Puerto Rico, or the U.S. Virgin Islands. See discussion in section 2.2.
VIRUSES AND VIROIDS				
Pospiviroid Citrus exocortis viroid (CEVd)	Vietnam Plant Protection, 2016	Vietnam Plant Protection, 2016	Systemic (Hajeri, 2010)	No. Restricted distribution in the United States (Arizona, California, Florida, Louisiana, and Texas) (CABI, 2019). No evidence of presence in Hawaii, Puerto Rico, or the U.S. Virgin Islands. See discussion in section 2.2.

2.2. Notes on pests identified in the pest list

Nipaecoccus viridis (Newstead); *Pseudococcus cryptus* Hempel

The mealybugs, *Nipaecoccus viridis* (Newstead) and *Pseudococcus cryptus* Hempel are highly unlikely to become established in the United States through imports of pummelo because fruit for consumption is unlikely to come into contact with citrus trees, and mealybugs have only limited mobility to find new hosts. Adult females and late instar nymphs are largely sessile, and although early instars are more active, they only move short distances. Grasswitz and James (2008) studied movement of *Pseudococcus maritimus* nymphs and found little tendency for them to move away from the point where they were released. The farthest movement was 90 cm, but most distances were considerably shorter. Cid et al. (2010) found that *Planococcus citri* nymphs hatched in bark crevices of grapevines and rarely made it up to the green parts of the vines unless populations were very large. Nymphs stopped moving upward when they encountered places in the bark to feed and did not appear to move between plants. In a study with the mealybugs

Rastrococcus mangiferae, *R. iceryoides*, and *R. invadens*, none of the *Rastrococcus* spp. actively migrated between trees, from trees to soil, or from trees to debris (Narasimham and Chacko, 1991).

Meliola citricola is a sooty mold (McKenzie, 2013), and although it is found in Vietnam and is potentially associated with pummelo, it is not pathogenic on the plant and is not quarantine significant (McKemy, 2010). Sooty molds grow on surfaces where deposits of honeydew from insects have accumulated (Laemmien, 2011).

'*Candidatus* Liberibacter asiaticus' was not selected for further analysis as the fruit alone is not a pathway for pathogen dissemination. While the pathogen is associated with the seed (Tatineni et al., 2008; Timmer et al., 2000), it is not considered to be transmitted by seed. The pathogen is vector transmitted by *Diaphorina citri* (Hall, 2008) and the vector is unlikely to be associated with harvested fruit.

Xanthomonas citri* subsp. *citri, the causal agent of citrus canker, has a limited distribution in the United States and is a quarantine pest. Although this bacterium is associated with fruits and may enter the country, several conditions need to occur in order for it to become established, (Agrios, 2005; Colhoun, 1973; IPPC, 2017b; Leben, 1974; Lichtenthaler, 1998). *Xanthomonas citri* subsp. *citri* cannot directly penetrate host tissues, and for infection to occur, the pathogen must have optimal temperature and moisture conditions, a vector, a susceptible host, and activation of virulence genes for an extended period of time (Agrios, 2005; Melotto et al., 2006; Vidaver and Lambrecht, 2004). This means that for transmission of bacteria from infected fruit to susceptible host plants, several events must occur at the same time: a) infected fruit must arrive in an area where hosts are available; b) a host must be at a susceptible stage for infection to occur; c) inoculum of *X. citri* subsp. *citri* must be produced on the imported fruit; d) inoculum produced on infected fruit must spread to susceptible host via an insect vector, by human assistance or wind-driven rain to result in infection and disease development (Agrios, 2005; Eigenbrode et al., 2018; Francl, 2001; Hirano and Upper, 2000; Kunkel and Chen, 2006; Leben, 1974; Melotto et al., 2006; Vidaver and Lambrecht, 2004). All of these events would need to occur with appropriate timing in order for *X. citri* subsp. *citri* to establish. We therefore conclude that imported infected fruit for consumption has a low to negligible likelihood of establishment. Based on this information, we did not further analyze this disease in this pest risk assessment; however, additional import requirements may be specified in the risk management document as a condition of entry for citrus fruit from Vietnam to the United States.

Citrus exocortis viroid (CEVd) is a pospiviroid that is graft-transmitted; dissemination occurs primarily through propagation of symptomless budwood. The viroid is also transmitted mechanically as a contaminant of cutting and pruning tools. Seed and vector transmission have not been demonstrated (Timmer et al., 2000). Fruit for consumption is considered to pose a low risk for establishment of viruses and viroids and is considered a dead end pathway. We concluded that the virus has a negligible likelihood of coming into contact with host material in the United States and Territories via fruit for consumption.

2.3.3. Organisms identified only to the genus level

For this pest list, we identified the following genera that are reported on pummelo in Vietnam: *Anormensis* sp., and *Lawana* sp. (Hemiptera: Flatidae) (Vietnam Plant Protection, 2016). We found no evidence that *Lawana* sp. occurs in the United States, so it would be considered a quarantine genus.

2.4. Pests selected for further analysis

We identified four quarantine pests for further analysis (Table 2).

Table 2. Pests selected for further analysis.

Pest type	Taxonomy	Scientific name
Arthropod	Diptera: Tephritidae	*Bactrocera dorsalis* (Hendel)
		Zeugodacus cucurbitae (Coquillett)
	Lepidoptera: Yponomeutidae	*Prays endocarpa* Meyrick
Fungi	Diaporthales: Cryphonectriaceae	*Cylindrocarpon lichenicola* (C. Massal.) D. Hawksw
	Botryosphaeriales: Botryosphaeriaceae	*Phyllosticta citriasiana* Wulandari, Crous & Gruyter

3. Assessing Pest Risk Potential

3.1. Introduction

For each pest analyzed, we estimate its overall pest risk potential. Risk is described by the likelihood of an adverse event, the potential consequences, and the uncertainty associated with these parameters. For each pest, we determine if an endangered area exists within the PRA area. The endangered area is defined as the portion of the PRA area where ecological factors favor pest establishment and where pest presence would likely result in economically important losses. If a pest causes an unacceptable impact, that means it would adversely affect agricultural production by causing 10 percent or greater yield loss or increasing production costs or would impact an environmentally important host or international trade. Once an endangered area has been determined, the overall risk of the pest is then determined by assessing the likelihood of its introduction into the endangered area on the imported commodity.

The likelihood of introduction is based on the likelihoods of entry and establishment. We qualitatively assess risk using the ratings Low, Medium, and High. The risk factors comprising the likelihood of introduction are interdependent, so the model is multiplicative rather than additive. We define the different risk categories as follows:

High: Pest introduction is highly likely to occur.

Medium: Pest introduction is possible, but for that to happen, the exact combination of required events needs to occur.

Low: Pest introduction is unlikely to occur because one or more of the required events are unlikely to happen or because the full combination of required events is unlikely to align properly in time and space.

Uncertainty is addressed within the assessment as follows:

Negligible uncertainty: Additional or better evidence is very unlikely to change the rating.

Low uncertainty: Additional or better evidence probably will not change rating.

Moderate uncertainty: Additional or better evidence may or may not change rating.

High uncertainty: Reliable evidence is not available.

3.2. Assessment results

3.2.1. *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae)

Bactrocera dorsalis is a destructive pest of fruits and vegetables in eastern Asia (Aketarawong et al., 2014) and across sub-Saharan Africa (Drew et al., 2005; Mwatawala et al., 2006). It is present in the United States (Hawaii) (Vargas et al., 2010). At least one outbreak of the pest was eradicated in southern Florida (Alvarez et al., 2015). The name *B. dorsalis* includes the Sri Lankan and African variant *B. invadens*, which has been shown to be extremely invasive across Africa (Schutze et al., 2015).

Defining the endangered area for *Bactrocera dorsalis* within the United States

Climatic suitability	*Bactrocera dorsalis* is present in tropical areas of southeastern Asia (Aketarawong et al., 2014) and sub-Saharan Africa (Drew et al., 2005), as well as in the United States (Hawaii) (Vargas et al., 2010). These areas correspond to global Plant Hardiness Zones 10-12 in the United States (Stephens et al., 2007; Takeuchi et al., 2019).
Hosts in PRA Area	Potential hosts within Plant Hardiness Zones 10-12 in the United States (excluding Hawaii, where *B. dorsalis* is established) include *Citrus* spp. *Mangifera indica* (mango), *Psidium guava* (guava), *Cucumis* spp. (melon), *Cucurbita* spp. (gourd), *Capsicum* spp. (pepper) (Goergen et al., 2011), *Prunus persica* (peach), and *Pyrus domestica* (pear) (Ye and Liu, 2005).
Economically important hosts at risk[a]	Economically important plants in Plant Hardiness Zones 10-12 include mango, guava, pepper, melon, and peach.
Pest potential on economically important hosts at risk	This pest is likely to cause unacceptable consequences because it feeds internally in fruit hosts, has a large host range, and has been shown to be very invasive in new areas such as Africa (Hanna et al., 2004).
Defined Endangered Area	The endangered area includes Puerto Rico and areas of the continental United States in Plant Hardiness Zones 10-12

[a] As defined by ISPM No. 11, supplement 2, "economically important hosts" refers to both commercial and non-market (environmental) plants (IPPC, 2017b).

Assessing the likelihood of introduction of *Bactrocera dorsalis* into the endangered area via pummelo fruit imported from Vietnam

Risk Element	**Risk Rating**	**Uncertainty Rating**	**Evidence for rating (and other notes as necessary)**
Likelihood of Entry			
Pest prevalence on the harvested commodity	Medium	Medium	In a study in Senegal, *B. dorsalis* infested pummelo at a rate of two flies per kilogram of fruit examined, compared to 155 flies per kilogram of guava (Boinahadji et al., 2019).

Risk Element	Risk Rating	Uncertainty Rating	Evidence for rating (and other notes as necessary)
Likelihood of surviving post-harvest processing before shipment	Medium	Low	Post-harvest processes were not considered in this assessment, so the rating stays at Medium.
Likelihood of surviving transport and storage conditions of the consignment	Medium	Low	Transport and storage conditions were not considered in this assessment, so the rating stays at Medium.
Overall Likelihood of Entry	Medium		
Likelihood of Establishment	High	High	*Bactrocera dorsalis* has wide host range (CABI, 2019), and adults are strong fliers, allowing them find new hosts over long distances (Chen et al., 2015).
Likelihood of Introduction (combined likelihoods of entry and establishment)	High		

3.2.2. *Zeugodacus cucurbitae* (Coquillett) (Diptera: Tephritidae)

Zeugodacus cucurbitae, the melon fly, infests fruits and vegetables of many plant species, many in the family Cucurbitaceae. Probably originally from India, the fly has spread into East Asia, several Pacific Islands, and parts of Africa (McQuate et al., 2017). It is also known from Hawaii (Carey et al., 1985).

Defining the endangered area for *Zeugodacus cucurbitae* within the United States

Climatic suitability	*Zeugodacus cucurbitae* is present in Vietnam, tropical regions of East and West Africa, India, Pakistan, Bangladesh, much of southeast Asia, and southern areas of China (McQuate et al., 2017). These areas correspond to global Plant Hardiness Zones 10-12 in the United States.
Hosts in PRA Area	There have been 136 plant taxa from 62 plant genera and 30 plant families identified as natural hosts of *B. cucurbitae* (McQuate et al., 2017). The preferred hosts are mostly in the plant families Cucurbitaceae, Solanaceae, and Fabaceae (McQuate et al., 2017). *Zeugodacus cucurbitae* can also feed on Citrus spp. (White and Elson-Harris, 1992).
Economically important hosts at risk[a]	Economically important plants in Plant Hardiness Zones 10-12 include melons, cucumbers, squash, peppers, and citrus.
Pest potential on economically	This pest is likely to cause unacceptable consequences because it feeds internally in fruit hosts, has a large host range, and has been shown to be

important hosts at risk	invasive in new areas such as Africa and Hawaii (White and Elson-Harris, 1992).
Defined Endangered Area	The endangered area includes Puerto Rico and areas of the continental United States in Plant Hardiness Zones 10-12.

[a] As defined by ISPM No. 11, supplement 2, "economically important hosts" refers to both commercial and non-market (environmental) plants (IPPC, 2017b).

Assessing the likelihood of introduction of *Zeugodacus cucurbitae* into the endangered area via pummelo fruit imported from Vietnam

Risk Element	Risk Rating	Uncertainty Rating	Evidence for rating (and other notes as necessary)
Likelihood of Entry			
Pest prevalence on the harvested commodity	Low	Medium	Only one study (Tan and Lee, 1982) reports *Z. cucurbitae* feeding on *C. maxima*. Other references to use of Citrus as a host are sporadic and generally considered atypical (McQuate et al., 2017).
Likelihood of surviving post-harvest processing before shipment	Low	Low	Post-harvest processes were not considered in this assessment, so the rating stays at Medium.
Likelihood of surviving transport and storage conditions of the consignment	Low	Low	Transport and storage conditions were not considered in this assessment, so the rating stays at Medium.
Overall Likelihood of Entry	Low		
Likelihood of Establishment	High	High	Females can lay multiple eggs inside a single fruit (Botha et al., 2004), so only one infested fruit has the potential to introduce the fly. The larvae leave the fruit in as little as 5 days to pupate (Botha et al., 2004). Once adults develop, they can fly to find new hosts (Dhillon et al., 2005). *Bactrocera cucurbitae* has wide host range (McQuate et al., 2017) and hosts are found throughout the endangered area.
Likelihood of Introduction (combined likelihoods of entry and establishment)	Medium		

3.2.3. *Prays endocarpa* Meyrick (Lepidoptera: Yponomeutidae)

Larvae of *Prays endocarpa* feed exclusively on fruit, especially pummelo (Vang et al., 2011). Early infestations cause fruit to drop, but when larvae infest more mature fruit, they cause blemishing on the surface. Although pummelo is not widely cultivated in the United States, the insect could potentialy become a problem on other citrus varieties.

Defining the endangered area for *Prays endocarpa* within the United States

Climatic suitability	The insect is present in Vietnam (Vang et al., 2011), parts of India, the Philippines, Malaysia, Indonesia, and the United States (Northern Mariana Islands and Guam) (CABI, 1990), corresponding to global Plant Hardiness Zones 11-12 in the United States (Takeuchi et al., 2019).
Hosts in PRA Area	*Prays endocarpa* larvae feed on pummelo and other citrus fruits (Vang et al., 2011). Citrus is grown in Puerto Rico, Florida, and California within Plant Hardiness Zones 11-12 (NASS, 2018).
Economically important hosts at risk[a]	Citrus is the only economically important host at risk.
Pest potential on economically important hosts at risk	This pest is likely to cause unacceptable consequences because larvae mine the peel of fruit, causing early stage fruit to drop and more mature fruit to develop tumors on the peel, which decreases the commercial value of the fruit (Vang et al., 2011). We have some uncertainty about whether infested fruit would ever be harvested and shipped. *Prays endocarpa* has never been intercepted at a U.S. port of entry (PestID, 2019).
Defined Endangered Area	The endangered area comprises parts of Florida, Puerto Rico and possibly California where citrus is grown in Plant Hardiness Zones 11-12.

[a] As defined by ISPM No. 11, supplement 2, "economically important hosts" refers to both commercial and non-market (environmental) plants (IPPC, 2017b).

Assessing the likelihood of introduction of *Prays endocarpa* into the endangered area via pummelo fruit imported from Vietnam

Risk Element	Risk Rating	Uncertainty Rating	Evidence for rating (and other notes as necessary)
Likelihood of Entry			
Pest prevalence on the harvested commodity	Low	High	Feeding by larvae usually causes fruit to drop. When larvae infest more mature fruit, the rind becomes discolored (Vang et al., 2011), making damage quite visible to harvesters.
Likelihood of surviving post-harvest processing before shipment	Low	Medium	Post-harvest processing was not considered in this risk assessment, so the rating from the previous step remains.

Risk Element	Risk Rating	Uncertainty Rating	Evidence for rating (and other notes as necessary)
Likelihood of surviving transport and storage conditions of the consignment	Low	Medium	Transport and shipping conditions were not considered in this risk assessment, so the rating from the previous step remains.
Overall Likelihood of Entry	Low		
Likelihood of Establishment	Medium	High	*Prays endocarpa* adults can fly to infest new hosts (Vang et al., 2011), but they would have to survive to adulthood in infested fruit that was placed near commercial orchards in order to become established.
Likelihood of Introduction (combined likelihoods of entry and establishment)	Medium		

3.2.4. *Cylindrocarpon lichenicola* (Diaporthales: Cryphonectriaceae)

Cylindrocarpon lichenicola (syn.: *Fusarium lichenicola*) is a saprophytic soil fungus generally considered to be a human and animal pathogen (Iwen et al., 2000; Summerbell and Schroers, 2002). In 2015, this pathogen was first discovered with fruit rot in pummelo during storage and transportation. Under experimental conditions, it has been shown to have the potential to infect other citrus fruits (Amby et al., 2015).

Defining the endangered area for *Cylindrocarpon lichenicola* within the PRA Area

Climatic suitability	**Africa:** Somalia (Iwen et al., 2000; Summerbell and Schroers, 2002); **Asia**: India (Usharani and Ramarao, 1981), Japan (Iwen et al., 2000; Summerbell and Schroers, 2002), Oman (Al-Sadi et al., 2011), and Vietnam (Amby et al., 2015); **Europe**: Germany (Iwen et al., 2000; Summerbell and Schroers, 2002); **North America**: the United States (Iwen et al., 2000; Summerbell and Schroers, 2002); **South America**: Argentina (Iwen et al., 2000; Summerbell and Schroers, 2002) and Ecuador (Thomas et al., 2008); **Oceania**: Papua New Guinea (Shaw, 1984) and Tahiti (Iwen et al., 2000; Summerbell and Schroers, 2002). The reports from Argentina, Germany, Somalia, and the United States were of *C. lichenicola* as a human pathogen. Based on a comparison of this distribution with a global map of Plant Hardiness Zones (Magarey et al., 2008), we estimate it could establish in Plant Hardiness Zones 9-13 in the United States. These Hardiness Zones include the southern continental United States, Hawaii and the island territories.

Hosts in PRA Area	Natural hosts *Citrus maxima* (pummelo) (Amby et al., 2015) and *Theobroma gileri* (mountain cocoa) (Thomas et al., 2008). Artificial inoculation hosts include *Citrus aurantiifolia* (lime) (Amby et al., 2015), *Citrus deliciosa* (mandarin), *Citrus latifolia* (Tahiti lime or Persian lime), *Citrus nobilis* (king orange), and *Citrus sinensis* (orange)(Amby et al., 2015). This pathogen has also been reported as causing corm rot of *Colocasia esculenta* (taro) (Usharani and Ramarao, 1981). All of these plants except Tahiti lime and mountain cocoa occur within the climatically suitable parts of the PRA area (GBIF, 2018; NRCS, 2019).
Economically important hosts at risk[a]	Orange and mandarin are economically important fruit crops (NASS, 2018).
Pest potential on economically important hosts at risk	*Cylindrocarpon lichenicola* is the causal agent of fruit rot in pummelo fruit during storage and transport. Infected fruits may decay completely in two to three days (Amby et al., 2015).
Defined Endangered Area	This species has previously been reported as a human pathogen in the continental United States (Iwen et al., 2000; Summerbell and Schroers, 2002), but we could not find evidence of its presence in Hawaii, Puerto Rico or the U.S. Virgin Islands. Therefore, the endangered zone includes areas of Hawaii, Puerto Rico and U.S. Virgin Islands within Plant Hardiness Zones 9-13.

[a] As defined by ISPM No. 11, supplement 2, "economically important hosts" refers to both commercial and non-market (environmental) plants (IPPC, 2017b).

Assessing the likelihood of introduction of *Cylindrocarpon lichenicola* into the endangered area via pummelo imported from Vietnam

Risk Element	Risk Rating	Uncertainty Rating	Evidence for rating (and other notes as necessary)
Likelihood of Entry			
Pest prevalence on the harvested commodity	High	Low	Pummelo is a host species, and fruits are the primary infection site of *C. lichenicola* (Amby et al., 2015).
Likelihood of surviving post-harvest processing before shipment	High	Low	Pummelo fruit rot has been reported to occur during storage and transportation, which indicates that this pathogen can survive post-harvest processing prior to shipment (Amby et al., 2015). Based on this evidence, the rating for the previous risk element was left unchanged.

Risk Element	**Risk Rating**	**Uncertainty Rating**	**Evidence for rating (and other notes as necessary)**
Likelihood of surviving transport and storage conditions of the consignment	High	Low	Transport and storage procedures in the exporting area are not being considered as part of this assessment; however, the losses reported in the literature occurred during storage and transport (Amby et al., 2015), which shows that this pathogen can remain viable under such conditions. We did not change the previous risk rating.
Overall Likelihood of Entry	High		
Likelihood of Establishment	Low	Medium	Pummelo will be imported for consumption only, which would limit the probability of introducing *C. lichenicola* directly into natural or agricultural environments where hosts may be available. Plant material for consumption, such as fresh fruits and vegetables, is generally considered to pose a low risk as a pathway for establishment of fungi (Palm and Rossman, 2003). Establishment by wind-blown spores is influenced by the quantity of spores produced, the number of spores that become airborne, wind direction and speed, the ability of spores to survive adverse environmental conditions, and the availability of susceptible hosts (Roberts and Boothroyd, 1972). These considerations suggest that a set of conditions optimal for the infection of new hosts would be unlikely to occur, so *C. lichenicola* would have a low likelihood of establishment.
Likelihood of Introduction (combined likelihoods of entry and establishment)	Medium		

3.2.5. *Phyllosticta citriasiana* Wulandari, Crous & Gruyter (Botryosphaeriales: Botryosphaeriaceae)

Phyllosticta citriasiana causes tan spots on fruits that eventually become necrotic. The symptoms caused by *P. citriasiana* closely resemble those of *Guignardia citricarpa*, the causal agent of citrus black spot (Wulandari et al., 2009).

Defining the endangered area for *Phyllosticta citriasiana* within the PRA Area

Climatic suitability	**Asia**: China (Guangdong, Guangxi, Fujian and Hangzhou) (Wang et al., 2012; Wulandari et al., 2009), Thailand (Wulandari et al., 2009), and Vietnam (Wulandari et al., 2009). Based on a comparison of this distribution with a global map of Plant Hardiness Zones (Takeuchi et al., 2019; Widrlechner, 1997), we estimate it could establish in Plant Hardiness Zones 9-13 in the United States. These Zones include the southern continental United States, Hawaii and the island territories.
Hosts in PRA Area	Pummelo is the only known host (Farr and Rossman, 2019; Wang et al., 2012; Wulandari et al., 2009)
Economically important hosts at risk[a]	We found limited information on the production of pummelo in the United States because it falls under the “other citrus” category in the official U.S. statistics. Production in this category is reported from Arizona, California, Hawaii, Louisiana, and Texas, with a total of 202 acres (NASS, 2019).
Pest potential on economically important hosts at risk	*Phyllosticta citriasiana* appears to be a harmful pathogen of pummelo, as it causes a tan spot on fruit (Wulandari et al., 2009). Small, pin-like, red to brown spots appear when infected fruits start maturing. The spots enlarge and become sunken with brown to grey centers and reddish brown rims (Wang et al., 2013).
Defined Endangered Area	The endangered zone includes areas of the continental United States, Hawaii, Puerto Rico, and the U.S. Virgin Islands within Plant Hardiness Zones 9-13 where hosts are present.

[a] As defined by ISPM No. 11, supplement 2, “economically important hosts” refers to both commercial and non-market (environmental) plants (IPPC, 2017b).

Assessing the likelihood of introduction of *Phyllosticta citriasiana* into the endangered area via pummelo imported from Vietnam

Risk Element	Risk Rating	Uncertainty Rating	Evidence for rating (and other notes as necessary)
Likelihood of Entry			
Pest prevalence on the harvested commodity	High	Low	Pummelo is a host species, and fruits are the primary infection sites of *P. citriasiana* (Wang et al., 2012; Wulandari et al., 2009).

Risk Element	Risk Rating	Uncertainty Rating	Evidence for rating (and other notes as necessary)
Likelihood of surviving post-harvest processing before shipment	High	Low	Disease caused by *P. citriasiana* was reported to occur during storage, transportation, and marketing, which indicates that this pathogen can survive post-harvest processing prior to shipment (Wang et al., 2012). Based on this evidence, the rating for the previous risk element was left unchanged.
Likelihood of surviving transport and storage conditions of the consignment	High	Low	Transport and storage procedures in the exporting area are not being considered as part of this assessment; however, disease was reported to continue developing in pummelo during storage and transport (Wang et al., 2012), which shows that this pathogen can remain viable under such conditions. We did not change the previous risk rating.
Overall Likelihood of Entry	High		

Risk Element	**Risk Rating**	**Uncertainty Rating**	**Evidence for rating (and other notes as necessary)**
Likelihood of Establishment	Low	Low	Pummelo is the only known host of *P. citriasiana* (Farr and Rossman, 2019; Wang et al., 2013; Wulandari et al., 2009). Pummelo fruit production is very limited within the United States. "Other citrus," which includes pummelo, was reported to be grown in the United States on a total of 202 acres in 2017. The majority of this was produced in California (107 acres), Hawaii (52 acres), and Texas (31 acres), with the remaining 12 acres in Arizona and Louisiana (NASS, 2019). This represents 0.024 percent of the total citrus acreage in the United States. Pummelo will be only imported for consumption, which will limit the probability of introducing *P. citriasiana* directly into natural or agricultural environments where hosts may be available. Plant material for consumption, such as fresh fruits and vegetables, is considered generally to pose a low risk as a pathway for establishment of fungi (Palm and Rossman, 2003). Several events must occur for *P. citriasiana* to move from imported fruit and infect pummelo in the United States. 1) Infected fruit must arrive in an area with available hosts that is conducive for infection and disease development; 2) a host needs to be in a susceptible physiological stage for infection to occur; 3) *P. citriasiana* spores must be produced on the fruit; 4) spores must be released from lesions on the infected fruit; 5) water contaminated with spores must be brought into contact with host tissue in a susceptible stage for infection; and 6) enough time must elapse with the relevant weather conditions remaining conducive for infection to occur. It is highly unlikely that all of these events would occur, so we conclude that this pathogen would have a low likelihood of establishment.

Risk Element	Risk Rating	Uncertainty Rating	Evidence for rating (and other notes as necessary)
Likelihood of Introduction (combined likelihoods of entry and establishment)	Medium		

4. Summary and Conclusions of Risk Assessment

Of the organisms associated with pummelo worldwide and present in the export area, we identified four that are quarantine pests for the PRA area, are likely to exceed the threshold for unacceptable consequences in the PRA area, and have a reasonable likelihood of following the commodity pathway (Table 3). Thus, these pests are candidates for risk management. These results represent a baseline estimate of the risks associated with the import commodity pathway as described in section 1.4.

Table 3. Summary of pests selected for further evaluation and determined to be candidates for risk management. All of these pests meet the threshold for unacceptable consequences of introduction and have a reasonable likelihood of following the commodity pathway.

Pest type	Taxonomy	Scientific name	Likelihood of Introduction overall rating
Arthropod	Diptera: Tephritidae	*Bactrocera dorsalis* (Hendel)	High
		Zeugodacus cucurbitae (Coquillett)	Medium
	Lepidoptera: Yponomeutidae	*Prays endocarpa* Meyrick	Medium
Fungi	Diaporthales: Cryphonectriaceae	*Cylindrocarpon lichenicola* (C. Massal.) D. Hawksw	Medium
	Botryosphaeriales: Botryosphaeriaceae	*Phyllosticta citriasiana* Wulandari, Crous & Gruyter	Medium

Detailed examination and choice of appropriate phytosanitary measures to mitigate pest risk are not addressed in this document.

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6. Appendix: Pests with non-quarantine status

We found some evidence of the below listed organisms being associated with pummelo and present in Vietnam. Because these organisms are not regulated for the United States (PestID, 2019; or as defined by ISPM 5, IPPC, 2017b), we did not list them in Table 1 of this risk assessment. Moreover, we did not evaluate the strength of the evidence for their association with pummelo or their presence in Vietnam. Because we did not evaluate the strength of the evidence, we consider the following pests to have only "potential" association with the commodity and presence in Vietnam. For organisms **not** present in the United States, we also provide justification for their non-actionable status.

All armored scales (Diaspididae) are non-actionable at U.S. ports of entry on fruit for consumption (NIS, 2008). Even if an armored scale species is not present in the United States, PPQ considers it non-actionable on fruit for consumption because these insects have a very limited ability to disperse to host plants so are highly unlikely to establish via this pathway (Miller et al., 1985; PERAL, 2007).

Organism	In Vietnam	In U.S.	Host association	Notes
ACARI				
Eriophyidae				
Phyllocoptruta oleivora Ashmead	Vietnam Plant Protection, 2016; Whittle, 1992	Non-quarantine (PestID, 2019; Rae et al., 2000; Vietnam Plant Protection, 2016)	Rae et al., 2000; Vietnam Plant Protection, 2016	
Tarsonemidae				
Polyphagotarsonemus latus (Banks)	Vietnam Plant Protection, 2016	Non-quarantine (PestID, 2019)	Vietnam Plant Protection, 2016	
Tetranychidae				
Panonychus citri (McGregor)	Vietnam Plant Protection, 2016; Whittle, 1992	Non-quarantine (PestID, 2019)	Rae et al., 2000; Vietnam Plant Protection, 2016	
INSECTA				
HEMIPTERA				
Aleyrodidae				
Dialeurodes citri (Ashmead)	Whittle, 1992	Non-quarantine (PestID, 2019)	Wang et al., 2013	
Aphididae				
Aphis fabae Scopoli syn.: *A. citricola* van der Goot	Whittle, 1992	CABI, 2019. Non-quarantine (PestID, 2019)	Zehavi and Rosen, 1987	
Toxoptera aurantii (Boyer de Fonscolombe)	Whittle, 1992	Non-quarantine (PestID, 2019)	Sankar et al., 2014	
Coccidae				
Coccus hesperidum (Linnaeus)	CABI, 2019	Non-quarantine (PestID, 2019)	Williams and Watson, 1990	

Coccus viridis (Green)	CABI, 1972	Non-quarantine (PestID, 2019)	Lin et al., 2013
Pulvinaria psidii Maskell, syn.: *Chloropulvinaria psidii* Borchsenius	Vietnam Plant Protection, 2016	Non-quarantine (PestID, 2019)	Vietnam Plant Protection, 2016
Saissetia coffeae (Walker)	Ben-Dov, 1994	Non-quarantine (PestID, 2019)	Ben-Dov, 1994William and Watson, 1990
Diaspididae (all non-actionable on fruit for consumption)			
Aonidiella aurantii (Maskell)	Vietnam Plant Protection, 2016	Non-quarantine (PestID, 2019)	Rae et al., 2000; Vietnam Plant Protection, 2016
Aonidiella citrina (Coquillett)	Dao et al., 2018		Dao et al., 2018
Aonidiella inornata McKenzie	Dao et al., 2018		Dao et al., 2018
Aspidiotus destructor Signoret	Dao et al., 2018		Dao et al., 2018
Aspidiotus excisus Green	Dao et al., 2018		Dao et al., 2018
Chrysomphalus aonidum (Linnaeus) syn.: *C. ficus* Ashmead	Dao et al., 2018	Non-quarantine (PestID, 2019)	Dao et al. 2018
Chrysomphalus bifasciculatus Ferris	Dao et al., 2018		Dao et al., 2018
Chrysomphalus dictyospermi (Morgan)	Dao et al., 2018		Dao et al., 2018
Fiorinia theae Green	Dao et al., 2018		Dao et al., 2018
Hemiberlesia cyanophylli (Signoret)	Dao et al., 2018		Dao et al., 2018
Lepidosaphes beckii (Newman)	Whittle, 1992		Dao et al., 2018
Lepidosaphes gloverii (Packard)	Dao et al., 2018		Dao et al., 2018
Lepidosaphes karkarica Williams & Watson	Dao et al., 2018		Dao et al., 2018
Octaspidiotus stauntoniae (Takahashi)	Dao et al., 2018		Dao et al., 2018
Parlatoria cinerea (Hadden in Doane & Hadden)	Dao et al., 2018		Dao et al., 2018
Parlatoria pergandii Comstock	Dao et al., 2018		Rae et al., 2000
Parlatoria ziziphi (Lucas)	Whittle, 1992		Dao et al., 2018
Pinnaspis aspidistrae (Signoret)	Dao et al., 2018		Dao et al., 2018
Pseudaonidia trilobitiformis (Green)	Dao et al., 2018		Dao et al., 2018

Unaspis citri (Comstock)	Dao et al., 2018		Dao et al., 2018
Margarodidae			
Icerya purchasi Maskell	Whittle, 1992	Non-quarantine (PestID, 2019)	Zhang, 2000
Pseudococcidae			
Planococcus citri (Risso)	Dang et al., 2016; Vietnam Plant Protection, 2016	Non-quarantine (PestID, 2019; Mani and Krishnamoorthy, 2008; Vietnam Plant Protection, 2016)	Mani and Krishnamoorthy, 2008; Vietnam Plant Protection, 2016
Pseudococcus longispinus (Targioni Tozzetti)	Ben-Dov, 1994	Non-quarantine (PestID, 2019; Mani and Krishnamoorthy, 2008; Vietnam Plant Protection, 2016)	Ben-Dov, 1994; Williams and Watson, 1988
THYSANOPTERA			
Thripidae			
Scirtothrips dorsalis Hood	Vietnam Plant Protection, 2016	Pangnakorn and Chuenchooklin, 2015; Vietnam Plant Protection, 2016	Pangnakorn and Chuenchooklin, 2015; Vietnam Plant Protection, 2016
NEMATODES			
Meloidogyne incognita (Kofoid & White) Chitwood	Vietnam Plant Protection, 2016	Sasser and Carter, 1985; UGA, 2018; Walters and Barker, 1994	Vietnam Plant Protection, 2016
Meloidogyne javanica (Treub) Chitwood	Vietnam Plant Protection, 2016	Sasser and Carter, 1985; UGA, 2018; Walters and Barker, 1994	Vietnam Plant Protection, 2016
Tylenchulus semipenetrans (Cobb)	Khuong, 1983	CABI, 2019; UGA, 2018	Goodey et al., 1965
FUNGI			
Alternaria alternata (Fr.: Fr.) Keissl.	Vietnam Plant Protection, 2016	French, 1989; Raabe, 1966; Stevenson, 1975	French, 1989
Alternaria citri Ellis & N. Pierce	Whittle, 1992	Farr and Rossman, 2019	French, 1989
Aspergillus flavus Link	Nguyen et al., 2000	French, 1989; Raabe, 1966; Stevenson, 1975	French, 1989
Aspergillus niger Tiegh.	Leong et al., 2007	Alfieri et al., 1984; Raabe,	Peregrine and Bin Ahmad, 1982

		1966; Stevenson, 1975	
Athelia rolfsii (Curzi) Tu & Kimbr. syn.: *Corticium rolfsii* Curzi, *Pellicularia rolfsii* E. West (anamorph: *Sclerotium rolfsii* Sacc.)	CABI, 2019	Alfieri et al., 1984; Raabe, 1966; Wellman, 1977	Alfieri et al., 1984
Botryosphaeria rhodina (Cooke) Arx [anamorph: *Lasiodiplodia theobromae* (Pat.) Griffon & Maubl.] syn.: *Physalospora rhodina* Cooke, *Diplodia natalensis* Pole-Evans	Farr and Rossman, 2019	Alfieri et al., 1984; Raabe, 1966; Wellman, 1977	French, 1989
Cephaleuros virescens Kunze	Vietnam Plant Protection, 2016	Ferwerda-Licha, 2002; Nelson, 2008; Wolf, 1930	Wolf, 1930
Elsinoë fawcettii (Britanc. & Jenkins) (anamorph: *Sphaceloma fawcettii* var. *fawcettii* Jenkins)	Whittle, 1992	CABI, 2019; Farr and Rossman, 2019	Peregrine and Bin Ahmad, 1982
Fusarium solani (Mart.) Sacc.	Vietnam Plant Protection, 2016	French, 1989; Stevenson, 1975; USDA-ARS, 1960	French, 1989
Glomerella cingulata (Stonem.) Spauld. & Schrenk [anamorph: *Colletotrichum gloeosporioides* (Stonem.) Spauld. & Schrenk]	Whittle, 1992	Alfieri et al., 1984; Raabe, 1966; Stevenson, 1975	Peregrine and Bin Ahmad, 1982
Mycosphaerella citri Whiteside 1972, syn.: *Zasmidium citri* (Whiteside) Crous 2009 [anamorph: *Stenella citri-grisea* (F.E. Fisher) Sivan.]	Maxwell et al., 2005	Alfieri et al., 1984; Pretorius et al., 2003; Stevenson, 1975	Pretorius et al., 2003
Penicillium digitatum (Pers.: Fr.) Sacc.	Vietnam Plant Protection, 2016	Alfieri et al., 1984; Raabe, 1966; Stevenson, 1975	Alfieri et al., 1984
Penicillium italicum Wehmer	Vietnam Plant Protection, 2016	Alfieri et al., 1984; Raabe,	Alfieri et al., 1984

		1966; Stevenson, 1975	
Phytophthora capsici Leonian	Drenth and Guest, 2004	Raabe, 1966; Stevenson, 1975; USDA-ARS, 1960	USDA-ARS, 1960
Phytophthora citrophthora (R.H. Sm. & E. Sm) syn.: *P. palmivora* Butl.	Drenth and Guest, 2004	French, 1989; Raabe, 1966; Stevenson, 1975	French, 1989
Phytophthora nicotianae Brenda de Haan, syn.: *P. parasitica* Dastur, *P. nicotianae* var. *parasitica* (Brenda de Haan) Tucker	Drenth and Guest, 2004	French, 1989; Raabe, 1966	French, 1989
Phytophthora palmivora var. *palmivora* (E.J. Butler) E.J. Butler, syn.: *P. palmivora* (E.J. Butler) E.J. Butler	Drenth and Guest, 2004	Alfieri et al., 1984; Stevenson, 1975; USDA-ARS, 1960	Erwin and Ribeiro, 1996
Pythium aphanidermatum (Edson) Fitzp.	Luong et al., 2010a	French, 1989; Raabe, 1966; Stevenson, 1975	French, 1989
Schizophyllum commune Fr.: Fr.	Kiet, 1998	French, 1989; Raabe, 1966; Stevenson, 1975	French, 1989
Sclerotinia sclerotiorum (Lib.) de Bary	Luong et al., 2010b	Raabe, 1966	French, 1989
Thanatephorus cucumeris (A. B. Frank) Donk, 1956	Thuan et al., 2008	French, 1989; Stevenson, 1975; USDA-ARS, 1960	French, 1989
VIRUS AND VIROIDS			
Citrus tristeza virus closterovirus (CTV)	Whittle, 1992	CABI, 2019; Roistacher and Moreno, 1990; Saponari and Yokomi, 2010	CABI, 2019