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Biosecurity Australia

Final import risk analysis report for fresh stone fruit from California, Idaho, Oregon and Washington

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Cover image:

Apricots, nectarines, peaches, plums and pluots are among the stone fruit varieties the USA may export to Australia. Image by Biosecurity Australia.

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Acronyms and abbreviations

ALOP	Appropriate level of protection.
APHIS	The Animal and Plant Health Inspection Service.
AQIS	Australian Quarantine and Inspection Service.
BA	Biosecurity Australia.
DAFF	The Australian Government Department of Agriculture, Fisheries and Forestry.
DAFWA	Department of Agriculture and Food, Western Australia.
FAO	Food and Agriculture Organization of the United Nations.
IPPC	International Plant Protection Convention.
IRA	Import Risk Analysis.
ISPM	International Standard for Phytosanitary Measures.
NT	The Northern Territory.
Qld	Queensland.
SA	South Australia.
Tas.	Tasmania.
USA	The United States of America
USDA	The United States Department of Agriculture.
Vic.	Victoria.
WA	Western Australia.
WTO	World Trade Organization.

Summary

This import risk analysis (IRA) assesses a proposal from the United States of America (USA) for market access to Australia for fresh stone fruit from California and the Pacific Northwest states (Idaho, Oregon and Washington).

Australia already has existing quarantine policy that allows the importation of cherries from the USA and New Zealand, as well as policy for other stone fruit from New Zealand.

This import risk analysis report recommends that the importation of fresh stone fruit from commercial production areas in California, Idaho, Oregon and Washington be permitted, subject to a range of quarantine conditions, including maintenance of area freedom from plum pox virus and a number of fruit flies in the export areas.

The report takes into account stakeholder comments on the *Draft import risk analysis report for fresh stone fruit from California, Idaho, Oregon and Washington* that was released in April 2008.

This report identifies 20 pests that require quarantine measures to manage risks to a very low level in order to achieve Australia's appropriate level of protection (ALOP). The pests requiring measures are apple maggot, peach twig borer, cherry fruitworm, lesser apple fruitworm, three species of mealybugs, seven species of leafrollers and four species of thrips.

The recommended quarantine measures also take account of regional differences. Two pests, oriental fruit moth and citrophilus mealybug have been identified as quarantine pests only for Western Australia. Any fruit to be exported to Western Australia will require additional measures for these two pests.

The recommended quarantine measures are a combination of risk management measures and operational systems that will reduce the risk associated with the importation of fresh stone fruit from the USA into Australia to achieve Australia's ALOP, specifically:

- a systems approach for peach twig borer that includes infield control measures, orchard surveys and fruit cutting in the packing house
- fruit cutting in the packing house to detect cherry fruitworm and lesser apple fruitworm
- sourcing fruit from pest free areas, or areas of low pest prevalence for oriental fruit moth (exports to Western Australia only)
- sourcing and packing fruit in areas recognised as free from apple maggot (for apricots, plums and their interspecific hybrids)
- visual inspection of all consignments for mealybugs, leafrollers and thrips and remedial action if quarantine pests are detected
- supporting operational systems to maintain and verify the phytosanitary status of consignments.

Biosecurity Australia has made a number of changes to the risk analysis following consideration of stakeholder comments on the draft IRA report. These changes include:

- addition of 33 arthropod, 26 fungal and 7 viral pests to the pest categorisation table, which has resulted in three arthropod species being added to the current risk assessments and a new risk assessment being included for *Tobacco necrosis viruses*

- recognition of the non host status of peaches and nectarines for apple maggot
- removal of the risk assessment for apricot ring pox as there is no valid pathway for it to establish in Australia
- inclusion of *Drosophila suzukii* for assessment in the pest categorisation tables, and a footnote outlining that this pest will be assessed in a separate pest-initiated pest risk analysis
- minor changes to the rating for probability of importation, distribution, establishment, spread, or consequences for a number of pests but resulting in no change to the unrestricted risk estimate.

1 Introduction

1.1 Australia's biosecurity policy framework

Australia's biosecurity policies aim to protect Australia against the risks that may arise from exotic pests entering, establishing and spreading in Australia, thereby threatening Australia's unique flora and fauna, as well as those agricultural industries that are relatively free from serious pests.

The import risk analysis (IRA) process is an important part of Australia's biosecurity policies. It enables the Australian Government to consider formally the risks that could be associated with proposals to import new products into Australia. If the risks are found to be above Australia's appropriate level of protection (ALOP), risk management measures are proposed to reduce the risks to an acceptable level. But, if it is not possible to reduce the risks to an acceptable level, then no trade will be allowed.

Successive Australian Governments have maintained a conservative, but not a zero-risk, approach to the management of biosecurity risks. This approach is expressed in terms of Australia's ALOP, which reflects community expectations through government policy and is currently described as providing a high level of protection aimed at reducing risk to a very low level, but not to zero.

Australia's IRAs are undertaken by Biosecurity Australia using teams of technical and scientific experts in relevant fields, and involving consultation with stakeholders at various stages during the process. The recommendations from Biosecurity Australia are provided to the Director of Animal and Plant Quarantine (the Secretary of the Australian Department of Agriculture, Fisheries and Forestry), who is responsible for determining whether imports can occur and under what conditions. The Australian Quarantine and Inspection Service (AQIS) is responsible for implementing the import protocol, including any risk management measures.

More information about Australia's biosecurity framework is provided in Appendix B of this report and in the *Import Risk Analysis Handbook 2007 (updated 2009)* located on the Biosecurity Australia website www.daff.gov.au/ba.

1.2 Scope of the market access request

A pest risk analysis (PRA) was initiated following receipt of a technical submission from the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) for stone fruit from California, Idaho, Oregon and Washington. APHIS requested access for apricots, nectarines, peaches and plums, as well as inter-specific hybrids including, but not limited to, pluots and plumcots.

1.3 Existing policy

Currently, various fresh stone fruit are permitted entry into Australia from New Zealand and the United States of America (USA). Cherries are currently permitted from New Zealand into all Australian states, while cherries from specific counties in the states of California, Idaho, Oregon and Washington are permitted into all Australian states except Western Australia. Apricots, nectarines, peaches and plums may be imported from New Zealand into all Australian states.

1.4 Review of policy

Biosecurity Australia made a preliminary assessment of the pests potentially associated with fresh stone fruit from the USA and determined whether those pests had already been considered in other pest risk assessments. The preliminary assessment identified those pests that were associated with stone fruit production in the USA and were likely to be found on mature harvested fruit packed for export.

Of these pests, consideration was then given to the potential for consequences should they establish in Australia, and any quarantine conditions that were already in place for those, or closely related species. This assessment determined that for most pests that might be imported with stone fruit, similar risks had already been assessed in existing pest risk assessments and that existing quarantine conditions would address the risks.

In Biosecurity Australia Policy Memorandum (BAPM) 2006/05 of 6 March 2006, Biosecurity Australia announced that the market access request from the USA would be progressed as an extension of existing policies.

1.5 Transition into the regulated process

On 12 September 2007, in BAPM 2007/20, Biosecurity Australia announced the transitional arrangements for the current animal and plant import proposal work program. In that memorandum stakeholders were advised that the import proposal for stone fruit from California and the Pacific Northwest would be finalised under the new regulated process. It was also advised that previous work or comparable steps already completed would not be repeated under the regulated process.

1.6 Contaminating pests

In addition to the pests of stone fruit in the USA identified in this IRA, there are other organisms that might be carried with the fruit. These organisms could include pests of other crops or predators and parasitoids of other arthropods. Biosecurity Australia considers these organisms to be contaminating pests that could pose sanitary and phytosanitary risks. These risks are addressed by AQIS's standard procedures.

2 Pest risk analysis method

This section sets out the method used for the pest risk analysis (PRA) in this report. Biosecurity Australia has conducted this PRA in accordance with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for Pest Risk Analysis* (FAO 2007) and ISPM 11: *Pest Risk Analysis for Quarantine Pests, including analysis of environmental risks and living modified organisms* (FAO 2004).

A PRA is 'the process of evaluating biological or other scientific and economic evidence to determine whether a pest should be regulated and the strength of any phytosanitary measures to be taken against it' (FAO 2009). A pest is 'any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products' (FAO 2009).

Quarantine risk consists of two major components: the probability of a pest entering, establishing and spreading in Australia from imports; and the consequences of this happening. These two components are combined to give an overall estimate of the risk.

Unrestricted risk is estimated taking into account the existing commercial production practices of the exporting country and that, on arrival in Australia, AQIS will verify that the consignment received is as described on the commercial documents and that its integrity has been maintained.

Restricted risk is estimated with phytosanitary measure(s) applied. A phytosanitary measure is 'any legislation, regulation or official procedure having the purpose to prevent the introduction and spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests' (FAO 2009).

A glossary of the terms used is provided at the back of this IRA report.

The PRA was conducted in the following three consecutive stages: initiation, pest risk assessment and pest risk management.

2.1 Stage 1: initiation

Initiation identifies the pest(s) and pathway(s) that are of quarantine concern and should be considered for risk analysis in relation to the identified PRA area.

The initiation point for this PRA was the receipt of a technical submission from the National Plant Protection Organisation (NPPO) for access to the Australian market for the commodity. This submission included information on the pests associated with the production of the commodity, including the plant part affected, and the existing commercial production practices for the commodity.

The pests associated with the crop and the exported commodity were tabulated from information provided by the NPPO of the exporting country and literature and database searches. This information is set out in Appendix A.

The identity of the pests is given in Appendix A. The species name is used in most instances but a lower taxonomic level is used where appropriate. Synonyms are provided where the current scientific name differs from that provided by the exporting countries NPPO or where the cited literature uses a different scientific name.

For this PRA, the 'PRA area' is defined as Australia for pests that are absent or of limited distribution and under official control. For areas with regional freedom from a pest, the 'PRA area' may be defined on the basis of a state or territory of Australia or may be defined as a region of Australia consisting of parts of a state or territory or several states or territories.

For pests that had been considered by Biosecurity Australia in other risk assessments and for which import policies already exist, a judgement based on the specific circumstances was made on the likelihood of entry of pests on the commodity and whether existing policy is adequate to manage the risks associated with its import. Where appropriate, the previous risk assessment was taken into consideration when developing the new policy.

2.2 Stage 2: pest risk assessment

A pest risk assessment (for quarantine pests) is: 'the evaluation of the probability of the introduction and spread of a pest and of the likelihood of associated potential economic consequences' (FAO 2009).

In this PRA, pest risk assessment was divided into the following interrelated processes:

2.2.1 Pest categorisation

Pest categorisation identifies which of the pests with the potential to be on the commodity are quarantine pests for Australia and require pest risk assessment. A 'quarantine pest' is a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled, as defined in ISPM 5: *Glossary of phytosanitary terms* (FAO 2009).

The pests identified in Stage 1 were categorised using the following primary elements to identify the quarantine pests for the commodity being assessed:

- presence or absence in the PRA area
- regulatory status
- potential for establishment and spread in the PRA area
- potential for economic consequences (including environmental consequences) in the PRA area.

The results of pest categorisation are set out in Appendix A. The quarantine pests identified during pest categorisation were carried forward for pest risk assessment and are listed in Table 4.1.

2.2.2 Assessment of the probability of entry, establishment and spread

Details of how to assess the 'probability of entry', 'probability of establishment' and 'probability of spread' of a pest are given in ISPM 11 (FAO 2009). A summary of this process is given below, followed by a description of the qualitative methodology used in this IRA.

Probability of entry

The probability of entry describes the probability that a quarantine pest will enter Australia as a result of trade in a given commodity, be distributed in a viable state in the PRA area and subsequently be transferred to a suitable host. It is based on pathway scenarios depicting necessary steps in the sourcing of the commodity for export, its processing, transport and storage, its utilisation in Australia and the generation and disposal of waste. In particular, the ability of the pest to survive is considered for each of these stages.

The probability of entry estimates for the quarantine pests for a commodity are based on the use of the existing commercial production, packaging and shipping practices of the exporting country. Details of the existing commercial production practices for the commodity are set out in Section 3. These practices are taken into consideration by Biosecurity Australia when estimating the probability of entry.

For the purpose of considering the probability of entry, Biosecurity Australia divides this step of this stage of the PRA into two components:

Probability of importation: the probability that a pest will arrive in Australia when a given commodity is imported

Probability of distribution: the probability that the pest will be distributed, as a result of the processing, sale or disposal of the commodity, in the PRA area and subsequently transfer to a susceptible part of a host.

Factors considered in the probability of importation include:

- distribution and incidence of the pest in the source area
- occurrence of the pest in a life-stage that would be associated with the commodity
- mode of trade (e.g. bulk, packed)
- volume and frequency of movement of the commodity along each pathway
- seasonal timing of imports
- pest management, cultural and commercial procedures applied at the place of origin
- speed of transport and conditions of storage compared with the duration of the life cycle of the pest
- vulnerability of the life-stages of the pest during transport or storage
- incidence of the pest likely to be associated with a consignment
- commercial procedures (e.g. refrigeration) applied to consignments during transport and storage in the country of origin, and during transport to Australia.

Factors considered in the probability of distribution include:

- commercial procedures (e.g. refrigeration) applied to consignments during distribution in Australia
- dispersal mechanisms of the pest, including vectors, to allow movement from the pathway to a suitable host
- whether the imported commodity is to be sent to a few or many destination points in the PRA area
- proximity of entry, transit and destination points to suitable hosts
- time of year at which import takes place
- intended use of the commodity (e.g. for planting, processing or consumption)
- risks from by-products and waste.

Probability of establishment

Establishment is defined as the 'perpetuation for the foreseeable future, of a pest within an area after entry' (FAO 2009). In order to estimate the probability of establishment of a pest, reliable biological information (life cycle, host range, epidemiology, survival, etc.) should be obtained from the areas where the pest currently occurs. The situation in the PRA area can then be compared with that in the areas where it currently occurs and expert judgement used to assess the probability of establishment.

Factors considered in the probability of establishment in the PRA area include:

- availability of suitable hosts, alternative hosts and vectors
- suitability of the environment
- reproductive strategy and potential for adaptation
- minimum population needed for establishment
- cultural practices and control measures.

Probability of spread

Spread is defined as 'the expansion of the geographical distribution of a pest within an area' (FAO 2009). The probability of spread considers the factors relevant to the movement of the pest, after establishment on a host plant or plants, to other susceptible host plants of the same or different species in other areas. In order to estimate the probability of spread of the pest, reliable biological information should be obtained from areas where the pest currently occurs. The situation in the PRA area can then be carefully compared with that in the areas where the pest currently occurs and expert judgement used to assess the probability of spread.

Factors considered in the probability of spread include:

- suitability of the natural and/or managed environment for natural spread of the pest
- presence of natural barriers
- the potential for movement with commodities, conveyances or by vectors
- intended use of the commodity
- potential vectors of the pest in the PRA area
- potential natural enemies of the pest in the PRA area.

Assigning qualitative likelihoods for the probability of entry, establishment and spread

In its qualitative PRAs, Biosecurity Australia uses the term 'likelihood' for the descriptors it uses for its estimates of probability of entry, establishment and spread. Qualitative likelihoods are assigned to each step of entry, establishment and spread. Six descriptors are used: high; moderate; low; very low; extremely low; and negligible (Table 2.1). Descriptive definitions for these descriptors and their indicative probability ranges are given in Table 2.1. The indicative probability ranges are only provided to illustrate the boundaries of the descriptors. These indicative probability ranges are not used beyond this purpose in qualitative PRAs. The standardised likelihood descriptors and the associated indicative probability ranges provide guidance to the risk analyst and promote consistency between different risk analyses.

Table 2.1: Nomenclature for qualitative likelihoods

Likelihood	Descriptive definition	Indicative probability (P) range
High	The event would be very likely to occur	0.7 < P ≤ 1
Moderate	The event would occur with an even probability	0.3 < P ≤ 0.7
Low	The event would be unlikely to occur	0.05 < P ≤ 0.3
Very low	The event would be very unlikely to occur	0.001 < P ≤ 0.05
Extremely low	The event would be extremely unlikely to occur	0.000001 < P ≤ 0.001
Negligible	The event would almost certainly not occur	0 ≤ P ≤ 0.000001

The likelihood of entry is determined by combining the likelihood that the pest will be imported into the PRA area and the likelihood that the pest will be distributed within the PRA area, using a matrix of rules (Table 2.2). This matrix is then used to combine the likelihood of entry and the likelihood of establishment, and the likelihood of entry and establishment is then combined with the likelihood of spread to determine the overall likelihood of entry, establishment and spread.

For example, if the probability of importation is assigned a likelihood of low and the probability of distribution is assigned a likelihood of moderate, then they are combined to give a likelihood of low for the probability of entry. The likelihood for the probability of entry is then combined with the likelihood assigned to the probability of establishment (e.g. high) to give a likelihood for the probability of entry and establishment of low. The likelihood for the probability of entry and establishment is then combined with the likelihood assigned to the probability of spread (e.g. very low) to give the overall likelihood for the probability of entry, establishment and spread of very low.

Table 2.2: Matrix of rules for combining qualitative likelihoods

	High	Moderate	Low	Very low	Extremely low	Negligible
High	High	Moderate	Low	Very low	Extremely low	Negligible
Moderate		Low	Low	Very low	Extremely low	Negligible
Low			Very low	Very low	Extremely low	Negligible
Very low				Extremely low	Extremely low	Negligible
Extremely low					Negligible	Negligible
Negligible						Negligible

Time and volume of trade

One factor affecting the likelihood of entry is the volume and duration of trade. If all other conditions remain the same, the overall likelihood of entry will increase as time passes and the overall volume of trade increases.

Biosecurity Australia normally considers the likelihood of entry on the basis of the estimated volume of one year's trade. This is a convenient value for the analysis that is relatively easy to estimate and allows for seasonal variations in pest presence, incidence and behaviour to be taken into account. Although the volume used will be different for different commodities, this method provides a consistent approach with respect to time. In contrast, the likelihood of entry, establishment and spread and subsequent consequences take into account events that might happen over a number of years even though only one year's trade is being considered. This difference reflects the fact that although pest or disease establishment may occur in the year of import, spread can take many years.

The use of a one year volume of trade has been taken into account when setting up the matrix that is used to estimate the risk and therefore any policy based on this analysis does not simply apply to one year of trade. Policy decisions that are based on Biosecurity Australia's method that uses the estimated volume of one year's trade are consistent with Australia's policy on appropriate level of protection and meet the Australian Government's requirement for ongoing quarantine protection. Of course, if there are substantial changes in the volume and nature of the trade in specific commodities then BA has an obligation to review the risk analysis and, if necessary, provide updated policy advice.

In assessing the volume of trade in this PRA, Biosecurity Australia assumed that imports of the commodity under assessment may form a substantial share of the market for the commodity in Australia.

2.2.3 Assessment of potential consequences

The objective of the consequence assessment is to provide a structured and transparent analysis of the likely consequences if the pests or disease agents were to enter, establish and spread in Australia. The assessment considers direct and indirect pest effects and their economic and environmental consequences. The requirements for assessing potential consequences are given in Article 5.3 of the SPS Agreement (WTO 1995), ISPM 5 (FAO 2009), and ISPM 11 (FAO 2004).

Direct pest effects are considered in the context of the effects on:

- plant life or health
- other aspects of the environment.

Indirect pest effects are considered in the context of the effects on:

- eradication, control, etc.
- domestic trade
- international trade
- environment.

For each of these six criteria, the consequences were estimated over four geographic levels, defined as:

- **Local**: an aggregate of households or enterprises (a rural community, a town or a local government area).
- **District**: a geographically or geopolitically associated collection of aggregates (generally a recognised section of a state or territory, such as 'Far North Queensland').
- **Regional**: a geographically or geopolitically associated collection of districts in a geographic area (generally a state or territory, although there may be exceptions with larger states such as Western Australia).
- **National**: Australia wide (Australian mainland states and territories and Tasmania).

For each criterion, the magnitude of the potential consequence at each of these levels was described using four categories, defined as:

- **Indiscernible**: Pest impact unlikely to be noticeable.
- **Minor significance**: Expected to lead to a minor increase in mortality/morbidity of hosts or a minor decrease in production but not expected to threaten the economic viability of production. Expected to decrease the value of non-commercial criteria but not threaten the criterion's intrinsic value. Effects would generally be reversible.
- **Significant**: Expected to threaten the economic viability of production through a moderate increase in mortality/morbidity of hosts, or a moderate decrease in production. Expected to significantly diminish or threaten the intrinsic value of non-commercial criteria. Effects may not be reversible.
- **Major significance**: Expected to threaten the economic viability through a large increase in mortality/morbidity of hosts, or a large decrease in production. Expected to severely or irreversibly damage the intrinsic 'value' of non-commercial criteria.

The estimates of the magnitude of the potential consequences over the four geographic levels were translated into a qualitative impact score (A–G)[1] using Table 2.3[2]. For example, a consequence with a magnitude of 'significant' at the 'district' level will have a consequence impact score of D.

Table 2.3: Decision rules for determining the consequence impact score based on the magnitude of consequences at four geographic scales

		Geographic scale			
		Local	District	Region	Nation
Magnitude	Indiscernible	A	A	A	A
	Minor significance	B	C	D	E
	Significant	C	D	E	F
	Major significance	D	E	F	G

The overall consequence for each pest is achieved by combining the qualitative impact scores (A–G) for each direct and indirect consequence using a series of decision rules (Table 2.4). These rules are mutually exclusive, and are assessed in numerical order until one applies.

[1] In earlier qualitative IRAs, the scale for the impact scores went from A to F and did not explicitly allow for the rating 'indiscernible' at all four levels. This combination might be applicable for some criteria. In this report, the impact scale of A-F has changed to become B-G and a new lowest category A ('indiscernible' at all four levels) was added. The rules for combining impacts in Table 2.4 were adjusted accordingly.

[2] The decision rules for determining the consequence impact score are presented in a simpler form in Table 2.3 from earlier IRAs, to make the table easier to use. The outcome of the decision rules is the same as the previous table and makes no difference to the final impact score.

Table 2.4: Decision rules for determining the overall consequence rating for each pest

Rule	The impact scores for consequences of direct and indirect criteria	Overall consequence rating
1	Any criterion has an impact of ‘G’; or more than one criterion has an impact of ‘F’; or a single criterion has an impact of ‘F’ and each remaining criterion an ‘E’.	Extreme
2	A single criterion has an impact of ‘F’; or all criteria have an impact of ‘E’.	High
3	One or more criteria have an impact of ‘E’; or all criteria have an impact of ‘D’.	Moderate
4	One or more criteria have an impact of ‘D’; or all criteria have an impact of ‘C’.	Low
5	One or more criteria have an impact of ‘C’; or all criteria have an impact of ‘B’.	Very Low
6	One or more but not all criteria have an impact of ‘B’, and all remaining criteria have an impact of ‘A’.	Negligible

2.2.4 Estimation of the unrestricted risk

Once the above assessments are completed, the unrestricted risk can be determined for each pest or groups of pests. This is determined by using a risk estimation matrix (Table 2.5) to combine the estimates of the probability of entry, establishment and spread and the overall consequences of pest establishment and spread. Therefore, risk is the product of likelihood and consequence.

Table 2.5: Risk estimation matrix

Likelihood of pest entry, establishment and spread	Negligible	Very low	Low	Moderate	High	Extreme
High	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Moderate	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Low	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk	High risk
Very low	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk
Extremely low	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk
Negligible	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk
	Consequences of pest entry, establishment and spread					

When interpreting the risk estimation matrix, note the descriptors for each axis are similar (e.g. low, moderate, high) but the vertical axis refers to likelihood and the horizontal axis refers to consequences. Accordingly, a ‘low’ likelihood combined with ‘high’ consequences, is not the same as a ‘high’ likelihood combined with ‘low’ consequences – the matrix is not symmetrical. For example, the former combination would give an unrestricted risk rating of ‘moderate’, whereas, the latter would be rated as a ‘low’ unrestricted risk.

2.2.5 Australia’s appropriate level of protection (ALOP)

The SPS Agreement defines the concept of an ‘appropriate level of sanitary or phytosanitary protection (ALOP)’ as the level of protection deemed appropriate by the WTO Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory.

Like many other countries, Australia expresses its ALOP in qualitative terms. Australia's ALOP, which reflects community expectations through government policy, is currently expressed as providing a high level of sanitary or phytosanitary protection aimed at reducing risk to a very low level, but not to zero. The band of cells in Table 2.5 marked 'very low risk' represents Australia's ALOP.

2.3 Stage 3: pest risk management

Pest risk management describes the process of identifying and implementing phytosanitary measures to manage risks to achieve Australia's ALOP, while ensuring that any negative effects on trade are minimised.

The conclusions from pest risk assessment are used to decide whether risk management is required and if so, the appropriate measures to be used. Where the unrestricted risk estimate exceeds Australia's ALOP, risk management measures are required to reduce this risk to a very low level. Since zero-risk is not a reasonable option, the guiding principle for risk management is to manage risk to achieve Australia's ALOP. The effectiveness of any proposed phytosanitary measure (or combination of measures) is evaluated, using the same approach as used to evaluate the unrestricted risk, to ensure it reduces the restricted risk for the relevant pest or pests to meet Australia's ALOP.

ISPM 11 (FAO 2004) provides details on the identification and selection of appropriate risk management options and notes that the choice of measures should be based on their effectiveness in reducing the probability of entry of the pest.

Examples given of measures commonly applied to traded commodities include:

- options for consignments – e.g., inspection or testing for freedom from pests, prohibition of parts of the host, a pre-entry or post-entry quarantine system, specified conditions on preparation of the consignment, specified treatment of the consignment, restrictions on end-use, distribution and periods of entry of the commodity
- options preventing or reducing infestation in the crop – e.g., treatment of the crop, restriction on the composition of a consignment so it is composed of plants belonging to resistant or less susceptible species, harvesting of plants at a certain age or specified time of the year, production in a certification scheme
- options ensuring that the area, place or site of production or crop is free from the pest – e.g., pest-free area, pest-free place of production or pest-free production site
- options for other types of pathways – e.g., consider natural spread, measures for human travellers and their baggage, cleaning or disinfestation of contaminated machinery
- options within the importing country – e.g., surveillance and eradication programs
- prohibition of commodities – if no satisfactory measure can be found.

Risk management measures are identified for each quarantine pest where the risk exceeds Australia's ALOP. These are presented in the 'Pest Risk Management' section of this report.

3 Stone fruit industry information

3.1 The USA stone fruit industry

3.1.1 Production statistics

Based on figures in the 'Noncitrus Fruits and Nuts 2008 Summary' (NASS 2009), the utilised peach production was almost unchanged from 2007, with a six per cent increase for nectarines, 36 per cent increase for plums and prunes, and a 13 per cent reduction for apricots. However, the total bearing acreage for these crops remained relatively unchanged from 2006 and 2007 figures.

In 2008 there was approximately 265 thousand acres of stone fruit production, excluding cherries, in the USA. The total yield from this areas was approximately 1.869 million metric tons (2.061 million US tons). Of this production, 55 per cent comprised of peaches, 26 per cent of prunes and plums, 15 percent of nectarines and 4 per cent apricots. The total value of the 2007 production was estimated at US$954 million.

California is the most important state for stone fruit production, having approximately half (56 000 acres) of the USA acreage of peach production and nearly all of the acreage of apricots, nectarines, plums and prunes. Other important states for peach production include South Carolina (14 000 acres), Georgia (9 500 acres), New Jersey (6 200 acres) and Texas (4 900 acres). These figures are significantly greater than in Idaho (1 200 acres), Oregon (650 acres) and Washington (2 300 acres). In contrast, the other important fresh stone fruit crop, sweet cherries, is strongly represented in Washington (32 000 acres) and Oregon (12500 acres), along with California (27 000 acres).

3.1.2 Climate in production regions

The two major production regions for stone fruit considered in this IRA are within the San Joaquin Valley in California, and Yakima Valley in Washington. The climatic conditions in these areas have been presented in Figure 3-1 and Figure 3-2 on page 24. As can be seen, the climate in Yakima (Figure 3-2), a stone fruit growing region in Washington State, is significantly colder than that observed for the San Joaquin Valley (Figure 3-1).

The climate in both of these regions can be described as Mediterranean, with cold wet winters and generally hot, dry summers. These conditions are similar to those found in many regions of Australia, including suburban areas where imported stone fruit could be sold, such as Melbourne (figure 3-3), Sydney (figure 3-4), Brisbane (Figure 3-5), and Perth (Figure 3-6), as well as in inland fruit growing regions such as Mildura (Figure 3-7) which are shown on pages 24 to 25.

While specific temperatures and rainfall levels vary between the stone fruit producing regions in California and the Pacific Northwest when compared to the selected locations in Australia, the yearly weather patterns are similar, with comparable maximum and minimum temperatures. While specific climatic modelling can be used to predict the potential establishment range of any introduced pests, the similarity presented in these figures suggests that the pests found in California and the Pacific Northwest would not be prevented from establishing based on climatic conditions alone.

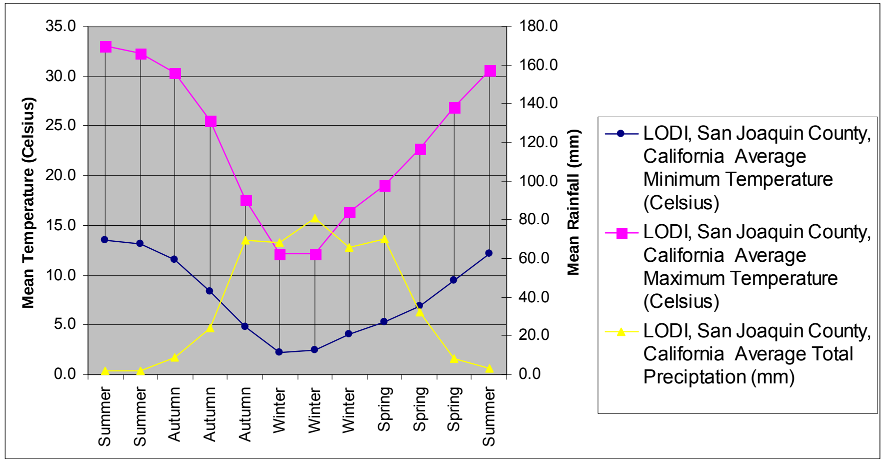

Figure 3-1 Average monthly minimum and maximum temperatures and average precipitation for Lodi, San Joaquin Valley, California, USA. (1961-1990)

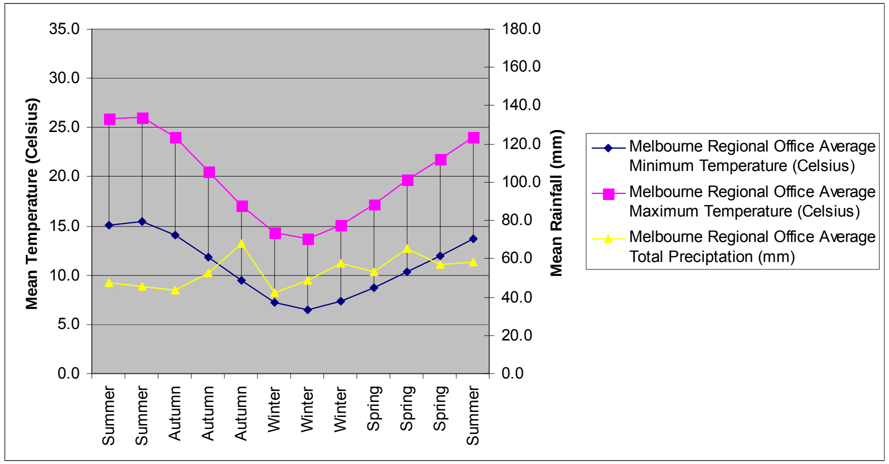

Figure 3-3 Average monthly minimum and maximum temperatures and average precipitation for Melbourne, Victoria, Australia. (1961-1990)

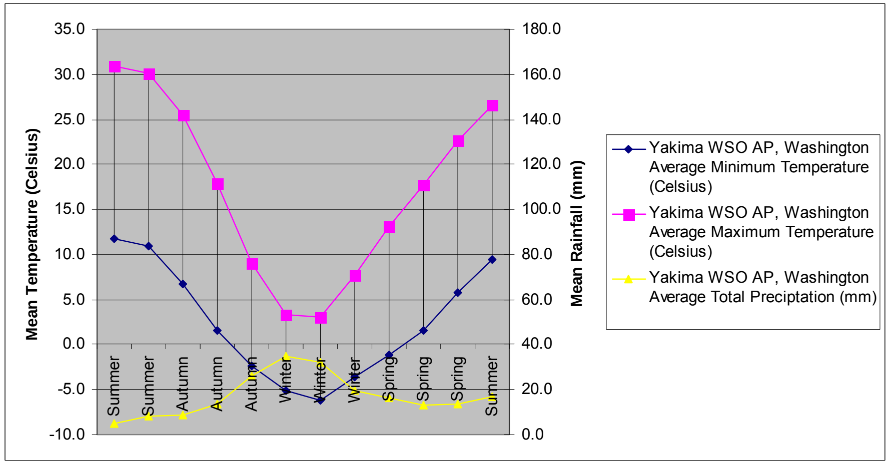

Figure 3-2 Average monthly minimum and maximum temperatures and average precipitation for Yakima WSO, Washington, USA. (1946-2007)

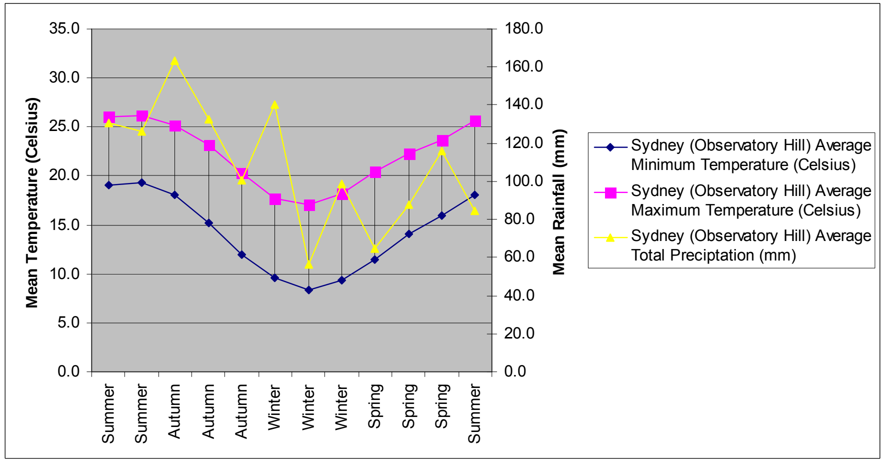

Figure 3-4 Average monthly minimum and maximum temperatures and average precipitation for Observatory Hill, Sydney, New South Wales, Australia. (1961-1990)

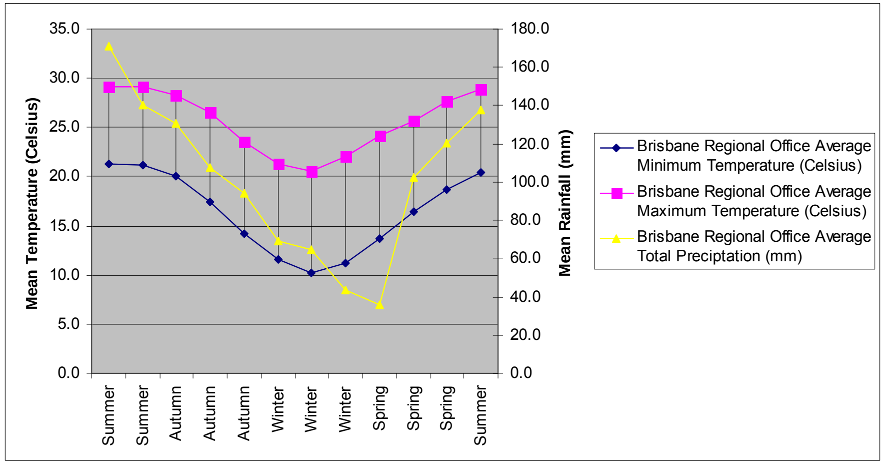

Figure 3-5 Average monthly minimum and maximum temperatures and average precipitation for Brisbane, Queensland, Australia. (1961-1990)

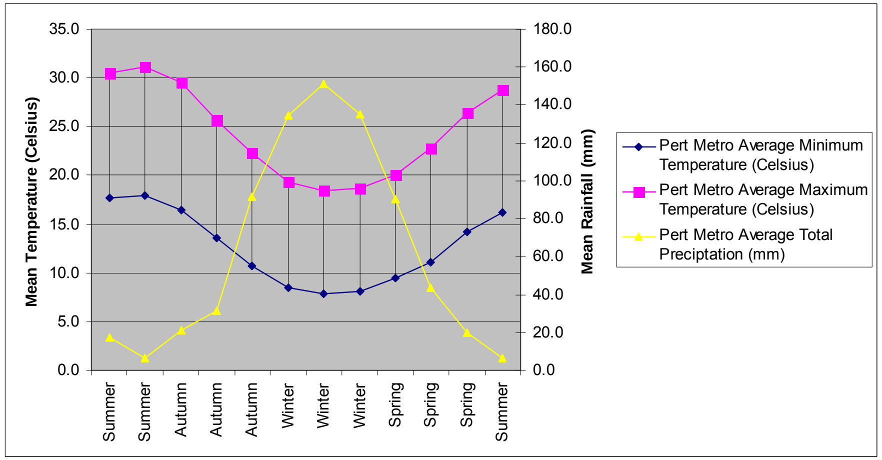

Figure 3-6 Average monthly minimum and maximum temperatures and average precipitation for Perth, Western Australia, Australia. (1961-1990)

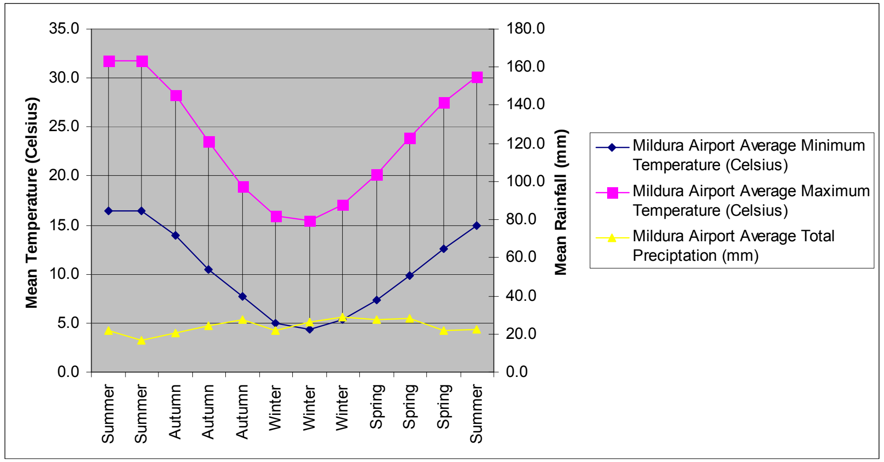

Figure 3-7 Average monthly minimum and maximum temperatures and average precipitation for Mildura airport, Victoria, Australia. (1961-1990)

3.1.3 Exports

According to the USDA Foreign Agricultural Service (Foreign Agricultural Service 2008), the USA was the worlds third largest exporter of peaches and nectarines in 2007. The total exports were estimated at 91 173 metric tons (101 304 US tons) with a total value of US$132 million. Exports of plums and prunes totalled 37 764 metric tons (41 960 US tons) while exports of apricots totalled 6 350 metric tons (7 056 US tons), with values of US$53 million and US$12 million respectively.

The USA exports stone fruit to Canada, Mexico and north Asian markets, particularly Taiwan and Japan. Canada is the largest market for US stone fruit accounting for half the total value exported by the US (Boriss and Brunke 2006; Boriss *et al.* 2006a; Boriss *et al. 2006b*).

Advice from APHIS (Ackerman 2007) is that the stone fruit harvest in California spans from late April through to early October, with some 75 per cent of the harvest from June to August each year. The harvest in Pacific Northwest states spans only four months, June to September, with approximately 70 per cent of the harvest occurring in July and August. After transit by air or sea freight, which could take from one to three weeks, stone fruit from California and the Pacific Northwest is likely to arrive in Australia from June until late October.

3.1.4 Production practices in the United States

In July–August 2006, officials from Biosecurity Australia visited stone fruit orchards and packing houses around Fresno, California, and Yakima, Washington. The purpose of those visits was to inspect the production practices in stone fruit orchards in California and the Pacific Northwest. In addition to the visits, APHIS provided Biosecurity Australia with information on production standards and legislated quality standards for stone fruit in the USA.

While the specific practices in orchards varies according to local conditions, pest pressures and available equipment, common points across the industry provide a baseline for the practices that would influence the presence of stone fruit pests on the harvested, and ultimately exported, commodity. These minimum common practices become the basis for the unrestricted risk estimates in the IRA report.

Good management of pests in the field is likely to be an important factor in reducing the number of pests associated with harvested fruit. Common pest concerns in the orchards visited included mites, scales, leafrollers and for California, oriental fruit moth. Oriental fruit moth is also reported in Washington State, but it is considered by growers to be a minor pest that is not present in all orchards, or necessarily detected every season.

Common practices reported in both states were the application of dormant sprays, including chemicals such as Lorsban® (active ingredient chlorpyrifos) with the intent of targeting scales and leafroller populations. Monitoring programs for pest populations were in place in all inspected orchards, although the targeted pests varied. In most cases, the single dormant spray was the only major insecticide spray during the season, with any subsequent sprays limited to those required to address specific problems that emerged during the season. If additional chemical sprays were required, spray timing was determined by monitoring insect emergence and pheromone trapping, and the subsequent use of day-degree modelling to predict the most appropriate time for effective applications.

Subsequent discussions with APHIS has highlighted that there is an increased use of selective insecticides early in the season, instead of the broad-spectrum organophosphates. These sprays are targeted at specific pests, such as the use of *Bacillus thuringiensis* (Bt) sprays at bloom for lepidopteran pests.

Additional measures in the field included pheromone based mating disruption for the main pests in the area, oriental fruit moth and codling moth (principally an apple pest). While mating disruption for oriental fruit moth was standard practice in California orchards, the lesser importance of this pest in Washington means that the decision on whether to employ specific controls is usually made on a yearly basis.

Stone fruit were harvested primarily into field crates (approximately 1 cubic metre), although some operators utilised individual buckets (approximately 10 litre) to minimise potential crushing damage to fruit. Pre-cooling of the fruit was undertaken in a number of forms, including chilling in refrigerated tents/sheds and water cooling in refrigerated water. Fruit were then emptied from bins into large water vats to commence the cleaning, grading and packaging operations.

While the sequence of events varied in some packing sheds, all fruit passed a number of common processes. Fruit were passed over rollers covered with a coarse brush which was mechanically rotated. The purpose of this was to remove extraneous trash material, such as twigs and leaves that may have been included in picking buckets or field crates. Fruit also passed through a second set of brushed rollers designed to remove the ‘fuzz’ from stone fruit. This was typically undertaken with a concurrent washing of the fruit in a mild chlorine solution, often delivered by overhead sprays. The concentration of the chlorine wash was reported to be about 40 parts per million, but as this spray was used for general cleaning and sanitation rather than as a measure against any specific pest, the risk assessments do not consider that the mild chlorine solution would have any effect against potential quarantine pests.

Grading operations followed which included both a manual grading for damaged/deformed fruit and removal of any remaining leaf trash. This first grading process enabled damaged fruit to be removed before it reached the second stage and therefore also minimised potential contamination of the machinery. This was followed by an electro-optical grading which used various optical methods to assess the colour, size and weight of the fruit to sort them according to quality standards. Fruit was then directed to appropriate packing lines. Fruit was either hand packed into trays or mechanically packed into boxes, depending on the grade and the intended market.

An exception to these processes was viewed by BA officers when ‘peento’ peaches were packed in one facility. It was reported that the flat nature of the variety prevented them being passed though the normal grading operations. In that case, the peaches were hand cleaned, graded and packed directly from field bins. However, this was discussed with APHIS and it has been stated that all varieties of peaches to be exported to Australia, including ‘peento’, will pass through the standard cleaning, grading and packing lines.

A final quality assurance measure for commercial stone fruit is the grading standards as legislated in the US Code of Federal Regulations Title 7 Part 51 (7CFR51). Stone fruit produced in the US are graded according to the USDA Agriculture Marketing Service inspection and grade standards. These define the minimum quality standards fruit must meet in order to be sold and include grades such as: ‘U.S. Fancy’, ‘U.S. No. 1’, ‘U.S. Combination’ and ‘U.S. No. 2’.

Apricots

There are two grades for apricots, ‘U.S. No. 1’ and ‘U.S. No. 2’, each comprising of mature fruit of one variety. The characteristics of ‘U.S. No. 1’ are well formed fruit, free from russeting and scab while ‘U.S. No. 2’ fruit are free from serious damage which seriously detracts from the appearance, or the edible/shipping quality of the apricot.

Nectarines

There are four grades for nectarines, ‘U.S. Fancy’, ‘U.S. Extra No. 1’, ‘U.S. No. 1’, and ‘U.S. No. 2’. The requirement of the ‘U.S. Fancy’ grade is that at least one-third of the surface of nectarines must have a red colour, which is characteristic of the variety. For nectarines to be graded ‘U.S. Extra No. 1’, at least 75 per cent must feature some blushed or red colour including a minimum of 50 per cent with at least one-third a red colour, characteristic of the variety. ‘U.S. No. 1’ consists of mature, well formed nectarines free from injury caused by split pit and the ‘U.S. No. 2’ grading incorporates fruit not badly misshapen which is free from serious damage.

Peaches

There are four grades for peaches, ‘U.S. Fancy’, ‘U.S. Extra No. 1’, ‘U.S. No. 1’ and ‘U.S. No. 2’. Each grade specifies fruit of one variety, which is mature and free from general damage. ‘U.S. Fancy’ requires that every peach has a minimum of one-third of its surface showing blushed, pink or red colour while ‘U.S. Extra No. 1’ requires 50 per cent of peaches in any lot to have no less than one-fourth of the surface showing the aforementioned colour. Peaches to be graded as ‘U.S. No. 1’ must be free of damage caused by leaf or limb rubs while peaches graded ‘U.S. No. 2’ must not be seriously damaged or badly misshapen.

Plums/Prunes

There are four grades for plums/prunes, ‘U.S. Fancy’, ‘U.S. No. 1’, ‘U.S. Combination’, and U.S. No. 2’. ‘U.S. Fancy’ consists of well formed, clean, mature fruit of one variety, not overripe and free from damage and decay, with 95% of the surface of Italian type prunes purple in colour. The plums/prunes are graded similarly for ‘U.S. No. 1’, except that the Italian prune three-quarters of the surface must be purple. ‘U.S. No.2’ comprises plums or prunes not badly misshapen and free of serious damage, while ‘U.S. Combination’ combines ‘U.S. No. 1’ and ‘U.S. No. 2’ with the requirement that a minimum of 75 per cent meet the ‘U.S. No. 1’ grade.

3.1.5 Conditions in storage and transport

After packing, stone fruit are typically chilled to 0–1.7°C to stop the ripening process, and minimise internal breakdown (Curtis *et al.* 1992*;* Ackerman 2007; California Tree Fruit Agreement 2009). Stone fruit are maintained in this temperature range during transport (Ackerman 2007; California Tree Fruit Agreement 2007a). Stone fruit from the US in this assessment would be transported to Australia via ship or air, with the total time in transit, from orchard until arrival in Australia, expected to take from a few days to three weeks (Ackerman 2007).

While the unrestricted risk assessments undertaken in this IRA do not impose any mandatory measures during storage and transport, common commercial practices may impact on the survival of some pests. If these conditions are applied to all consignments for a minimum period of time, then these conditions can be considered as part of the unrestricted risk assessment. As the minimum period in storage and transit is likely to be around one week, with a temperature of between 0°C and 1.7°C, the impact of these conditions on pests has been broadly considered in the risk assessment for each pest.

3.1.6 Main cultivar groups

Apricots (*Prunus armeniaca*): Cultivars can be divided into those grown for canning, juice, fresh markets or drying, but they are rarely considered suitable for more than one purpose. In 2006, 25% of US apricot production was destined for fresh markets, with the remaining 75% processed for canning, juice and dried apricots. Apricots are usually picked green because their soft flesh makes them particularly susceptible to bruising.

Peaches (*Prunus persica*): The major cultivar types of peaches are freestone and clingstone. Clingstone varieties tend to have firmer flesh and so are more often used in canning than freestone varieties. Both freestone and clingstone peaches come in yellow and white variations, yellow peaches are naturally tarter than the white variety, and so have a more complex palate when ripe. Generally, fresh market peaches are clingstone early in the season, moving to freestone in the middle of summer, with freestones continuing to the end of the season. Peaches for the fresh market are usually picked before ripening to reduce chill injury and increase shelf life.

Nectarines (*Prunus persica* var. *nucipersica*): Nectarines are a smooth skin variety of peach, a mutation that is thought to have occurred several times naturally. Nectarine production in the US occurs entirely in California and all produce is marketed fresh (Boriss and Brunke 2006). As with peaches, nectarines can be clingstone or freestone and yellow or white. Freestone nectarines are available only during the peak season (middle of summer), with clingstone varieties more common at the start and end of the season (California Tree Fruit Agreement 2007a).

Plums (*Prunus domestica* and *Prunus salicina*): The majority of fresh market plums grown in the US are hybrids of the Japanese and domestic plums. Fresh plums account for approximately one third of all plums grown in the US, with the rest being largely prune production. The French prune variety of plum tree is used for the majority of prune production.

3.2 The Australian stone fruit industry

3.2.1 Production

Commercial production of stone fruit in Australia occurs in all states and territories except the Northern Territory. Based on tonnage for the 2005/06 season, Victoria and New South Wales are the major producers with 69 per cent and 14 per cent of production respectively. South Australia and Western Australia both produce around 6 per cent and Queensland around 4 per cent (Australian Bureau of Statistics 2007). Tasmania is reported to produce less than one per cent of Australia's stone fruit crop, but has over 10 per cent of Australia's cherry production. In the 2006/07 season, production of stone fruit in Australia was 107 215 tonnes, compared to the 2002 figures of 148 917 tonnes; with a total farm-gate value of approximately A$200 million (Australian Bureau of Statistics 2007; Summerfruit Australia Limited 2006).

In Australia, peach production accounts for 49 per cent of the market followed by nectarines (27 per cent), plums (15 per cent) and apricots (9 per cent) (Australian Bureau of Statistics 2007). Stone fruit are seasonal fruits with the majority of the harvest during summer, although the seasons vary according to different production regions and different fruit varieties. For example, peaches are generally available for the whole season, from September to May, while nectarines are available from November to April, plums from December to April and apricots from November to January (Summerfruit Australia Limited 2006). The wide range of climatic conditions for Australian production, which ranges from the Burnett region in Queensland and Carnarvon in Western Australia, the northernmost low-chill regions, through to southern Western Australian, Victoria and Tasmania, extends the length of the harvest season.

3.2.2 Exports

Australia exported 36 928 tonnes of stone fruit in 2001/02, and 35 216 tonnes in 2002/03. Plums comprised approximately 49 per cent, nectarines 42 per cent, peaches 8 per cent and apricots 1 per cent of these exports.

3.2.3 Imports

During the 2001/02 season, 1 345 tonnes of stone fruit were imported of which 98 per cent was apricots. New Zealand was the most important exporter to Australia in that season, exporting all of the imported stone fruit with the exception of around one tonne of plums.

3.2.4 Interstate trade

Due to the earlier harvest in the low-chill regions through to the late harvest in the high-chill regions, there are opportunities for Australian grown stone fruit to be shipped interstate to take advantage of market opportunities. Quarantine conditions are applied to interstate trade, most importantly for Mediterranean fruit fly (present in Western Australia only) and Queensland fruit fly, with area freedom declarations and mandatory treatments as options for these pests. Oriental fruit moth is another important quarantine pest that is currently absent from Western Australia.

Historically, stone fruit from the eastern states had been prohibited access into Western Australia due to concerns about the fungi that causes brown rot (*Monilinia fructicola* and *M. laxa*). However, the detection of brown rot fungi in Western Australian in 1999 meant that stone fruit access from the eastern states could be considered. The Western Australian Department of Agriculture, now the Department of Agriculture and Food Western Australia (DAFWA), completed a risk assessment for apricots from South Australia and Tasmania in October 2004. This has permitted some stone fruit access into Western Australia under specific quarantine conditions.

4 Pest risk assessments for quarantine pests

Pest risk assessments are presented in this section for the pests associated with stone fruit that were found to be quarantine pests for Australia in the categorisation process in Appendix A. Pest risk assessment determines whether the risk posed by a pest is above Australia's ALOP and thus whether phytosanitary measures are required to manage the risk.

Some of the organisms assessed here have been considered previously in other risk assessments and import policies already exist for these pests. For those pests that had been considered by Biosecurity Australia in other risk assessments and for which import policies already exist, the need for new pest risk assessments was investigated. A judgement was made on the likelihood of entry of pests on the commodity and whether existing policy is adequate to manage the risks associated with the importation of stone fruit from California and the Pacific Northwest. Where appropriate, the previous policy has been adopted for these pests associated with stone fruit from California and the Pacific Northwest. To highlight the pests for which policy already exists, the superscript '**EP**' has been used.

Additionally, some organisms identified in this assessment have been recorded in some regions of Australia, but due to interstate quarantine regulations are considered pests of regional concern. These organisms are identified with a superscript of the state for which regional pest status is considered.

A total of 45 pests (arthropods, bacteria, fungi and viruses) were identified as quarantine pests requiring risk assessments and they are listed in Table 4.1. To simplify the assessment process, pests have been considered in groups where they belong to the same genera or family and share similar biological characteristics, behaviour on the host and pathway, and potential phytosanitary considerations. In all, 18 pests or groups of pests have been considered in this IRA.

Table 4.1: Quarantine pests for stone fruit from California, Idaho, Oregon and Washington

Pest	Common name
Spider mites [Acari: Tetranychidae]	
Tetranychus canadensis (McGregor, 1950)	Four-spotted spider mite
Tetranychus mcdanieli McGregor, 1931	McDaniel spider mite
Tetranychus pacificus (McGregor, 1919)	Pacific spider mite
Tetranychus turkestani Ugarov & Nikolski, 1937	Strawberry spider mite
Fruit Flies [Diptera: Tephritidae]	
Rhagoletis completa Cresson, 1929	Walnut husk fly
Rhagoletis pomonella (Walsh, 1867)	Apple maggot
Plant Bugs [Hemiptera: Miridae]	
Lygus elisus van Duzee, 1914	Pale legume bug; lucerne plant bug
Lygus hesperus Knight, 1917	Western tarnished plant bug
Lygus lineolaris (Palisot de Beauvois, 1818)	Tarnished plant bug
Closterotomus norvegicus (Gmelin, 1788)	Potato bug [WA]

Pest	Common name
Armoured Scales [Hemiptera: Diaspididae]	
Diaspidiotus forbesi (Johnson, 1896)	Forbes scale
Diaspidiotus juglansregiae (Comstock, 1881)	Walnut Scale
Diaspidiotus ostreaeformis (Curtis, 1843)	Oystershell scale [WA EP]
Parlatoria oleae (Colvée, 1880)	Olive parlatoria scale [WA]
Pseudaulacaspis pentagona (Targioni-Tozzetti, 1886)	Peach white scale [WA]
Pseudaulacaspis prunicola (Maskell, 1895)	White prunicola scale [WA]
Mealybugs [Hemiptera: Pseudococcidae]	
Phenacoccus aceris (Signoret, 1875)	Apple mealybug
Pseudococcus comstocki (Kuwana, 1902)	Comstock mealybug
Pseudococcus maritimus (Ehrhorn, 1900)	Grape mealybug
Pseudococcus calceolariae (Maskell, 1879)	Citrophilus mealybug [EP, WA]
Twig Boring Moth [Lepidoptera: Gelechiidae]	
Anarsia lineatella Zeller, 1839	Peach twig borer
Leafrollers [Lepidoptera: Tortricidae]	
Archips argyrospila (Walker, 1863)	Fruit-tree leafroller
Archips podana (Scopoli, 1763)	Great brown twist moth
Archips rosana (Linnaeus, 1758)	European leafroller
Argyrotaenia citrana (Fernald, 1889)	Orange tortrix
Choristoneura rosaceana (Harris, 1841)	Oblique banded leafroller
Pandemis pyrusana Kearfott, 1907	Pandemis leafroller
Platynota stultana Walsingham, 1884	Omnivorous leafroller
Fruit Boring Moths [Lepidoptera: Tortricidae]	
Cydia latiferreana (Walsingham, 1879)	Filbertworm
Cydia pomonella (Linnaeus, 1758)	Codling moth [WA, EP]
Grapholita packardi Zeller, 1875	Cherry fruitworm
Grapholita prunivora (Walsh, 1868)	Lesser apple fruitworm
Grapholita molesta (Busck, 1916)	Oriental fruit moth [WA EP]
Flower Thrips [Thysanoptera: Thripidae]	
Frankliniella occidentalis (Pergande, 1895)	Western flower thrips
Frankliniella tritici (Fitch, 1855)	Flower thrips
Frankliniella intonsa (Trybom, 1895)	Taiwan flower thrips
Taeniothrips inconsequens (Uzel, 1895)	Pear thrips
Bacteria	
Xylella fastidiosa Wells, Raju, Hung, Weisberg, Mandelco-Paul and Brenner, 1987	Phoney peach
Fungi	
Blumeriella jaapii (Rehm) Arx	Cherry leaf spot
Passalora circumscissa (Sacc.) U. Braun	Cercospora leaf spot [WA]
Podosphaera clandestina (Wallr.:Fr) Lév	Powdery mildew
Podosphaera tridactyla (Wallr.) de Bary	Cherry powdery mildew [WA EP]
Taphrina pruni Tul.	Plum pockets [WA EP]
Viruses	
Plum pox virus	Plum pox virus
Tobacco necrosis virus A, D, Nebraska isolate and other related viruses	Tobacco necrosis viruses

EP: Species considered previously and for which import policies already exist.
WA: A species identified as a quarantine pest only for the State of Western Australia.

4.1 Spider mites (Acari: Tetranychidae)

The species examined in this risk assessment are:

Tetranychus canadensis (McGregor, 1950)	Four-spotted spider mite
Tetranychus mcdanieli McGregor, 1931	McDaniel spider mite
Tetranychus pacificus (McGregor, 1919)	Pacific spider mite
Tetranychus turkestani Ugarov & Nikolski, 1937	Strawberry spider mite

The spider mite species considered in this assessment are recognised as pests of stone fruit production in California and the Pacific Northwest states. These species have been grouped together because of their related biology and taxonomy and are predicted to pose a similar risk and require similar mitigation measures. However, in the exporting regions, the most economically important species of spider mite assessed here is the Pacific spider mite in California and the McDaniel spider mite in Washington. Unless explicitly stated otherwise, the information presented is considered as applicable to all four species assessed.

Mites of the genus *Tetranychus* are commonly referred to as spider mites due to their habit of spinning silken webbing on plants. These mites feed on the contents of leaf cells, including chloroplasts (Berry 1998; Bentley *et al.* 2009a). This disrupts a plant's ability to photosynthesise and consequently reduces the vitality of the plant and therefore the size of the fruit (Berry 1998).

Adult spider mites range from 0.25–0.5 mm long (Berry 1998). Accurate identification of each species can prove to be difficult, often relying on examination of male genitalia and adult males often make up only a small percentage of a population. Adult spider mites are generally a yellow-green colour, while overwintering female spider mites are a bright orange colour and are typically found under bark or on weeds (Berry 1998; Bentley *et al.* 2009a). Overwintering females emerge in early spring in California (around March) and lay eggs on the underside of leaves (Pickel *et al.* 2006a). The eggs typically hatch within 4–6 days (Berry 1998) and adult female spider mites lay eggs continually until they die. A complete life cycle is completed within 1–3 weeks (Berry 1998), with many overlapping generations in summer (Bentley *et al.* 2009a).

All *Tetranychus* species are capable of both sexual reproduction and parthenogenesis, with unfertilised females producing only male offspring (Helle and Pijnacker 1985).

The risk posed by spider mites is that juvenile (nymphal) or adult spider mites may be present on imported stone fruit. While principally found on the leaves of host plants, spider mites may also be present on fruit, particularly if population densities are high. Spider mites have previously been intercepted on stone fruit imports from New Zealand (DAFF 2003).

4.1.1 Probability of entry

The probability of entry is considered in two parts, the probability of importation and the probability of distribution, which consider pre-border and post-border issues respectively.

Probability of importation

The probability that spider mites will arrive in Australia on fruit that has undergone standard production and post-harvest practices in the US is estimated to be **MODERATE**.

Supporting evidence for this assessment is provided in the text below:

Harvesting fruit for export

- Spider mites are associated with stone fruit production in California and the Pacific Northwest states. Pacific spider mite and two-spotted mite (*Tetranychus urticae*, a non quarantine pest for Australia) are the principal pest mites reported in California (Bentley *et al.* 2009a), while two-spotted mite and McDaniel spider mite are reported in Washington (Berry 1998).
- Spider mite populations can rapidly increase, particularly in hot and dry conditions. Severe infestations can result in defoliation, with regular monitoring of spider mites and associated predators recommended by crop monitors in the US (Bentley *et al.* 2009a). Natural predators may be sufficient to control spider mite populations in orchards, but this does not rule out the potential for large spider mite populations to be present during harvest.
- Spider mites are primarily a pest found on the leaves of plants and are reported to both feed and lay eggs on leaves (Berry 1998; Bentley *et al.* 2009a). However, spider mites are highly mobile and have the capacity to move onto all parts of the plant (Bentley *et al* 2009a).
- Pacific spider mite has been observed in the webbing in the stem cavity of nectarines sampled during packing house processes in California, confirming that spider mites do migrate onto fruit (Curtis *et al*. 1992).

Processing of fruit in the packing house

- While post-harvest defuzzing or brushing is expected to remove contaminants on fruit, such as mites and webbing, mites associated with webbing at the stem end of fruit have been recorded after post-harvest processing (Curtis *et al*. 1992).
- Sorting and grading operations may remove fruit with heavy webbing caused by spider mites (which would indicate a severe infestation). However, these operations would not be reliable for removing lightly infested fruit, as mites are small and difficult to see without the aid of a hand lens and clearly visible webbing may not be present on fruit.
- One study reported an average incidence of Pacific spider mite, after packing house processes, in California of 11 mites per 100 000 fruit with an even distribution of adults and nymphs (Curtis *et al*. 1992). In that study, most of the infestations came from one lot of fruit. This suggests that infield infestation levels are an important factor in assessing whether fruit is likely to be contaminated.

Pre-export and transport to Australia

- After packing, fruit is stored at around 1°C (Curtis *et al*. 1992).
- Transport of fruit to Australia would be either by air freight or by sea freight, with the total time in transit, from orchard until arrival in Australia, expected to take from a few days to three weeks.
- Female spider mites overwinter and can survive sub-zero temperatures (Veerman 1985). This suggests that cold treatment alone may not be sufficient to control these spider mites, although it is likely to reduce mobility, feeding and reproduction.
- Other species of spider mites (*Tetranychus* spp.) have been intercepted numerous times on stone fruit from New Zealand (DAFF 2003). While the time in transit from the US is likely to be longer than from New Zealand, the interception data demonstrates that spider mites can survive packing house procedures and in-transit cold storage.
-

Probability of distribution

The probability that spider mites, having entered Australia on infested fruit, will survive during the movement of fruit within Australia after it has been released from the port of entry and be transported in a reproductively viable state to a suitable host is estimated to be **MODERATE**.

Supporting evidence for this assessment is provided in the text below:

- Spider mites associated with fruit are likely to be in the nymphal or adult life stage (Curtis *et al*. 1992).
- Females that survive cold storage would be capable of laying eggs (Veerman 1985), but a suitable host would need to be located if a founding population were to be established. From the release of imported stone fruit at the point of entry to Australia, through to the retailing of stone fruit, there would be limited opportunities where suitable hosts are likely to be in close proximity to the imported commodity.
- Spider mites have a wide range of host plants. For example, the host range for McDaniel spider mite includes *Fragaria* spp. (strawberries), *Malus* spp. (apples), *Morus* spp. (mulberry), *Populus* spp. (poplar), *Prunus* spp. (stone fruit), and *Rubus* spp. (blackberries) (Baker and Tuttle 1994). Other hosts include *Cucumis* spp. (melons), *Vitis vinifera* (grapevine) *Citrullus* spp. (watermelon and desert vine), *Asclepia* spp. (milkweed), *Ceanothus* spp. (California lilac), *Chenopodium* spp. (goosefoot), and *Cotoneaster* spp (CABI 2007).
- Some of these hosts can be found in domestic gardens, as well as in urban environments as amenity plants or weeds. Many of the known host plants are deciduous and therefore suitable leaves for colonizing may not be readily available when stone fruit is imported from the US. This would limit the opportunity for reproductively viable spider mites to locate a suitable host. However, late season stone fruit entering Australia through September and into October would arrive when first flush leaf material is available. Evergreen hosts would present suitable material for spider mite colonisation throughout the import period.
- Females may be fertilised, giving rise to male and female offspring, or unfertilised, resulting in only male offspring (Veerman 1985). A colony could be initiated by only unmated female mites, but the male offspring would need to either find a female mite, or mate with their mothers if a reproductively viable population were to be possible (De Boer 1985).
- Nymphs could potentially emerge at unpacking and repacking facilities, retailers, on discarded fruit in waste, at landfills where the waste is disposed, during transportation of purchased fruit from retailers to households, or at the consumer's residence.
- Spider mites predominantly disperse within host plants through crawling (Kennedy and Smitley 1985) and may also crawl to other plants. Adult female spider mites can also be observed being carried on air currents (Kennedy and Smitley 1985). While there is the potential for long range transport on wind currents, aerial dispersal is believed to be initiated due to a shortage of food or dessication of host material that may be caused by high population densities (Kennedy and Smithley 1985). Dispersal by wind currents is entirely passive once mites are airborne (Kennedy and Smitley 1985). Most mites are thought to fall out of the air currents after only a short distance (Kennedy and Smitley 1985), though mites have been captured at altitudes as high as 10 000 feet. The probability of dispersers from a colony surviving long enough to locate a suitable host from the port of entry would be reduced, when considering the dispersal range, and the lack of suitable leaf material on deciduous hosts for most of the import period.
- Stone fruit showing obvious symptoms would likely be unmarketable and disposed of before sale. Fruit without symptoms, or with only minor infestations, are likely to be consumed.

Any waste material would need to be disposed of in the environment near suitable hosts given the limited dispersal capacity of larvae.

- Any fruit that are discarded are likely to be in bins or composting systems. The colonisation of fruit by saprophytic fungi or bacteria would quickly rot the fruit.
- Dispersal of mites could occur after fruit has left retail facilities as potential hosts could be relatively close to discarded fruit residues, but mites would need to survive until this time. From quarantine clearance at the border, one to two weeks could elapse before imported fruit is sufficiently close to spider mite hosts to allow for distribution of the pest. It is unlikely that spider mites would survive long enough to be transported in a reproductively viable state to a suitable host.

Overall probability of entry (importation x distribution)

The overall probability of entry for spider mites is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for spider mites is estimated to be **LOW**.

4.1.2 Probability of establishment

The probability that spider mites, having been distributed in a viable state to a susceptible site on a suitable host, will establish a persistent population into the foreseeable future is estimated to be **HIGH.**

Supporting evidence for this assessment is provided in the text below:

Availability of suitable hosts, alternate hosts and vectors in the PRA area

- The spider mites in this assessment are capable of surviving and reproducing on a wide variety of host plants (Bolland *et al.* 1998) and many suitable hosts are present in Australia .
- The wide host range of these spider mites, as presented in the probability of distribution, suggests that these mites would be able to find hosts. Some common hosts likely to be found in urban environments include *Fragaria* spp. (strawberry), *Malus* spp. (apple), *Populus* spp. (poplar), *Prunus* spp. (stone fruit), *Vitis vinifera* (grape vine) and *Cucumis* spp. (melons).

Suitability of the environment

- The spider mites in this assessment are found throughout California, the Pacific Northwest states and across North America. The McDaniel spider mite is also found in Quebec (Roy *et al.* 2005), and the strawberry spider mite has established in France (Bailly *et al.* 2004). The survival of these mites in a wide range of climates from cool coastal regions to hot, dry inland regions suggests that regions of Australia are likely to be suitable for the establishment of these species.
- Potential establishment of exotic spider mites is considered likely given that other species of *Tetranychus* are established in Australia.

Reproductive strategy and potential for adaptation

- Mites can reproduce both sexually and via parthenogenesis (development of an egg without the need for fertilisation) (Helle and Pijnacker 1985). Fertilised females produce both male and female offspring, while unfertilised females produce only male offspring (Helle and Pijnacker 1985). While parthenogenesis is possible, female mites would need to be available for males to mate with if a population is to develop. Parthenogenesis may enable a large population of male mites to develop quickly and thus increase the probability of finding a mate.

- Populations can start from a single mated female (Sabelis 1985a). Unmated females would only give rise to a male population (Helle and Pijnacker 1985), but if males from this populations mated with the females that 'established' the colony, then a reproductively viable population could establish. However, the likelihood of this occurring does not appear to have been studied.
- Spider mites have many generations per year and each female can lay up to 100 eggs (Sabelis 1985a). This increases the ability of the mite to establish populations when conditions are suitable, even in small 'windows of opportunity'.
- If populations established from a large number of individuals, their high fecundity could result in significant genetic diversity, thus increasing the potential for adaptation. Spider mites rapidly adapt to new host plants, even plants that are considered resistant to mites (Gould 1979).
- Spider mite populations are also reported to develop resistance to pesticides quickly (Cranham and Helle 1985). This may increase the chances of an exotic spider mite establishing in domestic or commercial environments where pesticides are being used.

Cultural practices and control measures

- Spider mite populations are usually kept low by predators, either natural or introduced (Ohlendorf 2000; Sabelis 1985b). Suitable natural enemies may be present in Australia, but their potential impact on these exotic spider mites is unknown.
- The use of pesticides can result in an increase in spider mite populations as predators are often more susceptible to pesticides than the pests (Ohlendorf 2000) and spider mites can develop resistance to pesticides (Cranham and Helle 1985; Rabbinge 1985). In the absence of suitable predators, spider mite populations could increase rapidly in Australian orchards or the environment.

4.1.3 Probability of spread

The probability that spider mites, having established a persistent population on a host in Australia, will spread to other susceptible hosts both in the local area and more widely is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Suitability of natural and/or managed environment

- These species have been reported from a variety of environments in North America, including California and the Pacific Northwest states (Bentlety *et al.* 2009a; Hollingsworth 2007). There are similar environments in Australia that would be suitable for their spread.
- These spider mite species are able to survive in both cooler and warmer areas of North America. Spider mites overwinter in North America as adults, hidden in protected areas such as bark cracks, bud scales or under debris on the ground (Cranshaw and Sclar 2006).
- Higher fecundity rates and reduced development times have been reported with increasing temperatures in some *Tetranychus* species, with the greatest rate of increase in populations occurring in the 30–35°C range (Wrensch 1985). Additionally, Tetranychid mites can undertake diapause to survive periods of unfavourable conditions such as cold winter temperatures (Veerman 1985). The comparatively warmer Australian environment may therefore provide a larger choice of suitable habitats for spider mites to expand in range.

Presence of natural barriers

- Wind assisted aerial dispersal is an important mechanism for spread within and between adjacent orchards or through urban areas (Kennedy and Smitley 1985; Smitley and Kennedy 1988).
- There is little information on the ability of these spider mites to spread beyond natural barriers such as deserts or mountain ranges.
- The long distances between some of the main Australian commercial orchards and production areas may make it difficult for these spider mites to disperse unaided from one production area to another.
- The polyphagous nature of these species may enable them to locate suitable hosts in the intervening areas, particularly in towns or suburban areas.
- Due to the small size of spider mites and limited capacity for independent dispersal by natural means, it is likely that the natural rate of spread of exotic spider mites in Australia would be relatively slow.

Potential for movement with commodities, conveyances, or by other vectors

- Spider mites may infest both leaves and fruit and may be associated with nursery stock or amenity trees in addition to commercial crops.
- Movement of infested nursery stock or other plants would be an important mechanism for long distance spread.
- Existing intra and interstate quarantine control on the movement of nursery stock and other plant material could reduce the rate of spread within and between states, but would rely on those measures being suitable against spider mites.
- Spider mites may also contaminate the clothing of orchard workers, machinery and other equipment associated with horticultural production in Australia, providing additional opportunities for spider mites to spread within orchards or long distances between orchards. Food deprivation studies conducted on *T. urticae* found that at 24^{o}C, mites were capable of surviving two days without food before fecundity and longevity decreased (Krainacker and Carey 1990). Therefore, the limited availability of suitable food resources may limit the ability of the spider mites assessed here to spread to suitable hosts in new habitats

4.1.4 Probability of entry, establishment and spread

The probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive probabilities shown in Table 2.2.

The overall probability that spider mites will enter Australia as a result of trade in stone fruit from California and the Pacific Northwest states and be distributed in a viable state to suitable hosts, establish and subsequently spread is estimated to be **LOW**.

4.1.5 Consequences

The consequences of the establishment of exotic spider mites in Australia have been estimated according to the methods described in Table 2.3. The justification for these ratings is provided below:

Impact scores for exotic spider mites	
Direct Impacts	**Estimate and Justification**
Plant life or health	**D** — Significant at the district level. These spider mites are capable of causing direct damage to host plants and are recognised agricultural pests requiring control measures. Some of the spider mites are rated as pests of economic concern in North America, where they damage the leaves and indirectly the fruit of the host plant (Ohlendorf 2000). Spider mites in large numbers may deplete nutrients from the host plant to such an extent as to cause severe damage, resulting in very heavy production losses and even death of the plant (Rabbinge 1985). Apples, pears, grapes, strawberries, melons, stone fruit and blackberries are all reported as commercial hosts of some or all of the mite species considered here.
Any other aspects of the environment	**B** — Minor at the local level. There are no known direct consequences of these species on the natural or built environment but their introduction into a new environment may lead to competition for resources with native mite species. These spider mites may also affect some native plants. Loss in plant vigour and the potential for defoliation of amenity plants may have perceptible effects in urban areas.
Indirect Impacts	**Estimate and Justification**
Eradication, control, etc.	**D** — Significant at the district level. Indirect consequences of control or an eradication program as a result of the introduction of the above identified spider mites may be: (i) an increase in the use of acaricides for control of the pest due to difficulties involved in estimating optimum times for application; (ii) disruption to IPM programs due to the increased need to use acaricides. Numerous acaricides have been recommended to control these particular spider mites and resistance to acaricides has also been reported (CABI 2007); (iii) additional applications of costly pesticides that may alter the economic viability of some crops; (iv) increases in control measures and impacts on existing production practices; (v) some of the reported natural enemies of spider mites such as the phytoseiid mite *Neoseiulus fallacis*, predatory thrips and ladybird beetles (*Stethorus* species) which are present in Australia are adversely affected by acaricides/pesticides (Azam 2002); (vi) subsequent increases in costs of production to producers; (vii) increased costs for crop monitoring and consultative advice to producers.
Domestic trade	**C** — Significant at the local level. If these spider mites become established in Australia it is likely to result in some intrastate and interstate trade restrictions on many commodities such as apples, apricots, nectarines, peaches, pears and plums. This could lead to loss of markets or additional costs to manage the pest on the commodity.
International Trade	**C** — Significant at the local level. The presence of these spider mites in commercial production areas on a wide range of horticultural commodities (e.g. apricots, nectarines, peaches, plums) may limit access to overseas markets where these pests are not present. However, measures are available to mitigate spider mites and it is not expected that these pests would result in a complete loss of markets, rather for increased costs to treat and inspect for these pests.
Environment	**B** — Minor at the local level. Additional pre-harvest pesticide applications would be required to contain and/or eradicate these pests and control them on susceptible crops. However, this is unlikely to impact on the environment to any greater extent than already occurs from run-off into waterways from commercial crops due to control measures for other pests.

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are ‘**D**’, the overall consequences are estimated to be **LOW**.

4.1.6 Unrestricted risk

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the estimate of consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

Unrestricted risk estimate for spider mites	
Overall probability of entry, establishment and spread	**Low**
Consequences	**Low**
Unrestricted risk	**Very low**

As indicated, the unrestricted risk for spider mites has been assessed as ‘very low’, which meets Australia’s ALOP. Therefore, specific risk management measures are not required for these pests.

4.2 Walnut husk fly (Diptera: Tephritidae)

The species examined in this risk assessment is:
Rhagoletis completa Cresson, 1929 Walnut husk fly

Walnut husk fly is a tephritid fruit fly pest of walnuts, but is also reported to affect some stone fruit, particularly peaches and nectarines (Yokoyama *et al.* 1992). It has one generation per year in California and oviposits in fruit (Yokoyama *et al.* 1992; Yokoyama and Miller 1997). It is also present in the Pacific Northwest states. Oviposition on fruit and larval feeding can result in damaged fruit and reduced marketability.

Tephritid fruit flies are recognised as potentially serious economic pests of horticulture as the larvae infest the fruit. Infested fruit are damaged by the larvae feeding on the flesh and sometimes the seeds. Damaged fruit has brown, rotten areas and oviposition wounds may also provide an entry site for secondary infection by bacteria or fungi. Damage to walnuts by walnut husk fly commences as a small 'sting' injury during oviposition. After the maggot emerges from the egg, feeding inside the walnut causes the flesh to turn soft and black (EPPO/CABI 1997a). Walnut husk fly has also been reported to attack some *Prunus* species, in particular peach (EPPO/CABI 1997a). However, studies into the host status of peaches and plums, which were considered potentially susceptible, has shown that peaches are poor hosts and plums are a non-host (Yokoyama and Miller 1993). In one study, 7 ovipositional sites per 1000 peach fruit and 94 ovipositional sites per nectarine fruit was recorded, compared with 196 ovipositional sites per 1000 walnut fruit. However, on average, only one pupae developed from every two ovipositional sites in peaches and only one pupae per four ovipositional sites in nectarines. This is in contrast to the average four and half pupae per ovipositional site in walnuts (Yokoyama and Miller 1993).

The adult fly has a yellow spot just below the base of the wings, has a dark triangular band at the tip of the wings and is about the size of a housefly, with females being slightly larger than males (Bentley *et al* 2009b). Adults emerge from pupae in the soil from late June to early September in California, with a peak emergence around mid-August (Bentley *et al* 2009b).

Eggs are deposited in groups of about 15 in the fruit or under the husk and hatch into maggots after about five days (Bentley *et al* 2009b). The maggots are initially white, but become yellow as they mature. Mature maggots drop and burrow into the soil to pupate after about two to five weeks of feeding (Bentley *et al* 2009b). Most emerge in the following summer as adults, but some pupae remain in the soil for two years or more (Bentley *et al* 2009b).

The risk posed by walnut husk fly is that larval fruit flies could be present in imported stone fruit and lead to the introduction of this species into Australia.

4.2.1 Probability of entry

The probability of entry is considered in two parts, the probability of importation and the probability of distribution, which consider pre border and post border issues respectively.

Probability of importation

The probability that walnut husk fly will arrive in Australia on fruit that has undergone standard production and post-harvest practices in the US is estimated to be **VERY LOW**.

Supporting evidence for this assessment is provided in the text below:

Harvesting fruit for export

- Walnut husk fly's primary hosts are walnut species, both the common walnut (*Juglans regia*) and various wild walnut species (*Juglans* spp.). While nectarines, peaches and plums have been reported as potential hosts, peaches are considered poor hosts and plums a non-host (Yokoyama and Miller 1993).
- After walnut husk fly was determined to be a quarantine pest for New Zealand, research was undertaken to determine a pest-free period for walnut husk fly. It was determined that, in California, adult flies did not emerge from their puparium until after 1 July (Yokoyama *et al.* 1992; Yokoyama and Miller 1993; Yokoyama *et al.* 1996), but that depends on climatic conditions.
- In California, stone fruit is harvested from late April to early October, and most early maturing varieties would be harvested before June (Yokoyama and Miller 1993; Yokoyama and Miller 1994). The emergence of adult walnut husk fly after 1 July suggests that a proportion of the fruit would be harvested before there is any potential for walnut husk fly oviposition. In cooler areas, slower development and later emergence of adult walnut husk flies would further reduce the potential for oviposition in exported commodities.
- However, eggs could be laid in fruit from July to October, resulting in infested fruit being harvested for export.
- While New Zealand lists walnut husk fly as a regulated organism, it is not included in the pest list for the importation of peaches and nectarines from California (New Zealand Ministry of Agriculture and Forestry 2000). There are no records of economic fruit flies becoming established in New Zealand and the absence of specific measures for walnut husk fly suggests that the risk posed by this species is minimal.
- Walnut husk fly is present in Italy, Germany, and Switzerland, but is not listed as a pest of stone fruit in those countries (EPPO/CABI 1997a). This also supports the poor host status on *Prunus* species.
- Further research has shown that walnut husk fly, while ovipositing in plums in no-choice experiments, does not complete development and when given a choice between plums and walnuts will not oviposit in plums (Yokoyama and Miller 1999).
- Viable pupae have been reared from peaches and nectarines, although the numbers reared were small (Yokoyama and Miller 1997). Field sampling in a peach orchard that was adjacent to a walnut orchard failed to find pupae in the soil or rear pupae from fallen fruit, even though adult walnut husk flies were captured in the orchard (Yokoyama *et al.* 1992).

Processing of fruit in the packing house

- Fruit is washed and brushed/defuzzed after harvest. However, these processes are unlikely to affect the viability of any larvae.
- Post-harvest grading and sorting operations may detect fruit showing signs of infestation, including physical wounds or rots. However, fruit may not have detectable symptoms and so some infested fruit could pass undetected through this process. Generally, detection of oviposition sites requires optical magnification.

Pre-export and transport to Australia

- After packing, fruit is stored at around 1°C (Curtis *et al.* 1992).
- Transport of fruit to Australia would be either by air freight or by sea freight, with the total time in transit, from orchard until arrival in Australia, expected to take from a few days to three weeks.

- Laboratory trials on walnuts showed that exposure to cold treatment of 1.1–1.7°C for 7, 14 or 21 days significantly reduced survival rates of walnut husk fly eggs and larvae (Yokoyama and Miller 1996). While there may be some mortality of walnut husk fly larvae during cold storage of fruit, the survival has not been quantified and would be dependant on mandatory temperature-time regimes.

Probability of distribution

The probability that walnut husk fly, having entered Australia on infested fruit, will survive during the movement of fruit within Australia after it has been released from the port of entry and be transported in a reproductively viable state to a suitable host is estimated to be **LOW**.

Supporting evidence for this assessment is provided in the text below:

- Walnut husk fly eggs or larvae infesting fruit arriving in Australia would still need to develop into mature larvae, find a suitable pupation site and then develop into adults (Yokoyama and Miller 1996).
- Infested fruit would need to be discarded in a location where walnut husk fly could potentially pupate. This means that fruit would need to be discarded into the environment where soil is present. Fruit would also need to remain in a suitable condition for larvae to complete development.
- Larvae feed on fruit for two to five weeks, and then pupate in the soil. Pupae overwinter and emerge in the following summer (EPPO/CABI 1997a; Yokoyama *et al.* 1992). Pupae may remain in the soil for two years or more (Bentley *et al.* 2009b).
- It is not known what, if any, biological cues lead to overwintering of pupae and what conditions are required to subsequently break diapause. Adults emerge after 1 July in California, which is in mid summer (early January in Australia).
- The conditions in Australia may be suitable for pupae to emerge in the summer immediately after they arrive in Australia, or pupae may be require to diapause until the following summer (approximately 15–18 months). In the study by Yokoyama *et al.* (1992), a small proportion of the population did not enter diapause. Pupae have also been found to remain viable in the soil for up to four years (Yokoyama *et al.* 1992).
- Walnut husk fly females prefer to oviposit in mature slightly coloured fruits (Yokoyama and Miller 1993). Assuming pupal diapause is broken by environmental conditions, adults would likely emerge in summer when suitable host material is available. Otherwise, suitable site for oviposition may not be available.
- As sexual reproduction is necessary in this species, emerging adults would need to find a mate and then female flies would need to locate a host. However, this appears to occur in the opposite order, whereby flies are found in aggregations around host plants where mating then occurs (Prokopy and Papaj 2000). *Rhagoletis* species can detect host fruit from at least 20 meters (Prokopy and Papaj 2000), but the attraction of a limited number of flies to different plants would reduce the opportunities for successful mating, even where multiple larvae are imported in a single fruit.
- Average dispersal distances of approximately 225 ft for males and 100 ft for females have been reported in field trials (Opp *et al.* 2003). Flies were fed on sucrose or sucrose/yeast diets for 2-9 days prior to release. Diet quality was also shown to affect dispersal range as flies fed on sucrose/yeast diets flew shorter distances than those fed on sucrose alone (Opp *et al.* 2003).
- Distribution of walnut husk fly from the port of entry is likely to be limited by the availability of food and water resources, especially after transport of the fruit to Australia.

Additional factors such as age, gender, and environmental conditions would also affect the ability of flies to disperse from the port of entry (Opp *et al.* 2003). Furthermore, the more restricted dispersal range of females (Opp *et al.* 2003) would limit the ability of this species to find suitable hosts in a reproductively viable state.

- Host plants appear to be limited to walnut species, nectarines and peaches, which may be found in rural and suburban areas. However, when compared with the likelihood of a polyphagous fruit fly finding a suitable host, walnut husk fly would have a lower probability of finding a suitable host plant.

Overall probability of entry (importation x distribution)

The overall probability of entry for walnut husk fly is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for walnut husk fly is estimated to be **VERY LOW**.

4.2.2 Probability of establishment

The probability that walnut husk fly, having been distributed in a viable state to a suitable host, will establish a persistent population into the foreseeable future is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Availability of suitable hosts, alternate hosts and vectors in the PRA area

- Walnut husk fly is a pest of walnut (*Juglans regia*) and some *Prunus* species, particularly peach and nectarine (CABI 2007). However, these *Prunus* species are generally recognised as poor hosts. These hosts are present in Australia.
- While walnut trees may not be as common in back yard environments as *Prunus* species, they may be present in suburban areas. Commercial orchards of walnuts would also present numerous suitable host trees.

Suitability of the environment

- Warmer conditions are more favourable to the development of walnut husk fly, as determined in laboratory studies (Kasana and AliNiazaa 1994).
- Walnut husk fly is distributed widely through the western half of the US, ranging from Washington to Texas (CABI 2007). Climatic conditions in these areas are similar to those of Australia. Walnut husk fly has also established in Italy, Switzerland and Germany (New Zealand Ministry of Agriculture and Forestry 2000; EPPO 2004a). The wide range of climatic conditions where this pest is known to occur, would suggest the Australian environment would be suitable for the establishment of walnut husk fly.
- While most of the walnut husk fly population enters diapause, Yokoyama *et al*. (1992) found that a small proportion of the population did not. Warmer conditions could increase the chance of a viable second generation of this pest (Yokoyama *et al.* 1992).

Reproductive strategy and the potential for adaptation

- Walnut husk fly reproduces sexually and females lay between 200–400 eggs in a lifetime (Christenson and Foote 1960).
- Walnut husk fly typically has one generation per year (Yokoyama *et al.* 1992).
- In California, adults begin to emerge from pupae in the soil in July, with the peak emergence from August to October (Yokoyama *et al.* 1992; Yokoyama and Miller 1994).

- Laboratory trials have shown that oviposition occurs 11 days after adult emergence (Yokoyama and Miller 1994). Higher temperatures decrease the pre-ovipositional period (Kasana and AliNiazee 1994).
- Populations can start from one mated female (Christenson and Foote 1990).

Cultural practices and control measures

- As an internal pest of the fruit, most insecticide spray regimes are not expected to have any impact on the establishment of walnut husk fly in Australia. To be effective, sprays would need to be timed when adults are active, or soil drench sprays used against pupae. Systemic insecticides may have some affect on eggs and larvae in the fruit, but are not commonly used unless control of fruit flies of economic concern is required. Only systemic insecticides would be likely to have any affect.
- Currently, there are no selective trapping measures implemented to effectively detect *Rhagoletis* species in Australia. This would likely increase the potential for the establishment of this species, once distributed to a suitable host from the port of entry, as an outbreak could continue undetected and uncontrolled for a significant period of time.

4.2.3 Probability of spread

The probability that walnut husk fly, having established a persistent population on a suitable host in Australia, will spread to other susceptible hosts both in the local area and more widely is estimated to be **MODERATE**.

Supporting evidence for this assessment is provided in the text below:

Suitability of natural and/or managed environment

- Walnut husk fly has been reported from a variety of environments in North America. Walnut husk fly has also established in Italy, Switzerland and Germany (New Zealand Ministry of Agriculture and Forestry 2000; EPPO 2004a). The wide range of climatic conditions, and that there are similar environments in Australia to some of those where this pest is known to occur, would suggest the Australian environment would be suitable for the spread of walnut husk fly.
- Specifically, walnuts are gown commercially in Australia in south-eastern Australia and in Tasmania where the climate is similar to areas in southern Europe.

Presence of natural barriers

- There is little information on the ability of walnut husk fly to spread beyond natural barriers such as deserts or mountain ranges.
- The long distances between some of the main Australian commercial orchards and production areas may make it difficult for walnut husk fly to disperse unaided from one area to another.
- Walnut husk fly is considered to be limited in its ability to fly long distances (EPP/CABI 1997a). The dispersal ranges of walnut husk flies in field trials was found to be approximately 225 feet for males and 100 feet for females when fed on sucrose diets for 2–9 days prior to release (Opp *et al.* 2003). The ability to spread under natural conditions would however be limited by the availability of food and water, environmental conditions, and the shorter dispersal range of females (Opp *et al.* 2003).

Potential for movement with commodities, conveyances, or by other vectors

- Walnut husk fly's primary host is walnut, while stone fruit is considered a poor host (Yokoyama and Miller 1993). Walnuts and stone fruit would be used mostly for human consumption and would be distributed around the country. Such distribution would aid the spread of walnut husk fly.
- The transportation of infested fruit would aid the movement of walnut husk fly within and between orchards as well as between growing areas and states. Existing interstate quarantine controls on the movement of fruit and soil due to other fruit fly risks could reduce the rate of spread.
- Other fruit fly traps utilised in Australia are not expected to effective attract and trap walnut husk fly. Therefore, these traps are not expected to limit the spread of walnut husk fly in any way.

4.2.4 Probability of entry, establishment and spread

The probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive probabilities shown in Table 2.2.

The overall probability that walnut husk fly will enter Australia as a result of trade in stone fruit from California and the Pacific Northwest states and be distributed in a viable state to suitable hosts, establish and subsequently spread, is estimated to be **VERY LOW**.

4.2.5 Consequences

The consequences of the establishment of walnut husk fly in Australia have been estimated according to the methods described in Table 2.3. The justification for these ratings is provided below:

Impact scores for walnut husk fly	
Direct Impacts	**Estimate and Justification**
Plant life or health	**D** — Significant at the district level. Walnut husk fly is capable of causing direct damage to host plants though larval feeding on fruit/nuts. Walnuts are the natural host, while nectarines and peaches are considered poor hosts (Yokoyama and Miller 1993). The walnut industry in Australia is small but growing producing around 1000 tonnes per year. While stone fruit is a larger industry in Australia, this pest is likely to have only limited impacts given its poor host status.
Any other aspects of the environment	**A** — Indiscernible at the local level. Walnut husk fly has a small host range, is an internal fruit feeder, and would be unlikely to have effects on the environment apart from direct damage to fruit of hosts. There are no known native hosts so there would be no direct effects on natural ecosystems.

Indirect Impacts	Estimate and Justification
Eradication, control, etc.	**D** — Significant at the district level. Control of walnut husk fly is usually achieved using general orchard hygiene practices. Additional insecticidal sprays may be required during heavy outbreaks (Bentley *et al.* 2009b). However, eradication would be costly and Australia's trapping grid for fruit fly species of economic concern does not target any *Rhagoletis* species. Eradication could require the removal of host plants, particularly wild or unmanaged hosts, along with ongoing trapping and monitoring, but if this pests were to spread rapidly, eradication may not be possible. Sterile insect releases which are part of a successful strategy for other fruit fly pests would not be possible in Australia as there are no production facilities for these flies in Australia. Such facilities would need to be established at significant cost.
Domestic trade	**C** — Significant at the local level. Regional outbreaks of walnut husk fly may require additional quarantine measures and increase the cost of production. This is likely to affect only limited areas due to the poor host status of stone fruit and the small size of the walnut industry.
International Trade	**C** — Significant at the local level. The presence of walnut husk fly may impact on trade with overseas markets. Trading partners may change import conditions due to the presence of walnut husk fly in stone fruit and walnuts. However, countries like New Zealand do not recognise walnut husk fly as a pest of stone fruit and Australia's walnut production is small and primarily a domestic market.
Environment	**A** — Indiscernible at the local level. Walnut husk fly has a small host range and would be unlikely to have indirect effects on the environment.

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**D**', the overall consequences are estimated to be **LOW**.

4.2.6 Unrestricted risk

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

Unrestricted risk estimate for walnut husk fly	
Overall probability of entry, establishment and spread	**Very Low**
Consequences	**Low**
Unrestricted risk	**Negligible**

As indicated, the unrestricted risk for walnut husk fly has been assessed as 'negligible', which meets Australia's ALOP. Therefore, specific risk management measures are not required for this pest.

4.3 Apple maggot (Diptera: Tephritidae)

The fruit fly species examined in this risk assessment is:
Rhagoletis pomonella (Walsh, 1867) Apple maggot

The apple maggot is native to North America (Weems Jr and Fasulo 2002) and is widespread throughout California and Oregon and present in Washington (CABI 2007). This pest has a wide host range with apple (*Malus domestica*) being the favoured commercial host while the natural host is hawthorn (*Crataegus* spp.) (Weems Jr and Fasulo 2002; Caprile *et al.* 2009a; CABI 2007). This pest has also adapted to other commercial fruit hosts including apricot and plum (Yee and Goughnour 2006, 2008). While Bush (1966) listed peaches as a host, this appears to be an erroneous citation of Porter (1928) and no references confirming peaches or nectarines as a host have been found.

The apple maggot attacks the fruit of its hosts and maggots feed internally on the fruit (Weems Jr and Fasulo 2002). The irregular tunnels in the fruit turn brown and may cause premature fruit drop. Minor infestations may not display symptoms initially, but when the fruit ripens, the burrows show as dark trails beneath the skin of the fruit. Oviposition wounds may also be visible on the outside of the fruit as small punctures, but optical magnification may be required to see this damage.

The adult flies are black and smaller than the average house fly (Weems Jr and Fasulo 2002; Caprile *et al.* 2009a). They have clear wings marked with four characteristic oblique black bands (Weems Jr and Fasulo 2002; Caprile *et al.* 2009a). There is a pronounced white spot on the back of the thorax and the black abdomen has white bands, of which the females have four and the males have three (Weems Jr and Fasulo 2002; Caprile *et al.* 2009a). The larvae are white-yellowish coloured and approximately 1.0-1.5cm in length, with a blunt posterior and a tapered front end that contains two black mouth hooks (Weems Jr and Fasulo 2002; Caprile *et al.* 2009a).

The adult female lives for up to 30 days and can lay 300-400 eggs in her lifetime (Dean and Chapman 1973). The larvae found in a fruit may be from a single female or from multiple females (Dean and Chapman 1973). The principal injury to the fruit is caused by burrowing larvae that feed on the flesh of the fruit (Caprile *et al.* 2009a). The larvae feed on the pulp of developing fruit but do not move between fruit (Prokopy and Papaj 2000). Injury to fruit can also leave the infested fruit prone to secondary infection by pathogens causing further fruit rotting (Caprile *et al.* 2009a. After feeding, larvae exit the fruit and pupate in the upper layers of the soil (Dean and Chapman 1973; Weems Jr and Fasulo 2002).

The risk posed by apple maggot is that imported fruit may contain eggs or larvae of this pest, resulting in the entry, establishment and spread of apple maggot in Australia.

4.3.1 Probability of entry

The probability of entry is considered in two parts, the probability of importation and the probability of distribution, which consider pre border and post border issues respectively.

Probability of importation

The probability that apple maggot will arrive in Australia in fruit that has undergone standard production and post-harvest practices in the US is estimated to be **MODERATE**.

However, for peaches and nectarines only, noting that there is no evidence for pest-host association, the probability is estimated to be **NEGLIGIBLE**.

Supporting evidence for this assessment is provided in the text below:

Harvesting fruit for export

- The apple maggot is native to North America and widespread throughout California and Oregon and present in Washington (Fisher and Olsen 2002; Weems Jr and Fasulo 2002; CABI 2007).
- Although the natural host is hawthorn (*Crataegus* spp.) and the main commercial host is apple (*Malus domestica*) (Weems Jr and Fasulo 2002; Caprile *et al.* 2009a; CABI 2007), this pest has also adapted to other commercial fruit hosts including apricot and plum (Yee and Goughnour 2006, 2008).
- There are no records indicating that apple maggot infests peaches or nectarines. While peach has occasionally been cited as a host, these reports refer to Bush (1966), which is a mis-citation of Porter (1928).
- There are a number of stimuli that affect the acceptance of fruit for oviposition, including chemicals in surface waxes, physical attributes such as shape, colour and size of fruit and the chemical composition and physical structure of the fruit flesh (Prokopy and Papaj 2000). Although the differences between infestation levels in apple and *Prunus* species hosts are yet to be determined (Prokopy and Papaj 2000), there is a significant positive correlation between fruit size and the number of larvae per fruit (Aluja *et al.* 2001).
- Infested fruit contains eggs and larvae inside the fruit that are visible to the naked eye when the fruit is cut open (CABI 2007). The maggots bore into the fruit forming irregular, winding tunnels beneath the skin which turn brown as the fruit ripens (Weems Jr and Fasulo 2002).
- Minute egg punctures and distorted, pitted areas may show on the surface, but recent or minor infestations may show no external indication of presence (Weems Jr and Fasulo 2002). Heavy infestations will reduce the fruit to a brown, rotten mass filled with fly larvae, often causing premature dropping of fruit (Weems Jr and Fasulo 2002).

Processing of fruit in the packing house

- The post-harvest grading, washing, brushing and packing procedures are likely to cull symptomatic fruit showing heavy infestations. However, minor or recent infestations without conspicuous symptoms may not be culled by packing house processes.

Pre-export and transport to Australia

- After packing, fruit is stored at around 1°C (Curtis *et al.* 1992).
- Transport of fruit to Australia would be either by air freight or by sea freight, with the total time in transit, from orchard until arrival in Australia, expected to take from a few days to three weeks.
- Research has demonstrated that larvae in fruit can be killed by cold storage at 0°C for 40 days (Weems Jr and Gasulo 2002) and this is accepted by some regulatory agencies (Hallman 2004a). This suggests that the standard shipping conditions for US stone fruit would not by sufficient to cause significant mortality of apple maggot.

Probability of distribution

The probability that apple maggot, having entered Australia on infested fruit, will survive during the movement of fruit within Australia after it has been released from the port of entry and be transported in a reproductively viable state to a suitable host is estimated to be **MODERATE**.

Supporting evidence for this assessment is provided in the text below:

- Apple maggot eggs or larvae entering Australia would need to develop into mature larvae, find a suitable pupation site and then develop into adults.
- Larvae pupate in the soil, but other substrata may be suitable. For example, moistened sawdust or vermiculite can be used in the laboratory. Fruit would also need to remain in a suitable condition for larvae to complete development, which may take from two weeks to three months (Weems Jr and Fasulo 2002).
- Fruit that are discarded into household trash or compost bins are likely to degrade quickly and become unsuitable for larvae to complete development.
- After feeding on the fruit, larvae exit the fruit and pupate in the upper layers of the soil (Dean and Chapman 1973; Weems Jr and Fasulo 2002). Therefore, larvae present inside discarded fruit or fruit scraps have the opportunity to continue the next stage of development in the soil.
- There may be up to three generations in a year, after which larvae overwinter in the soil and emerge as adults during the following growing season (Weems Jr and Fasulo 2002).
- In general, *Rhagoletis* species are not known to fly long distances (Fletcher 1989). Apple maggot adults have been recorded moving up to 100 m in the presence of hosts, but up to 1.5 km when released away from an orchard (Fletcher 1989). Although the small body size contributes to the comparatively short dispersal capability of the adults (Prokopy and Papaj 2000), they could disperse locally through wind assisted flight.
- Oviposition also relies on the availability of fruit on suitable hosts. The main natural host, hawthorn, is known to flower in late spring from October-November, with fruit production occurring shortly thereafter (Government of South Australia 2007). Flowering and fruiting in apple varies with variety, however, flowering generally occurs in late spring (approximately October) and fruit are harvested from February-May (Horticulture Australia Limited 2003). Given the different seasons for the time of import, there is the potential for some overlap between the US growing season and fruit production in warmer regions, such as low-chill stone fruit in northern New South Wales and southern Queensland.
- Stone fruit and apples are popular home grown tree fruits and are widely distributed throughout urban and suburban areas. Major hosts such as apple and hawthorn may have some fruit available, however, fruit are not likely to become available until well after the importation period for US stone fruit.

Overall probability of entry (importation x distribution)

The overall probability of entry for apple maggot is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for apple maggot is estimated to be **LOW**.

However, for peaches and nectarines only, noting the different assessment for pest-host association, the overall probability of entry is estimated to be **NEGLIGIBLE**.

4.3.2 Probability of establishment

The probability that apple maggot, having been distributed in a viable state to a suitable host, will establish a persistent population into the foreseeable future is estimated to be **HIGH.**

Supporting evidence for this assessment is provided in the text below:

Availability of suitable hosts, alternate hosts and vectors in the PRA area

- The apple maggot has been recorded on 23 plant host species across 8 genera throughout North America (CABI 2007). The favoured commercial host is apple while the natural host is hawthorn (Weems Jr and Fasulo 2002; Caprile *et al.* 2009a; CABI 2007). This pest has also been recorded on three species considered in this assessment, peach, apricot and plum, as well as on chokeberry, crab apple, cranberry, dogwood, cherry, Chickasaw plum and Siberian crab apple (Weems Jr and Fasulo 2002; Caprile *et al.* 2009a; CABI 2007). Other alternative hosts include Japanese rose and sour cherry (Weems Jr and Fasulo 2002).
- Suitable hosts are present in Australia and are widespread in both gardens, amenity plantings and commercial orchards. It is expected that the availability of hosts would not restrict the establishment of apple maggot.

Suitability of the environment

- The apple maggot is widespread throughout North America in a range of climates including dry, temperate and continental climates (CABI 2007).
- The prevalence and spread of the apple maggot in diverse regions throughout North America suggests that there would be environmental conditions in various regions of Australia that would be suitable for the establishment of apple maggot.

Reproductive strategy and the potential for adaptation

- During the early part of the apple maggot season, adults of both sexes are likely to be seen on the foliage of host plants. The odour of ripening fruit attracts both sexes. As the season progresses, the males become more concentrated, particularly on the fruit and the males produce a pheromone to attract the females. The pheromones released from the males and volatile compounds emitted from the ripening fruit initiate and facilitate mating (Prokopy and Papaj 2000).
- A limitation for the successful distribution of apple maggot is the location of a mate so that mating and oviposition can occur. The female lives for up to 30 days and can lay 300-400 eggs in a lifetime (Dean and Chapman 1973). The larvae from an individual fruit can result from oviposition by a single female or from several ovipositions by multiple females (Dean and Chapman 1973). Therefore it is possible that both sexes of the species can eventuate from fruit or fruit scraps and that mating partners can be found.
- Larvae would need to find a suitable pupation site in the soil to develop into adults (Weems Jr and Fasulo 2002). As a single mated female is capable of laying enough eggs to establish a population, even a single fruit could contain enough larvae to establish a population in Australia.
- Larval development takes from two weeks to three months depending on the host fruit (Weems Jr and Fasulo 2002). The larvae leave the fruit and enter the soil to form puparia, which survive the winter.
- The apple maggot has a number of host plants in a range of environments worldwide. This suggests that this pest is potentially capable of adapting to a diverse range of environments where different climatic conditions occur or where different hosts are available.
- The apple maggot is believed to have shown adaptive capacity by infesting sour cherry (*Prunus cerasus*), a species exotic to the USA, in Utah (Weems Jr and Fasulo 2002).

Cultural practices and control measures

- IPM programs have been adopted and include monitoring the emergence and dispersal of adults to effectively time treatments in the US (Caprile *et al.* 2009a; CABI 2007).

- Currently, there are not any effective and/or selective traps used to detect *R. pomonella.* Ammonium carbonate traps have been trialled where this pest is found but have not been shown to be highly effective or selective, especially where non-target flies reduce the ease of inspection (Yee *et al.* 2006). A synthetic attractant based on butyl hexanoate is used to detect apple maggot in areas where this pest is present (International Atomic Energy Agency 2003). However, butyl hexanoate traps have had limited effectiveness and selectivity against apple maggot (Rull and Prokopy 2000). Additionally, immature flies appear to respond poorly to these traps (Rull and Prokopy 2000. Additionally, these traps are not routinely used in Australia, and even if they were, the limited effectiveness, low specificity, and likelihood that immature flies would be at the port of entry, reduces the likelihood of detection.
- While biological control has been attempted with Hymenopteran parasitoids (Weems Jr and Fasulo 2002), there is no evidence that parasitoids in Australia would attack apple maggot.
- Systemic organophosphates, such as dimethoate, are highly effective at killing eggs, larvae and adult stages (Boller and Prokopy 1976). Pyrethroids are only effective when pest activity is low (Bélanger *et al.* 1985). While similar chemicals may be used in Australian orchards, they are targeted at other pests. Therefore the timing of these sprays may not be efficacious against apple maggot. Further, such controls are not used in organic systems or by many backyard gardeners.

4.3.3 Probability of spread

The probability that apple maggot, having established a persistent population on a suitable host in Australia, will spread to other susceptible hosts both in the local area and more widely is estimated to be **MODERATE**.

Supporting evidence for this assessment is provided in the text below:

Suitability of natural and/or managed environment

- The apple maggot is widespread throughout North America (CABI 2007) and many of the regions where this pest is prevalent have similar environments to regions in Australia. This suggests that the apple maggot could spread within Australia.
- The broad host range of the apple maggot (Weems Jr and Fasulo 2002; Caprile *et al.* 2009a; CABI 2007 suggests that the Australian environment would be potentially amenable to their spread, with many crop and native host species in Australia being potentially susceptible to infestation.

Presence of natural barriers

- Adult apple maggots have been known to fly short distances of up to 1.5km (Fletcher 1989; Prokopy and Papaj 2000). Long distance dispersal assisted by wind may be limited due to the presence of natural barriers such as deserts, mountains and regions lacking suitable hosts. The long distance between some of the main Australian orchards may limit the capacity for the apple maggot to spread between production areas.
- Facilitated transport of the apple maggot with commodities and plant propagative material is important for long distance spread (CABI 2007).

Potential for movement with commodities, conveyances or vectors

- In general, *Rhagoletis* species are not known to fly more than short distances. *Rhagoletis* has been recorded moving up to 100 m in the presence of hosts and up to 1.5 km when released away from an orchard (Fletcher 1989). Although the small body size contributes to the

comparatively short dispersal capability of the adults (Prokopy and Papaj 2000), the adults could disperse locally through wind assisted flight.
- The other major means of dispersal to previously uninfected areas are the transport of infected fruits and soil from beneath host plants, such as nursery stock, which suggests a favourable potential for movement with commodities or conveyances.
- The apple maggot has already demonstrated the capacity to spread from its original range in eastern North America to western US (EPPO/CABI 1997b). In the western US, it was first recorded from Portland, Oregon in 1979 and has since spread through the Pacific Northwest (Bellows and Fisher 1999).
- The limited effectiveness and selectiveness of current trapping measures for apple maggot suggests that the spread of this pest would not be limited by any fruit fly trapping in Australia.

4.3.4 Probability of entry, establishment and spread

The probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive probabilities shown in Table2.2.

The overall probability that apple maggot will enter Australia as a result of trade in stone fruit from California and the Pacific Northwest states and be distributed in a viable state to suitable hosts, establish and subsequently spread, is estimated to be **LOW**.

4.3.5 Consequences

The consequences of the establishment of apple maggot in Australia have been estimated according to the methods described in Table 2.3. The justification for these ratings is provided below:

Impact scores for apple maggot	
Direct Impacts	**Estimate and Justification**
Plant life or health	**F** — Significant at the national level. *Rhagoletis pomonella* is capable of causing direct harm to its hosts through feeding and oviposition. Minute external damage from egg punctures may be observed and larvae can tunnel through the fruit flesh, causing damage of major significance to susceptible hosts. *Rhagoletis pomonella* has more than 30 hosts in the family Rosaceae, including *Aronia* spp., *Crataegus* spp., *Malus* spp., *Pyrus* spp., *Prunus* spp. and *Rosa* spp. (see Appendix B). Some of these commercial hosts constitute major horticultural markets in Australia and given their size and distribution, the introduction of *R. pomonella* could cause considerable damage to these industries. It is not known if any native species of Rosaceae or amenity plants such as hawthorns (*Crataegus*) would be susceptible. This species has the potential to inhabit the cool temperate regions of Australia and other pest free areas where infield controls, other than monitoring, are generally not applied for fruit flies. Furthermore, the chemicals currently being applied by organic growers and home gardeners against endemic fruit flies may not control *R. pomonella*.
Any other aspects of the environment	**A** — There are no known direct consequences of this species on any other aspects of the environment, but its introduction into a new environment many lead to competition for resources with native species.

Indirect Impacts	Estimate and Justification
Eradication, control, etc.	**E** — Significant at the regional level. Existing control programs may be effective for this species and its hosts (e.g. broad spectrum pesticide applications), however, additional programs are likely to be necessary to minimise the impact of the apple maggot on host plants. The limited effectiveness and selectivity of monitoring and trapping methods would also make this pest difficult to detect, eradicate and control if introduced.
Domestic trade	**E – Significant at the regional level:** The introduction of *R. pomonella* into commercial production areas may have a significant effect at the regional level as restrictions in interstate movement and trade are likely to be imposed to limit the spread of this pest on a range of commodities (e.g. apples, pears, stone fruit, ornamentals, trees and shrubs).
International Trade	**E – Significant at the regional level:** The distribution of *R. pomonella* is currently restricted to North America (Canada, Mexico and the US). This pest is listed as a quarantine pest by several countries. For example, it is listed as A1 quarantine organism by EPPO (EPPO 2008) and as a regulated pest of high impact by New Zealand (MAFBNZ 2005). The presence of *R. pomonella* in commercial production areas of a range of commodities (e.g. apples, pears and stone fruit) may have a significant effect at the regional level due to any limitations to access to overseas markets where this pest is absent.
Environment	**B** — Indiscernible at the local level. Additional pesticide applications or other control activities would be required to control this pest on susceptible crops however any impact on the environment is likely to be minor at the local level.

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**F**', the overall consequences are estimated to be **HIGH**.

4.3.6 Unrestricted risk

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

Unrestricted risk estimate for apple maggot	
Overall probability of entry, establishment and spread	**Low**
Consequences	**High**
Unrestricted annual risk	**Moderate**

As indicated, the unrestricted risk for apple maggot has been assessed as 'moderate', which is above Australia's ALOP. Therefore, specific risk management measures are required for this pest.

However, as peaches and nectarines are not considered a host for apple maggot, the unrestricted risk would be 'negligible' for these fruits and specific risk management measures are not required.

4.4 Plant bugs (Hemiptera: Miridae)

The species of plant bugs examined in this risk assessment are:

Lygus elisus van Duzee, 1914	Pale legume bug
Lygus hesperus Knight, 1917	Western tarnished plant bug
Lygus lineolaris (Palisot de Beauvois, 1818)	Tarnished plant bug

This analysis also considers the following species that is of quarantine significance to Western Australia:

Closterotomus norvegicus (Gmelin, 1788)	Potato bug [WA]

The three species of plant bugs of the genus *Lygus* are not present in Australia (CABI 2007) and are considered quarantine pests of national concern. The potato bug is widely distributed around the world but confirmed records from within Australia are only known from Tasmania. As there are no quarantine measures implemented to limit the movement of this pest between Tasmania and the eastern mainland Australian states, it is considered a regional quarantine pest for Western Australia in this assessment. These species have been grouped together because of their related biology and taxonomy and are predicted to pose a similar risk and require similar mitigation measures. Due to the recognised importance and the quantity of information available, the tarnished plant bug, has been used as the basis for this assessment.

The family Miridae includes a large number of species, most of which feed on plants. Mirids are also referred to as plant bugs and are characterised as generalised plant feeding insects that use needle-like mouthparts to extract plant juices from their hosts at all stages of their life, from nymph to adult (University of Missouri 2000). They may also feed upon the fruit of their hosts as well as other reproductive plant tissues such as flowers and buds (CABI 2007).

Plant bugs overwinter as adults in dead weeds, leaf litter, under tree bark, in rock piles in fields, timber margins, stream and ditch banks and roadsides. During spring, females will lay eggs in a wide variety of plants that hatch into nymphs, undergoing a number of nymphal phases (instars) before becoming adults. At this stage, they are very active and mobile with a short life cycle, which for the tarnished plant bug is around 30 days with 2–5 generations per year (Broadbent *et al.* 2006; CABI 2007). Within California, there have been reports of up to ten overlapping generations in a year of some plant bug species (Pickel *et al.* 2006b).

Along with commercial crops, plant bugs can lay eggs and feed on weedy hosts. The presence of weeds is an important factor that influences the number of plant bugs that may be found in a commercial crop, so control of weeds is usually recommended (Broadbent *et al.* 2006).

Plant bugs are highly mobile and easily disturbed. Therefore, it is considered highly unlikely that nymphal or adult plant bugs would remain associated with imported stone fruit. The principal risk from plant bugs is that eggs laid into fruit will enter Australia, and result in the establishment of exotic plant bugs in Australia.

4.4.1 Probability of entry

The probability of entry is considered in two parts, the probability of importation and the probability of distribution, which consider pre-border and post-border issues respectively.

Probability of importation

The probability that plant bugs will arrive in Australia on fruit that has undergone standard production and post-harvest practices in the US is estimated to be **VERY LOW**.

Supporting evidence for this assessment is provided in the text below:

Harvesting fruit for export

- Fruit is typically picked into picking bags or buckets before being transferred into field bins kept on the ground in the orchard for transportation of fruit to the packing house.
- Adult or nymphal plant bugs are highly mobile and easily disturbed. The process of picking fruit is very likely to dislodge any plant bugs associated with the fruit, but eggs in the fruit would not be affected.
- The presence of adult plant bugs in orchards is linked to the drying up of primary host material around the orchard, at which time the adults migrate to the irrigated orchards (Pickel *et al.* 2006b).
- It is noted that nymphs are only rarely seen in orchard trees (Pickel *et al*. 2006b), suggesting that eggs are preferentially laid into other hosts. The availability and sequence of flowering in weedy hosts is thought to be a critical factor in their population dynamics (CABI 2007). Although, eggs may be laid into fruit from around mid May until late in the season, females preferentially deposit eggs in stems, leaf parts and flowers of orchard weeds (Pickel *et al.* 2006b).

Processing of fruit in the packing house

- All harvested stone fruit is washed and brushed/defuzzed following harvest. These actions would almost certainly remove the highly mobile adults and nymphs, including any that become associated with the fruit after harvest.
- Unless fruit damage or other symptoms are obvious, fruit containing eggs is not expected to be removed by grading and culling operations.

Pre-export and transport to Australia

- After packing, fruit is stored at around 1°C (Curtis *et al.* 1992).
- Transport of fruit to Australia would be either by air freight or by sea freight, with the total time in transit, from orchard until arrival in Australia, expected to take from a few days to three weeks.
- Eggs are the stage expected to be associated with exported fruit, but there is no evidence that in-transit cold storage under commercial conditions would result in significant mortality. It has been shown that eggs can survive 10°C temperatures for 15 days without any notable level of mortality (Snodgrass and McWilliams 1992).
- Unidentified species in the Miridae family have been intercepted on New Zealand stone fruit, with the most recent interception in 1990, supporting the very low incidence of nymphal and adult plant bugs on imported fruit (DAFF 2003).

Probability of distribution

The probability that plant bugs, having entered Australia on infested fruit, will survive during the movement of fruit within Australia after it has been released from the port of entry and be transported in a reproductively viable state to a suitable host is estimated to be **MODERATE**.

Supporting evidence for this assessment is provided in the text below:

- As stated in the probability of importation, the stage expected to be associated with fruit is the egg as adults or nymphs would have been removed during harvest, washing and grading operations.
- While nymphs and adults are known to overwinter, eggs may also be able to survive the cold temperatures during distribution of fruit within Australia. It has been shown that eggs can survive 10°C temperatures for 15 days without any notable level of mortality (Snodgrass and McWilliams 1992).
- Reduced temperatures during storage and transport are expected to prevent the development of eggs. Therefore, egg development would only continue after fruit are removed from cool storage. The lower developmental threshold for the western tarnished plant bug is 54°F (12°C) (Zalom *et al.* 2008).
- Following the movement of fruit from cold storage, plant bug eggs would have a limited time to complete their development before fruit is consumed or disposed. This might be from a few days to a few weeks.
- Successful transfer to a suitable host would require the plant bug to locate a host. The tarnished plant bug is known to feed on a wide selection of hosts besides stone fruit: cotton, soybeans, strawberries, potatoes, apples and more than 50 other crops, plus commercially-grown flowers, fruit trees, forest trees, and weeds (CABI 2007).

Overall probability of entry (importation x distribution)

The overall probability of entry for plant bugs is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for plant bugs is estimated to be **VERY LOW**.

4.4.2 Probability of establishment

The probability that plant bugs, having been distributed in a viable state to a suitable host, will establish a persistent population into the foreseeable future is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Availability of suitable hosts, alternate hosts and vectors in the PRA area

- Potato bug, pale legume bug and tarnished plant bug are found in a variety of species including wheat, flax, various nuts, stone fruit and other fruits and vegetables (CABI 2007).
- Tarnished plant bug is known to feed on a wide selection of hosts besides stone fruit, including cotton, soybeans, strawberries, potatoes, apples, and more than 50 other crops, plus commercially-grown flowers, fruit trees, forest trees and weeds (CABI 2007). It is suggested that the tarnished plant bug may have the widest host range of any arthropod (Young 1986).
- Lygus bugs in general have been collected from a wide range of hosts from multiple plant families during one study in Central Washington (Fye 1982).
- Thus, a large majority of the species known to be hosts of plant bugs are grown commercially in Australia. There is sufficient availability of suitable hosts for the establishment of these pests.

Suitability of the environment

- Potato bug is widespread throughout Canada and the western US, Europe (Norway, Germany, Italy and France), north Africa (Morocco, Algeria, Libya), the eastern Mediterranean region (Israel, Turkey), New Zealand, as well as being introduced to Tasmania (Haye *et al*. 2006; Schuh 2008; ABRS 2009).
- Pale legume bug is present throughout the western United States and into Canada. It was described from California and its range extends into Canada and Alaska (Mueller *et al.* 2003; Mueller *et al.* 2005, CABI 2007).
- Western tarnished plant bug is predominantly distributed throughout western US (California, Arizona, Nevada, Washington), and into Canada and Mexico (Mueller *et al.* 2003; CABI 2007).
- Tarnished plant bug occurs in all Canadian provinces, the continental US and most of the states of Mexico (Young 1986).
- The environment and climate in Australia, ranging from southern temperate regions to tropical and subtropical climatic regions, as well as Mediterranean areas, is similar to climatic regions in the US, Canada, Europe, central America, north Africa as well as Mediterranean Islands and would be suitable for establishment of these plant bugs.

Reproductive strategy and the potential for adaptation

- For plant bugs to establish, they need to reproduce sexually. Pheromones may assist with the location of a mate and there are some cross-species similarities between these secreted chemicals (Wardle and Borden 2003).
- A limiting step in their reproduction would be the potential for a single plant bug to find a mate. Given that imported fruit will be distributed across a wide area, the prevalence of exotic plant bugs is likely to be very low.
- The female tarnished plant bug lays 50–150 eggs (Stewart 2003), which are laid singly in a sheltered location and hatch in 7–12 days (Dixon and Fasulo 2006). It takes approximately 15–25 days for nymphs to develop into adults during summer, with reproduction starting when adults are about one week old.
- There are usually between two and five generations during spring to autumn, after which adults overwinter in a sheltered site, usually close to the ground (CABI 2007). Sex ratio in *Lygus* spp. heavily favours the female during overwintering, but is approximately 1:1 for the remainder of the year (Bommireddy *et al.* 2004).
- The large number of eggs that can be laid by plant bugs, over 100 eggs (Dixon and Fasulo 2006), suggests that a single mating pair would be sufficient to found a population.
- Plant bugs are able to be controlled with a wide range of pesticides (Lorenz III *et al.* 2000). However, the tarnished plant bug has built up resistance to some treatments used in the US (Zhu *et al,* 2004).
- The use of insecticides to control *Lygus* has directly or indirectly (through control measures for other pests) led to increasing insecticide resistance in *L. hesperus* (Cleveland 1985).

Cultural practices and control measures

- Successful approaches used in the US to control tarnished plant bug are mainly based on insecticides, as biological agents generally have not established. Chemical agents have effectively reduced the numbers and impact of these pests, but resistance has been recorded, compromising effectiveness (CABI 2007). While chemical controls used in Australia for other insect pests, including other species of plant bugs, may be effective against these exotic species, the overall effect is not known.
- Cultural practices have also proven useful. For example, the most effective approach is reducing the foliage of weeds near crops, as this is where most eggs are laid (CABI 2007).

Additionally, crop location relative to non-commercial vegetation that may provide alternative hosts should be considered. This can be further augmented by using chemicals on the foliage of plants on the orchard floor to eliminate the pest from plantation areas (Pickel *et al.* 2006b).

- These approaches, while generally useful in reducing the pressure of pests on crops would not be likely to impact on the potential establishment of these pests, as plant bugs would likely establish in suburban areas where these control practices are not applied.

4.4.3 Probability of spread

The probability that plant bugs, having established a persistent population on a suitable host in Australia, will spread to other susceptible hosts both in the local area and more widely is estimated to be **MODERATE**.

Supporting evidence for this assessment is provided in the text below:

Suitability of natural and/or managed environment

- All of the *Lygus* species considered here are widespread throughout the US on many hosts (CABI 2007). Australia shares similar environmental conditions and is therefore suitable for the spread of this pest.
- While parasitoid wasps are effective against tarnished plant bug (Sohati *et al.* 1992) and other *Lygus* species (Broadbent *et al.* 2006), it is not clear what role, if any, endemic parasitoids would play in Australia.

Presence of natural barriers

- Natural barriers such as deserts or mountain ranges may limit the natural movement of plant bugs beyond specific regions. However, noting the wide hose range and that many weedy plants are among the host list, it is possible that only deserts would present a significant barriers to natural dispersal.
- Research has shown that cotton pests such as western tarnished plant bug move within cotton fields and disperse between these fields and adjacent areas in California. Adults are highly mobile and are readily move up to 15 metres/day. This dispersal can be readily explained by a random walk model (Bancroft 2005).
- Tarnished plant bug and western tarnished plant bug are well-adapted colonisers that are capable of flying with a full complement of eggs, allowing them to readily exploit new habitats (Blackmer *et al.* 2004). Flight periods of up to 22 minutes were recorded and bugs travelled vertically at up to 50 $cm.s^{-1}$ (Blackmer *et al.* 2004). Tarnished plant bugs has also been captured up to 5km out to sea (MacCreary 1965 in Blackmer et al. 2004), indicating that these pests can cover significant distance in a single flight.

Potential for movement with commodities, conveyances, or by other vectors

- Dispersal between regions and over long distances would be greatly assisted by the movement of infested commodities such as nursery stock. The movement of fruit is unlikely to be a significant factor in the spread of plant bugs between regions.
- Restrictions on the movement of nursery stock exist between some regions, such as Western Australia and the eastern states. This is likely to restrict the spread of exotic plant bugs.
- Potato bug, while recorded from Tasmania, has not been recorded from mainland Australia. This provides some evidence that the spread of plant bugs across significant natural barriers may be limited.

4.4.4 Probability of entry, establishment and spread

The probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive probabilities shown in Table 2.2.

The overall probability that plant bugs will enter Australia as a result of trade in stone fruit from California and the Pacific Northwest states and be distributed in a viable state to suitable hosts, establish and subsequently spread, is estimated to be **VERY LOW**.

4.4.5 Consequences

The consequences of the establishment of exotic plant bugs in Australia have been estimated according to the methods described in Table 2.3. The justification for these ratings is provided below:

Impact scores for exotic plant bugs	
Direct Impacts	**Estimate and Justification**
Plant life or health	E –Significant at regional level. The tarnished plant bug is regarded as having more plant hosts than any other arthropod (Young 1986). It significantly reduces plant vigour and crop yield. Thus, it can have a very negative effect on many plants, both commercial and wild. In U.S. cotton, Lygus bugs infested 53 per cent of cotton crops and caused a 0.72 per cent yield reduction in 2002 (Williams 2003), but yield losses have been reported to reach 4.7 per cent (Anonymous 2003). The western tarnished plant bug and pale legume bug are the most serious pests of alfalfa grown for seed in the Pacific Northwest and California, causing direct yield reductions caused by feeding on alfalfa flowers and seeds (Seymour *et al.* 2005). Economically, western tarnished plant bug is the principal mirid pest on a range of fruit and vegetable crops in the US, and is found in all agricultural regions in North America (Barlow *et al.* 1999; CABI 2007; Mueller *et al.* 2003). The western tarnished plant bug is a key pest of cotton and strawberries, both highly valued crops in California (Pickett *et al.* 2005). The tarnished plant bug is a major pest of horticultural crops in the US including strawberries (Rancourt *et al.* 2000; Young 1986). Potato bug is a pest of lucerne, lotus, white clover seed crops and potato and has been reported to breed on apple in New Zealand (Eyles 1999). Host plants of the assessed mirid plant bugs such as cotton, strawberries, lucerne (alfalfa) and seedling conifers are also economically important to the Australian economy at the regional level. The gross value of production for cotton and strawberries to the Australian economy alone is 623 million dollars (Australian Bureau of Statistics 2010) and 308 million dollars (HAL 2009) respectively.
Any other aspects of the environment	B – Minor significance at the local level. There is no known direct impact of these plant bugs on any other aspects of the environment but their introduction into a new environment may lead to competition for resources with native plant bugs. Native grasses and ecological communities associated with grasses may be a suitable host for these exotic plant bugs and may be impacted by establishment of new species.

Indirect Impacts	Estimate and Justification
Eradication, control, etc.	**D** –Significant at the district level. Existing control programs (for example, broad spectrum pesticide applications) can be effective for some hosts but not all hosts (for example, where specific integrated pest management programs are used). Existing IPM programs may be disrupted because of the need to re-introduce or increase the use of organophosphate insecticides. This may result in a subsequent increase in cost of production. Additionally, costs for crop monitoring and consultant's advice to manage the pest may be incurred by the producer. Additionally, these existing practices may need to be altered to control plant bugs in a manner that is detrimental to the successful operation of the integrated pest management programs.
Domestic trade	**C** – Significant at the local level. The presence of these plant bugs in commercial production areas may have a significant effect due to any resulting interstate trade restrictions on a wide range of commodities. These restrictions may lead to a loss of markets, which in turn would be likely to require industry adjustment.
International Trade	**C** – Significant at the local level. The presence of these plant bugs in commercial production areas of a wide range of horticultural commodities may limit access to overseas markets where these pests are not present.
Environment	**B** – Minor significance at local level. Additional pre-harvest pesticide applications would be required to contain and/or eradicate these pests and control them on susceptible crops. However, this is unlikely to impact on the environment to any greater extent than already occurs from run-off into waterways from commercial crops. Increased insecticide use could cause undesired effects on the environment. The introduction of new biocontrol agents might also affect existing biological control programs. The necessity to undertake cultural methods of countering overwintering and egg-laying may have an impact on surrounding vegetation (CABI 2007). However, such controls may, in some areas, already be applied for other pests.

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**E**', the overall consequences are considered to be **MODERATE**.

4.4.6 Unrestricted risk

Unrestricted risk is the result of combining probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

Unrestricted risk estimate for exotic plant bugs	
Overall probability of entry, establishment and spread	**Very Low**
Consequences	**Moderate**
Unrestricted annual risk	**Very low**

As indicated, the unrestricted risk for plant bugs has been assessed as 'very low', which meets Australia's ALOP. Therefore, specific risk management measures are not required for these pests.

4.5 Armoured scales (Hemiptera: Diaspididae)

This unrestricted risk assessment includes the following species which are of quarantine significance to the whole of Australia:

Diaspidiotus forbesi (Johnson, 1896)	Forbes scale
Diaspidiotus juglansregiae (Comstock, 1881)	Walnut Scale

The assessment also includes the following species that are of quarantine significance to Western Australia:

Diaspidiotus ostreaeformis (Curtis, 1843)	Oystershell scale **WA EP**
Parlatoria oleae (Colvée, 1880)	Olive parlatoria scale **WA**
Pseudaulacaspis pentagona (Targioni-Tozzetti, 1886)	Peach white scale **WA**
Pseudaulacaspis prunicola (Maskell, 1895)	White prunicola scale **WA**

Oystershell scale has previously been assessed with the importation of stone fruit from New Zealand. In that assessment, the probability of entry, establishment and spread was estimated to be 'very low' and the consequences estimated to be 'low'. As a result the unrestricted risk was assessed to be 'negligible' and no specific quarantine measures were determined to be necessary.

The existing policy for oystershell scale is adopted for the importation of stone fruit from California, Idaho, Oregon and Washington as the risks of importation and distribution are judged to be similar. Therefore oystershell scale is not considered in the risk assessment presented here.

The other armoured scales which are considered in detail this risk assessment are recognised as being potentially associated with stone fruit production in California and the Pacific Northwest states. However, while a number of scales are considered to the most important pests in these states, for example San Jose scale, those scales are either already present in Australia or not associated with the fruit import pathway and are therefore not considered. The scales considered here have a limited distribution within the exporting states and/or are not often associated with stone fruit production (Gill 1997; Nakahara 1982; Watson 2006). Overall, these species have been grouped together because of their related biology and taxonomy and are predicted to pose a similar risk and require similar mitigation measures.

The name 'armoured scale' is applied to the members of the Diaspididae family due to the insect's production of a hard, fibrous, wax like covering (Carver *et al.* 1991) that attaches the scale to the host plant. Unlike the soft scales, armoured scales do not produce honeydew like secretions that commonly cause sooty mould to develop (Beardsley and Gonzalez 1975).

Armoured scales affect their hosts by removing sap, as well as by injecting toxic saliva during feeding (Kosztarab 1990). The feeding process results in cell death, deformation of plant parts and the formation of galls and pits, as well as increased susceptibility to other destructive agents such as frost, disease and other pests (Kosztarab 1990). High populations of scales can cause the death of trees (Beardsley and Gonzalez 1975; Smith *et al.* 1997).

In general, scale nymphs settle and feed on branches and fruit of the host plant, becoming immobile as they develop into late instar nymphs (Beardsley and Gonzalez 1975; Koteja 1990). The female reaches sexual maturity without undergoing true metamorphosis, remaining legless and immobile on the host plant (Koetja 1990). This contrasts the male scale which has a pupal stage, emerging as a winged adult form. The female life stages include adult, egg and nymph while the male has adult, egg, nymph, pre-pupa and pupa stages. There is no pupal stage in the female lifecycle. The mature adult female is approximately 1.0–1.5 mm in length (Takagi 1990).

The mature male is seldom seen and is rarely more 1 mm in length (Giliomee 1990). The adult male is winged, does not feed at all and lives for 1–3 days (Beardsley and Gonzalez 1975; Koteja 1990).

Asexual reproduction by parthenogenesis is fairly common among scale species, particularly in the worst pest species (Nur 1990), but sexual reproduction as well as asexual reproduction can occur in a single species (Watson 2005). Sometimes parthenogenesis is initiated by a pathogen (Provencher *et al.* 2005). The species assessed here are all reported to reproduce sexually (Watson 2006).

Crawlers, which are the first nymphal instar, are the primary dispersal stage and move to new areas of the plant or are dispersed by wind or animal contact (Watson 2005). Although wind is an agent of dispersal, it can also cause mortality because crawlers dislodged by wind may not land on a host plant (Koteja 1990). At the end of the wandering period (dispersal phase), crawlers secure themselves on a leaf or stem with their mouthparts. Crawlers prefer to settle on a rough or dusty surface of a young leaf. Once settled, the larvae draw their legs beneath the body and flatten themselves against the host (Koteja 1990). They then insert their piercing and sucking mouthparts into the plant tissue and start feeding on plant juices (Beardsley and Gonzalez 1975; Koteja 1990).

Forbes scale is a polyphagous species attacking plants belonging to 22 genera in 11 plant families (Watson 2006). It is a well-known pest of fruits, mainly apples (Kozar 1990), but is also known to infest cherries and plum in North America (Miller and Davidson 2005). There are two generations per year (Davidson and Miller 1990), with mated females overwintering. Adult males are wingless (Kosztarab 1963).

Walnut scale is highly polyphagous and has been recorded from hosts belonging to 40 genera in 10 plant families mostly trees (Davidson and Miller 1990). Preferred hosts are deciduous trees, especially walnut (*Juglans*) and ash (*Fraxinus*) species (Zahradnik 1990), although it is occasionally found on conifers (Gill 1997). Walnut scale can be a serious pest of some ornamental trees in California, killing birch (*Betula*) species and killing or severely weakening ash species (Gill 1997). Walnut scale has been detected on nectarine fruit in California after packing house procedures (Curtis *et al.* 1992). Elsewhere in the US it is regarded as a minor pest of walnut orchards (Gill 1997). On the East coast of the US there is one generation per year and overwintering is as second instars (Gill 1997; Watson 1006). In other parts of the US there may be two or more generations each year, and overwintering is usually as adult females (Davidson and Miller 1990; Gill 1997).

Until recently, white prunicola scale was considered as a synonym of white peach scale but was reinstated as a separate species in 1980 by Kawai (Davidson and Miller 1990). Consequently, many of the host and distribution records prior to this are likely to be white prunicola scale. The assessment for white peach scale here, will therefore also apply to white prunicola scale.

Crawlers hatch from eggs and are active between December and early June, with peak emergence between mid-December and mid-April. Once the crawlers settle down on the plant to feed, they become immobile and develop a protective covering (McLaren *et al.* 1999).

The risk posed by scales is that crawlers or immobile juvenile or adult scales will be associated with fruit during harvest and be imported to Australia.

4.5.1 Probability of entry

The probability of entry is considered in two parts, the probability of importation and the probability of distribution, which consider pre-border and post-border issues respectively.

Probability of importation

The probability that armoured scales will arrive in Australia on fruit that has undergone standard production and post-harvest practices in the US is estimated to be **LOW**.

Supporting evidence for this assessment is provided in the text below:

Harvesting fruit for export

- Forbes scale and walnut scale are reported to have a general distribution within the US and are considered to be polyphagous (Nakahara 1982). However, Forbes scale is considered to be rare in California, and walnut scale is only considered a minor pest of walnut and a pest of ornamental trees in California (Gill 1997).
- Forbes scale is recognised as a potentially serious pest of peach (Chandler 1950), but is considered rare in California (Gill 1997). There are some records that this scale can be found on fruit, causing red spotting similar to San Jose scale (Oklahoma State University 2007), but there are no such records from California.
- Walnut scale is considered a minor pest of walnut (Gill 1997) and is reported to be associated with the bark of its hosts (Ben-Dov *et al.* 2006; Miller and Ben-Dov 2006; Watson 2006). However, walnut scale has been detected on nectarine fruit in California after packing house procedures (Curtis *et al.* 1992).
- Olive parlatoria scale is reported from California and while principally a pest of olive it also infests most deciduous fruit trees (Gill 1997). Fruit can be affected (Watson 2006). The University of California Davis Integrated Pest Management Program reports that this scale is under biological control and is rarely an economic problem (Dreistadt *et al.* 2007a; Gill 1997).
- Peach white scale has been collected in California, but not since 1920 (Gill 1997). This scale is reported from Oregon (Nakahara 1982). While fruit may be attacked, this is considered rare (Watson 2006).
- The principal scale pest in most stone fruit production regions is San Jose scale which is a non-quarantine pest. Dormant sprays and biological control are generally effective at keeping this pest under effective control. Other scales are controlled as part of the management program for San Jose scale.
- Armoured scale infestations would cause visible symptoms on the fruit and is likely to cause the fruit to be rejected. Crawlers are the only mobile stage that could contaminate clean fruit.
- All stages except for crawlers and adult males are firmly attached to the fruit and unable to move.

Processing of fruit in the packing house

- The washing and brushing/defuzzing process would likely dislodge crawlers and a proportion of the sessile scales on the surface of fruit.
- Sorting and grading would remove some fruit that is contaminated with scale as they are easily seen. However, some infested fruit with scales in the stem end, may remain undetected.
- The incidence of walnut scale and San Jose scale have both been detected on nectarines after packing house procedures (Curtis *et al.* 1992).

Pre-export and transport to Australia

- Fruit is stored at around 1°C (Curtis *et al.* 1992; Yokoyama and Miller 1999).
- Transport of fruit to Australia would be either by air freight or by sea freight, with the total time in transit, from orchard until arrival in Australia, expected to take from a few days to three weeks.
- Low temperatures would slow or prevent development of scales. Walnut scale overwinter as second instar nymphs while olive parlatoria scale and peach white scale overwinter as adults or eggs (Watson 2006).

Probability of Distribution

The probability that armoured scales, having entered Australia on infested fruit, will survive during the movement of fruit within Australia after it has been released from the port of entry and be transported in a reproductively viable state to a suitable host is estimated to be **LOW**.

Supporting evidence for this assessment is provided in the text below:

- The stages associated with imported fruit would be immature forms or adults. However, it is only the adult males and crawlers that are able to move, with other stages remaining attached to their host and incapable of independent dispersal (Beardsley and Gonzalez 1975; Koteja 1990.
- The principal dispersive stages of scale insects are the first instar crawlers (Beardsley and Gonzalez 1975). Adult males, while capable of independent flight are incapable of laying eggs and thus would not be able to move the scale infestation onto a new host.
- Either mated female scales would need to arrive in Australia with stone fruit, or male scales would need to complete development, emerge and locate a female for mating, before eggs could be laid. Emerging crawlers would then need to locate a suitable host to infest.
- Crawlers are capable of independent movement, and can be dispersed by wind (Beardsley and Gonzalez 1975). Crawlers generally do not move more than one meter from the parent female before settling to feed, and establishment of the feeding position occurs for only a limited period of time after birth (Ker and Walker 1990). However, if assisted by wind, some species have been recorded to travel by wind assistance up to 2.8km (Beardsley and Gonzalez 1975), although most crawler travelled much shorter distances. Additionally, there is a high mortality rate for crawlers during the dispersal stage due to abiotic factors such as unsuitable environments and temperatures (Watson 2006).
- The scales assessed here have a wide host range. This would increase the opportunity for a scale to find a suitable host. Some hosts include apples, pears, plums (European and Japanese), cherry, peach, prune, almond, nectarine, quince, currants, blueberry, and walnuts. Amenity hosts include willows, birches, elms, alders, poplars, rowans, and other common ornamental trees (Nakahara 1982).

Overall probability of entry (importation x distribution)

The overall probability of entry for armoured scales is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for armoured scales is estimated to be **VERY LOW**.

4.5.2 Probability of establishment

The probability that armoured scales, having been distributed in a viable state to a suitable host, will establish a persistent population into the foreseeable future is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Availability of suitable hosts, alternate hosts and vectors in the PRA area

- The scales assessed here have a wide potential host range (Watson 2006). For example, forbes scale has hosts from 20 genera, walnut scale has hosts from 28 genera, olive scale has hosts from 127 genera and peach white scale has hosts from 211 genera (Ben-Dov *et al.* 2006).
- The hosts include apples, pears, plums (European and Japanese), cherry, peach, prune, almond, nectarine, quince, currants, blueberry, and walnuts. Amenity hosts include willows, birches, elms, alders, poplars, rowans, and other common ornamental trees (Nakahara 1982).
- Shelter trees are often the most important sources for oystershell scale dispersing in the orchard environment in New Zealand (HortResearch 1999). This is generally true of other scale species where overwintering hosts and alternative hosts are important sources of infestation in orchards (HortResearch 1999). This emphasises the ability of these scales to establish on a wide range of hosts and disperse into orchards.

Suitability of the environment

- Forbes scale is found in Canada, Mexico, the US (several states including California), Puerto Rico and South Africa (Ben-Dov *et al.* 2006).
- Walnut scale is found in Canada, Mexico and multiple states of the US, including California (Ben-Dov *et al.* 2006).
- Olive scale is widespread, with significant distribution across all continents except Antarctica. This includes California, New South Wales and Queensland (Ben-Dov *et al.* 2006).
- Peach white scale has hosts in an even wider range, again inclusive of states of concern in the US (California and Oregon) and is already established in Australia (New South Wales and Queensland) (Ben-Dov *et al.* 2006).
- Olive parlatoria scale and peach white scales have already established in some regions of Australia, demonstrating that the Australian environment and climate are suitable for the establishment of these armoured scales from the US.

Reproductive strategy and the potential for adaptation

- The species assessed here are all reported to reproduce sexually (Watson 2006). Female scales release a sex pheromone during the day when males are active, which attracts the winged males for mating. Males fly for up to a few days and may locate females after flight or by walking over the bark of the host tree.
- Females have a high fecundity, on reaching adulthood (30–50 days old), and may produce over 100 eggs over a period of 2–3 months (HortResearch 1999l Watson 2006). This may result in a large population increase (HortResearch 1999).
- The number of generations per year depends on the species and environmental conditions. Walnut scale has one or more generations per year, while olive parlatoria scale and peach white scale have from 2–5 generations per year, depending on the environmental conditions (Watson 2006).
- The scales assessed here are only minor pests in the exporting states of the US which suggests that existing control measures, such as insecticide sprays and biological controls, are

effective. Thus, while resistance to insecticides may develop, this does not appear to be affected the ability to control these pests in the US.

Cultural practices and control measures

- Scales are often controlled by small parasitic wasps and predators including beetles, bugs, lacewings, and mites (Dreistadt *et al.* 2007a).
- Existing chemical controls in commercial orchards may impact on the establishment of these exotic scales, but such controls would not be applied in all the environments where these scales could establish such as in urban environments.

4.5.3 Probability of spread

The probability that armoured scales, having established a persistent population on a suitable host in Australia, will spread to other susceptible hosts both in the local area and more widely is estimated to be **MODERATE**.

Supporting evidence for this assessment is provided in the text below:

Suitability of natural and/or managed environment

- Climatic factors, in particular temperature and humidity, influence every aspect of the scale life history. The number of days for each developmental stage and the number of generations per year depend on temperature, humidity and rainfall, with the fastest development generally occurring in warm, dry areas (Beardsley and Gonzalez 1975).
- Peach white scale is found in New South Wales and Queensland (Ben-Dov *et al.* 2006), and the climate in areas of Western Australia is comparable and would likely be suitable for its spread.
- These scales are widely distributed within the US and some other countries (Watson 2006) where a wide range of environmental conditions exist. It is likely that these scales would have the capacity to spread throughout Australia where suitable hosts are found.

Presence of natural barriers

- There are considerable natural geographic barriers between some of the fruit production districts in Australia. It would be difficult for the scales to disperse unaided from one district, state or region to another as scales have limited dispersal capabilities, with only the winged adult males and young crawlers being mobile.
- However, due to the wide host range, these scales are likely to be able to disperse locally, from plant to plant and so slowly spread between areas.
- Wind dispersal may also be important, noting that some species have been recorded to travel with wind assistance up to 2.8km (Beardsley and Gonzalez 1975). This would allow these scales to potentially move between adjacent orchards and throughout production regions.

Potential for movement with commodities, conveyances or vectors

- Movement of infested planting material or produce would be an important means to spreading armoured scales. The most common mode of dispersal of sessile stages is on plant parts transported by human activities (Watson 2005). In particular, long-range dispersal of the sessile female scale can only occur by transport on infested plant material. Passing animals or people can also can vector crawlers over great distances. The crawler stage can be carried by other vertebrates such as birds and invertebrates, particularly ants, as well as wind currents (Beardsley and Gonzalez 1975).

- Some restrictions on the movement of plant material between states exist, but these may not be sufficient to prevent the intrastate spread of these pests.

4.5.4 Probability of entry, establishment and spread

The probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive probabilities shown in Table 2.2.

The overall probability that armoured scales will enter Australia as a result of trade in stone fruit from California and the Pacific Northwest states and be distributed in a viable state to suitable hosts, establish and subsequently spread, is estimated to be **VERY LOW**.

4.5.5 Consequences

The consequences of the establishment of exotic armoured scales in Australia have been estimated according to the methods described in Table 2.3. The justification for these ratings is provided below:

Impact scores for exotic armoured scales	
Direct Impacts	**Estimate and Justification**
Plant life or health	**D** –Significant at the district level. The scales assessed here are polyphagous with potential hosts including commercial crops such as apples, pears, cherry, peach, plum, almond, nectarine, quince, currants, blueberry, and walnuts (Nakahara 1982). Some of these commercial hosts constitute major horticultural markets in Australia. Infestation by armoured scales can cause direct damage to the fruit, whereby the feeding of scales causes discolouration, usually near the calyx (if present) or stem end of the fruit (HortResearch 1999). In the absence of natural predators and parasites, armoured scale populations can increase to levels where feeding on the sap causes a reduction in crop yield or death of the branch (Davidson and Miller 1990; McClure 1990). Current control measures in commercial orchards for other scale pests, such as San Jose scale, and other pests in general may reduce the impact of exotic scales, but chemical spray timings may not be optimised for these species and current natural enemies may not be able to control the scales. Infestations in suburban environments are unlikely to be controlled until after plant symptoms are seen.
Any other aspects of the environment	**B** – Indiscernible at the local level. There is no known direct impact of armoured scales on any other aspects of the environment but their introduction into a new environment may lead to competition for resources with native species.

Indirect Impacts	Estimate and Justification
Eradication, control, etc.	**C** – Significant at the local level. Existing control programs can be effective for some hosts (for example, broad spectrum pesticide applications) but not all hosts (for example, where specific integrated pest management programs are used). Forbes scale and walnut scale are of concern to all of Australia, and have a limited host range compared to some other scales assessed here, but could have significant impacts. However, controls are already employed for other, already established, scales of economic concern and these are likely to have some effect on the exotic scales assessed here. Existing IPM programs may be disrupted because of the need to re-introduce or increase the use of organophosphate insecticides. This may result in a subsequent increase in cost of production. Additionally, costs for crop monitoring and consultant's advice to manage the pest may be incurred by the producer.
Domestic trade	**C** – Significant at the local level. Trade restrictions in the sale or movement of fruit between states could result from the establishment of Forbes scale or walnut scale in regions of Australia. The establishment of the scales of regional concern to Western Australia is unlikely to require additional interstate quarantine restrictions as those scales are recorded from the eastern states.
International Trade	**C** – Significant at the local level. Forbes scale and walnut scale are restricted in distribution to specific areas in North and South America. Establishment of these scale in Australia could result in new quarantine regulations being imposed on Australian exports, potentially disrupting trade while new export protocols are established. The establishment of peach white scale in Western Australia may lead to the loss of markets where these pests are not present, but commodities that are susceptible to these pests can be exported from the eastern states, so any impacts are expected to be minor. The establishment of olive parlatoria scale in Western Australia is unlikely to result in loss of any markets as this is already present in all continents.
Environment	**B** – Minor significance at the local level. Additional pre-harvest pesticide applications would be required to contain and/or eradicate these pests and control them on susceptible crops. However, this is unlikely to impact on the environment to any greater extent than already occurs from run-off into waterways from commercial crops. Increased insecticide use could cause undesired effects on the environment. Many of the hosts of theses scales are introduced deciduous trees that are commonly grown as ornamentals or as shelter belt trees. Serious infestation of those amenity trees could have recognisable impacts, but those hosts are already subject to scale infestations.

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**D**', the overall consequences are considered to be **LOW.**

4.5.6 Unrestricted risk

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5. The unrestricted risk estimation for armoured scales is shown below.

Unrestricted risk estimate for armoured scales	
Overall probability of entry, establishment and spread	**Very Low**
Consequences	**Low**
Unrestricted risk	**Negligible**

As indicated, the unrestricted risk for armoured scales has been assessed as ‘negligible’, which meets Australia’s ALOP. Therefore, specific risk management measures are not required for these pests.

4.6 Mealybugs (Hemiptera: Pseudococcidae)

The species considered in this risk assessment are:

Phenacoccus aceris Signoret, 1875)	Apple mealybug
Pseudococcus comstocki (Kuwana, 1902)	Comstock mealybug
Pseudococcus maritimus (Ehrhorn, 1900)	Grape mealybug

This analysis also considers the following species which is of quarantine significance to Western Australia:

Pseudococcus calceolariae (Maskell, 1879)	Citrophilus mealybug **[EP, WA]**

Citrophilus mealybug has previously been assessed with the importation of stone fruit from New Zealand. In that assessment, the probability of entry, establishment and spread was estimated to be ‘moderate’ and the consequences estimated to be ‘low’. As a result the unrestricted risk was assessed to be ‘low’ and quarantine measures were determined to be necessary to manage the risk.

The existing policy for citrophilus mealybug is adopted for the importation of stone fruit from California, Idaho, Oregon and Washington as the risks of importation and distribution are judged to be similar. Therefore citrophilus mealybug, a quarantine pest for Western Australia, is not considered further in the risk assessment presented here.

The other mealybug species considered in this assessment are recognised as pests of stone fruit production in California and the Pacific Northwest states. While the Californian Department of Agriculture suggest that the Comstock mealybug is not commonly found on Rosaceae in California, it is reported to be a serious pest of peach in the eastern US (Ben-Dov *et al*. 2006).

These species have been grouped together because of their related biology and taxonomy and are predicted to pose a similar risk and require similar mitigation measures. In this assessment, the term ‘mealybug’ is used to refer to these species unless otherwise specified.

Mealybugs are sucking insects that injure plants by extracting large quantities of sap and producing honeydew which serves as a substrate for the development of sooty mould. The sooty mould prevents photosynthesis in addition to making the plant, including the fruit, unsightly. Many mealybug species pose serious problems to agriculture, particularly when introduced into new areas of the world where their natural enemies are not present (Miller *et al.* 2002).

Mealybugs are so-called as many species secrete a mealy or powdery wax like covering over their body (Carver *et al.* 1991). Many species of mealybugs also have prominent filaments extending from around their body which may be useful diagnostic features for some species. Pseudococcidae (the mealybug family) includes a number of important crop pests of both aerial and subterranean plant parts (Osborne 2000). Mealybugs develop from an egg and through a number of nymphal (immature instar) stages before undergoing a final moult into the adult form (CABI 2007). In at least some species, the late instars may be non-feeding and this is particularly true for male mealybugs (CABI 2007). After moulting, the male mealybug emerges as a tiny winged form, while the adult female mealybug is oval in shape and around 4 mm long (CABI 2007). The adult female Comstock mealybug is a reddish-brown colour and ranges from 2.5–5.5mm long (Spangler and Agnello 1991) while the adult female citrophilus mealybug is a darker purple-red colour and 4–5mm long (CABI 2007). Reproduction in mealybugs is sexual and there may be multiple generations per year.

The risk posed by mealybugs is that eggs, juveniles or adult females may be present on imported stone fruit. While mealybugs are sap sucking insects and usually associated with leaves and stems, they may also be associated with fruits where they can be found in sheltered areas such as the calyx (when present) or the stem end of fruit.

4.6.1 Probability of entry

The probability of entry is considered in two parts, the probability of importation and the probability of distribution, which consider pre-border and post-border issues respectively.

Probability of importation

The probability that mealybugs will arrive in Australia on fruit that has undergone standard production and post-harvest practices in the US is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Harvesting fruit for export

- Mealybugs occur at the calyx or stem end of fruit (CABI 2007). The Comstock mealybug is generally associated with apples, pears and peach in the US, but is only infrequently reported as a fruit pest (Spangler and Agnello 1991). The grape mealybug is recognised as being associated with stone fruit, however grapes and pears are considered to be the primary hosts of these pests (Bush *et al.* 2009). The apple mealybug is considered to be fairly rare in orchards in Washington state, but may be found on all species of deciduous fruit trees, including plum and apricot (Beers 2007).
- The potential for viable mealybug eggs, nymphs or adults to remain associated with fruit after harvesting, packing house processing and transport would be significant. They generally remain anchored to the host and due to their small size may be difficult to detect on fruit during sorting, especially at low population levels (Taverner and Bailey 1995).
- Mealybug infestations may cause visible symptoms such as sooty mould on the fruit. Fruit with sooty mould may be rejected at the point of harvest, however symptoms would need to be severe for rejection to occur at this point.

Processing of fruit in the packing house

- Sorting and grading would remove some fruit that is contaminated with mealybugs if clear symptoms of infestation are present. It is expected that some infested fruit would remain undetected. Low level infestations may be difficult to detect (Taverner and Bailey 1995).
- The washing and brushing/defuzzing process would reduce the number of mealybugs on the fruit. Younger, less physically established specimens may be more easily dislodged. However, brushing may not be effective against mealybugs that may be firmly anchored to the fruit or that are in cryptic areas such as the stem end of fruit (Taverner and Bailey 1995).
- Due to the small size of nymphs and the tendency of adult mealybugs to remain anchored to the fruit, not all individual pests will be removed in the handling and washing procedure (Taverner and Bailey 1995).

Pre-export and transport to Australia

- Fruit is stored at around 1°C (Curtis *et al.* 1992; Yokoyama and Miller 1999).
- Transport of fruit to Australia would be either by air freight or by sea freight, with the total time in transit, from orchard until arrival in Australia, expected to take from a few days to three weeks.

- It has been shown that cold storage of commodities can be an effective disinfestation technique for obscure mealybug (*Pseudococcus viburni*), which is believed to be one of the more cold tolerant mealybugs (Hoy and Whiting 1997). In that study, the lethal treatment for 99 per cent of the population ranged from 16 days at 0°C for first instars to 77 days at 4°C for adult females. Cold storage during transport may result in some mortality, but these values suggest that live mealybugs would arrive, even after three weeks transit.

Probability of distribution

The probability that mealybugs, having entered Australia on infested fruit, will survive during the movement of fruit within Australia after it has been released from the port of entry and be transported in a reproductively viable state to a suitable host is estimated to be **MODERATE**.

Supporting evidence for this assessment is provided in the text below:

- Mealybugs would need to survive post entry shipping and storage. Although cold storage may impact the survival of mealybugs, some mealybugs are likely to survive storage and distribution.
- Stone fruit will be distributed throughout Australia for retail sale with the majority of fruit retailers, processors and consumers located in metropolitan and suburban areas. Nymphs and/or adults need to survive transport and processing from the port of entry, sale and disposal of stone fruit. They need to disperse in sufficient numbers and in proximity to susceptible hosts to ensure that females can be located by males, mating occur and then a susceptible host located on which to lay eggs or live young, depending on species. Finally, environmental conditions need to be suitable for population development.
- While the ability of mealybugs to self-disperse is limited, this is offset by the capacity of mealybugs to produce large numbers of offspring and by other means of dispersal. Juveniles are the most mobile stage and may be blown or crawl onto susceptible host plants. Adult females are slow moving, but they may be transported by attendant ant species (Williams 2004). In the San Joaquin Valley, California, the grey field ant *Formica aerata*, and the Argentine ant (*Linepithema humile)* are the main ants responsible for the movement and protection of mealybugs from parasites and predators in pomegranate orchards (Carroll *et al.* 2006). Argentine ant as well as those in the genus *Formica* are also present in Australia (Shattuck 1999), potentially facilitating the spread of exotic mealybugs.
- Adult males are winged, fragile and short-lived and do not persist for more than several days. They detect females through pheromones and are able to fly to them in order to mate (Grimes and Cone 1985).
- While mealybugs retain the ability to move during all life stages, the nymphs are sessile from the second instar (larval) stage onwards (Carver *et al.* 1991).
- Adult female mealybugs would need to be carried onto hosts by vectors such as people or other insects. Adult females can only crawl a few metres, restricting their ability to move from discarded fruit waste to a suitable host (CABI 2007).
- Short-range dispersal would occur easily by the random movement of crawlers with wind currents and biological or mechanical vectors. Crawlers are small and less robust than adult females, but they can be dispersed onto other plants up to several hundred metres by wind (Rohrbach *et al.* 1988). All stages of these pests can survive for a few days without food (Ben-Dov 1994) and are likely to be transferred to a susceptible host.
- The long-range dispersal of mealybugs requires the movement of adults and nymphs with fresh material.

Overall probability of entry (importation x distribution)

The overall probability of entry for mealybugs is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for mealybugs is estimated to be **MODERATE**.

4.6.2 Probability of establishment

The probability that mealybugs, having been distributed in a viable state to a suitable host, will establish a persistent population into the foreseeable future is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Availability of suitable hosts, alternate hosts and vectors in the PRA area

- The Comstock mealybug has hosts from 40 plant families including apples, citrus, pears, pine trees, honeysuckle, camellia and rhododendron. The grape mealybug includes hosts from 41 families, including apples, pears, grapes, grevillea and rhododendron. The apple mealybug has hosts from 27 families and over 100 species or subspecies including apple, apricot, blueberry, cherry, grape and pear (Ben-Dov *et al.*2006; Beers 2007) A wide range of suitable hosts (e.g. apples, citrus, grapes, mango and pineapple) would be available in Australia for the mealybugs assessed here.
- While only the crawlers and adult males are considered the significant dispersive stages (Carver 1991), the high reproductive capacity of mealybugs means that a founding population could quickly increase in number and disperse to other nearby hosts.

Suitability of the environment

- The Comstock mealybug is reported to prefer drier temperate areas although their distribution does include coastal, more humid regions (CABI 2007). In California, the grape mealybug is primarily a problem within inland regions but may also be a pest in coastal regions (Bentley *et al.* 2008).
- Grape mealybug is recorded in most of the US and a wide range of other countries which includes Canada, Mexico, Argentina, Indonesia, Chile and Poland (Ben-Dov *et al.* 2006). Apple mealybug is believed to be of European origin but currently, its distribution is cosmopolitan (Beers 2007). The Comstock mealybug is recorded from fewer states in the US and many other countries including Japan, Cambodia, Argentina, China, Iran, Russia and Brazil (Ben-Dov *et al.* 2006). The wide distribution of these pests suggests that the environment in Australia is suitable for these species.
- Citrophilus mealybug has already established in eastern Australia, suggesting the environment would be suitable to other related mealybug species (APPD 2009).

Reproductive strategy and potential for adaptation

- Mealybugs have a high reproductive rate; with the grape mealybug able to lay over 100 eggs (Grimes and Cone 1985).
- The successful reproductive strategy of these pests relies on the longevity and fecundity of the adult female, the mobility of the short-lived adult male and the ability of the crawlers to disperse via crawling, vectors or wind and locate new hosts (Williams 2004).
- Parthenogenesis is not reported from any of these mealybug species and so male mealybugs must locate female mealybugs for a population to establish. The female releases a sex pheromone during the day when males are active, which attracts nearby males by walking or

more distant males by flying distances of over one metre. Females do not feed after laying eggs and die shortly thereafter. There are three to four generations per annum (CABI 2007).

- Male mealybugs are small, non-feeding insects with a short life span, usually just a few days (Williams 2004). Their short life span and short dispersal range, limits the opportunity for males to find mates from long distances. This would therefore restrict their ability to successfully establish a persistent population once distributed from the port of entry.

Cultural practices and control measures

- Controls in place for other pests of economic concern are applied in agricultural ecosystems which may reduce the likelihood of establishment of mealybugs. However, many hosts available in Australia would be present in urban and suburban areas as well as in unmanaged environments.

4.6.3 Probability of spread

The probability that mealybugs, having established a persistent population on a suitable host in Australia, will spread to other susceptible hosts both in the local area and more widely is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Suitability of natural and/or managed environment

- The Australian climate is expected to be conducive to the spread of Comstock mealybug and grape mealybug. The worldwide distribution of hosts suggests that both species could be expected to become widespread once established in Australia due to similar climates (CABI 2007).

Presence of natural barriers

- Due to the limited distance mealybugs can move by crawling or wind dispersal, natural barriers such as deserts, mountains or large areas where hosts are not present would limit the ability of these mealybug species to disperse between some areas.
- First instar nymphs of longtailed mealybug have been predicted to be able to travel distances greater than 50km when assisted by wind (Barrass *et al.* 1994). This would allow mealybug populations to potentially spread between growing areas.
- The natural desert barrier between Western Australia and the eastern states, coupled with Western Australian quarantine regulations and inspections may be important factors in having prevented the spread of citrophilus mealybug.

Potential for movement with commodities, conveyances or vectors

- Historically, long-distance dispersal of mealybugs is completely dependent upon the distribution of infested nursery stock and by winds, as females are incapable of flight whereas males are only capable of short flights which may be directed by the presence of female pheromones (Ben-Dov 1994).
- Adult female mealybugs are slow-moving, but they may be transported and protected from natural enemies by attendant ant species such as *Pheidole megacephala* and *Acropyga* sp., both of which are found in Australia (Shattuck 1999; Williams 2004). Some species of mealybugs may be carried by ants to new host plants (Carter 1962; Beardsley *et al.* 1982).

4.6.4 Probability of entry, establishment and spread

The probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive probabilities shown in Table 2.2.

The overall probability that mealybugs will enter Australia as a result of trade in stone fruit from California and the Pacific Northwest states and be distributed in a viable state to suitable hosts, establish and subsequently spread, is estimated to be **MODERATE**.

4.6.5 Consequences

The consequences of the establishment of exotic mealybugs in Australia have been estimated according to the methods described in Table 2.3. The justification for these ratings is provided below:

Impact scores for exotic mealybugs	
Direct Impacts	**Estimate and Justification**
Plant life or health	**D** – Significant at the district level. Mealybugs can cause direct harm to a wide range of plant hosts and have also been reported as disease vectors (Ben-Dov 1994). Fruit quality can be reduced by the sooty mould that can grow on the honeydew produced by the mealybugs. Many fruit varieties often exhibit cosmetic damage on the skin where mealybugs have been feeding (McLaren *et al.* 1999). Mealybugs can reduce plant vigour and crop yield.
Any other aspects of the environment	**B** – Minor at the local level. There is no known direct impact of mealybugs on any other aspects of the environment but their introduction into a new environment may lead to competition for resources with native species. The wide host range and potential for some impact on plant vigour suggests that minor impacts on amenity plants and ecological communities could be observed.
Indirect Impacts	**Estimate and Justification**
Eradication, control, etc.	**D** –Significant at the district level. Additional programs to minimise the impact of these pests on host plants may be necessary. Existing control programs can be effective for some hosts (for example, broad spectrum pesticide applications) but not all hosts (for example, where specific integrated pest management programs are used). Existing IPM programs may be disrupted because of the need to re-introduce or increase the use of organophosphate insecticides. This may result in a subsequent increase in cost of production. Additionally, costs for crop monitoring and consultant's advice to manage the pest may be incurred by the producer.
Domestic trade	**D** – Significant at the district level The presence of these pests in commercial production areas may have a significant effect at the local level due to any resulting interstate trade restrictions on a wide range of commodities. These restrictions may lead to a loss of markets. Trade restrictions in the sale or movement of fruit between districts in Western Australia may be imposed by the state quarantine agency. However, there would not be any interstate trade restrictions imposed.
International Trade	C – Significant at the local level. The presence of mealybugs in commercial production areas of a range of commodities that are hosts to these mealybugs may limit access to overseas markets where these pests are absent. While present in many Asian, European and American countries, some of these species are absent from important trading partners such as Japan, China

	and New Zealand. Therefore, some restrictions on trade could occur if these species were to establish in Australia.
Environment	B – Minor at the local level. Mealybugs introduced into a new environment will compete for resources with native species. While existing mealybug eradication programs, which include biological control, may contain introduced mealybugs, additional pesticide applications or other activities would be necessary to manage these pests on susceptible crops. Any additional insecticide usage may affect the environment.

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**D**', the overall consequences are considered to be **LOW**.

4.6.6 Unrestricted risk

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

Unrestricted risk estimate for mealybugs	
Overall probability of entry, establishment and spread	**Moderate**
Consequences	**Low**
Unrestricted risk	**Low**

As indicated, the unrestricted risk for mealybugs has been assessed as 'low', which is above Australia's ALOP. Therefore, specific risk management measures are required for these pests.

4.7 Peach twig borer (Lepidoptera: Gelechiidae)

The species examined in this risk assessment is:
Anarsia lineatella Zeller, 1839 Peach twig borer

The peach twig borer is considered a major pest of stone fruit across North America, Europe, Asia and North Africa (EPPO/CABI 1997c). The larvae can damage growing shoots causing shoot strike or feed directly on the fruit (Pickel *et al.* 2006c). The larvae bore into the fruit and feed just below the skin (Pickel *et al.* 2006c).

Larvae overwinter on trees as either first or second instars and emerge early in spring (March to April) and feed on emerging leaves and shoots (Pickel *et al.* 2006c). Pupation normally occurs in protected places on the tree, though has been reported from the stem end cavity of fruit. The first generation adults subsequently emerge from April to May each year and there are two or more generations per year (Pickel *et al.* 2006c).

Oval shaped eggs are initially white before turning a yellowish-orange colour and may be laid on twigs, leaves or fruit (Pickel *et al.* 2006c; CABI 2007). The juvenile larvae is white with a black head, while the mature larvae is around 12mm long and a reddish-brown colour with distinctive light bands around the body (Pickel *et al.* 2006c). Adult moths are grey and have a wingspan of 14 –16mm (CABI 2007).

Peach twig borer is recorded as a pest of apricots, nectarines, peaches and plums in California (Bentley and Day 2006a; Pickel *et al.* 2006c; Bentley *et al.* 2009c; Coates and Van Steenwyck 2009). The risk posed by peach twig borer is that eggs, larvae, and in some cases pupae, could be introduced with imported stone fruit and subsequently establish in Australia.

4.7.1 Probability of entry

The probability of entry is considered in two parts, the probability of importation and the probability of distribution, which consider pre-border and post-border issues respectively.

Probability of importation

The probability that peach twig borer will arrive in Australia on fruit that has undergone standard production and post-harvest practices in the US is estimated to be **MODERATE**.

Supporting evidence for this assessment is provided in the text below:

Harvesting fruit for export

- Infestation by peach twig borer in stone fruit affects both the shoots and fruit(Gencsoylu *et al.* 2006; Pickel *et al.* 2006c). Larvae bore just below the surface of the fruit and damage to the fruit is usually severe with clearly visible symptoms (Weakley *et al.* 1990). Given these distinct visual indicators, it is likely that affected fruit showing symptoms will be culled during the harvest process.
- Larvae emerge in spring and attack blossoms and shoots. Newly emerged larvae usually enter fruit through the stem-end and feed just under the skin (Bentley *et al.* 2009c; Pickel *et al.* 2006c). Moths from this generation lay eggs on fruit, leaves or twigs, but the ability to attack fruit depends on the availability of fruit at the time (EPPO/CABI 1997c; Pickel *et al.* 2006c).

- Fruit are highly susceptible, particularly from colour break to harvest (Coates and Van Steenwyck 2009; Pickel *et al.* 2006c). Given the distinct symptoms and broad timeframe in which infection can be initiated, it is unlikely that symptomatic fruit would go undetected.
- Eggs laid on fruit are small and are unlikely to be detected during harvest.
- Fruit damage may be less in some peach varieties (Gencsoylu *et al.* 2006). There are conflicting reports as to whether early maturing or late maturing varieties are more susceptible to peach twig borer infestation (Brunner and Rice 1984; Weakley *et al* 1990; Curtis *et al.* 1992; Gencsoylu *et al.* 2006). This conflict may be due to pesticide spray timing (Weakley *et al.*1990; Curtis *et al.* 1992).
- Secondary rots may follow initial tunnelling causing further damage to the fruit. Secondary rots may be detected during harvest.

Processing of fruit in the packing house

- Eggs, larvae or pupae on the external surface of the fruit are likely to be removed by brushing, though it is unlikely that peach twig borer eggs will be found on the surface of the fruit (Pickel *et al.* 2006c).
- Sorting and grading would remove some fruit that is contaminated with external larvae or fruit that exhibit clear symptoms of internal infestation such as heavy webbing or deposits of frass (Pickel *et al.* 2006c).
- Microbial breakdown can occur in infested fruit and such fruit may be detected during packing house procedures (Curtis *et al.* 1992).
- Trials undertaken in California determined that the incidence of peach twig borer on nectarine, following packing house procedures, was 4 insects per 100 000 fruit. Nearly all were in the larval stage (92%) while the remainder were pupae (Curtis *et al.* 1992).

Pre-export and transport to Australia

- Fruit is stored at around 1°C (Curtis *et al.* 1992). Transport of fruit to Australia would be either by air freight or by sea freight, with the total time in transit, from orchard until arrival in Australia, expected to take from a few days to three weeks.
- The lower threshold temperature for egg development is 10ºC (Brunner and Rice 1984). Therefore, eggs present in exported fruit would cease development until the fruit were returned to warmer temperatures.
- The peach twig borer overwinters in early larval stages and thus these stages are likely to be the most cold tolerant (Pickel *et al.* 2006c).
- The effect of cold treatment on peach twig borer is unknown, and therefore it is assumed that peach twig borer could survive cold storage and transport.

Probability of distribution

The probability that peach twig borer, having entered Australia on infested fruit, will survive during the movement of fruit within Australia after it has been released from the port of entry and be transported in a reproductively viable state to a suitable host is estimated to be **LOW**.

Supporting evidence for this assessment is provided in the text below:

- The peach twig borer is associated with fruit in the egg, larval and pupal stages (Brunner and Rice 1984; Curtis *et al.* 1992).
- If the egg or larvae were to survive fruit harvesting, processing, cold and/or controlled atmosphere, storage, and transport to Australia, it would still need appropriate conditions to complete development and subsequently find a site to pupate.

- Pupation can occur in the stem cavity on fruit (Curtis *et al.* 1992; Pickel *et al.* 2006c), although this only appears to occur relatively infrequently.
- Pupation time for peach twig borer during summer conditions in Washington was 13 days (Brunner and Rice 1984).
- Sexual reproduction is essential for the peach twig borer and females attract males with pheromones (Roelofs *et al.* 1975). After successful pupation, adults would therefore need to disperse and locate a mate, which will constrain their capacity to distribute in a reproductively viable state to a suitable host. After mating, eggs would be laid on a suitable host plant once located.
- Suitable host plants include almond, apricot, nectarine, peach, plum and pear (EPPO/CABI 1997c; Bentley and Day 2006a). These hosts are present in Australia.
- If peach twig borer were to remain with the fruit as a larvae and be distributed to the consumer, successful distribution would rely on the consumer disposing of the fruit and the pest. The larvae would remain feeding on the fruit until development is completed and would then pupate. The disposal environment may be household compost or landfill and may have fruit and a possibly sites suitable for pupation. After pupation moths would emerge, mate (if other peach twig borer moths were present) and lay eggs on a suitable host. However, discarded fruit is likely to degrade quickly and become unsuitable for larvae to complete development. Therefore this distribution pathway would likely have a narrow window for successful distribution.
- Alternately the larvae could mature before the fruit reaches the consumer. The larvae would pupate on the fruit and emerge. Again, adults would need to disperse and locate a suitable mate, which may limit their capacity to distribute in a reproductively viable state to a suitable host. Furthermore, suitable host plants for oviposition may not be in the immediate vicinity, however the adult moth could fly to locate hosts.
- Prunus, especially stone fruit, are considered to be the main hosts for peach twig borer (EPPO/CABI 1997c). The narrow host range for peach twig borer is likely to limit the potential of this pest to distribute from the port of entry to a suitable host.

Overall probability of entry (importation x distribution)

The overall probability of entry for peach twig borer is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for peach twig borer is estimated to be **LOW**.

4.7.2 Probability of establishment

The probability that peach twig borer, having been distributed in a viable state to a suitable host, will establish a persistent population into the foreseeable future is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Availability of suitable hosts, alternate hosts and vectors in the PRA area

- Peach twig borer moth principally feeds on *Prunus* spp. (Ahmad and Khadhum 1986). However, the shoots of pear (*Pyrus* spp.) are also suitable (EPPO/CABI 1997c). *Prunus* species are common is residential and amenity plantings and are also commercially grown in many areas of Australia.

Suitability of the environment

- The peach twig borer is widespread in North America, Europe, Asia and North Africa in climatic conditions similar to those of Australia (EPPO/CABI 1997c).

Reproductive strategy and the potential for adaptation

- Peach twig borer has up to four generations per year depending on climate (Brunner and Rice 1984; Ahmad 1988).
- Eggs are laid singly and laboratory studies have shown that females lay an average of 130 eggs each (McElfresh and Millar 1993).
- Populations can begin from a single mated female. After larvae have hatched from eggs they can develop, pupate and become adults and mate before laying their eggs to establish a new population.
- Pesticide resistance can develop within peach twig borer populations (Summers *et al*. 1959; Zalom *et al.* 2002).

Cultural practices and control measures

- Biological control has not been effective in controlling peach twig borer populations in the US (Pickel *et al.* 2006c; Bentley *et al.* 2009c; Coates and Van Steenwyck 2009). Organic treatment can be achieved using sprays of *Bacillus thuringiensis* and *Saccharopolyspora spinosa*, as well as mating disruption (Pickel *et al.* 2006c; Bentley *et al.* 2009c; Coates and Van Steenwyck 2009).
- Specific control measures and pheromone disruption for this pest is no used in Australia and so there is unlikely to be any impact on the establishment of this pest should it arrive in Australia.

4.7.3 Probability of spread

The probability that peach twig borer, having established a persistent population on a suitable host in Australia, will spread to other susceptible hosts both in the local area and more widely is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Suitability of natural and/or managed environment

- The peach twig borer is found in a variety of environments in North America, Europe, Asia and North Africa. It is likely that peach twig borer could spread to suitable environments in Australia where hosts are present.

Presence of natural barriers

- The adult peach twig borer is capable of independent flight, thus allowing for unassisted movement between areas. Information about flight lengths and times is unknown.
- There is little information on the ability of peach twig borer to spread beyond natural barriers such as deserts or mountain ranges.
- The long distances between some of the main Australian commercial orchards and production areas may make it difficult for peach twig borer to disperse directly from one production area to another unaided.
- This species has a demonstrated ability to spread. It has spread from the Mediterranean to most of Europe, parts of Asia and North America (CABI 2007).

Potential for movement with commodities, conveyances, or by other vectors

- The transportation of infested host material would aid the movement of peach twig borer within and between orchards. Existing interstate quarantine controls on the movement of nursery stock could reduce the rate of spread.

4.7.4 Probability of entry, establishment and spread

The probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive probabilities shown in Table 2.2.

The overall probability that peach twig borer will enter Australia as a result of trade in stone fruit from California and the Pacific Northwest states and be distributed in a viable state to suitable hosts, establish and subsequently spread, is estimated to be **LOW**.

4.7.5 Consequences

The consequences of the establishment of peach twig borer in Australia have been estimated according to the methods described in Table 2.3. The justification for these ratings is provided below:

Impact scores for peach twig borer	
Direct Impacts	**Estimate and Justification**
Plant life or health	**E** — Significant at the regional level. Peach twig borer can cause direct harm to its hosts, affecting fruit quality and plant health of nectarines, peaches and plums (Bentley and Day 2006a; Pickel *et al.* 2006c, Bentley *et al.* 2009c, Bentley *et al.* 2009c, Coates and Van Steenwyck 2009). These stone fruit hosts represent significant economic crops in Australia. Peach twig borer is a major pest of stone fruit across North America, Europe, Asia and North Africa (EPPO/CABI 1997c), where they damage the leaves, shoot and fruit (Pickel *et al.* 2006c; CABI 2007). It is likely the effect on the Australian stone fruit industry would be significant.
Any other aspects of the environment	**A** — Indiscernible at the local level. There are no known direct consequences of peach twig borer on any other aspects of the environment, but its introduction into a new environment may lead to competition for resources with native species.
Indirect Impacts	**Estimate and Justification**
Eradication, control, etc.	**D** — Significant at the district level. Establishment of this pest would require additional chemical treatment to control and eradicate this pest on is hosts (Pickel *et al.* 2006c; Bentley *et al.* 2009c; Coates and Van Steenwyck 2009). Control practices such as pheromone mating disruption and Spinosad® sprays have been effective in the US and would need to be applied in Australia to control this pest, should it establish. Eradication programs, if attempted, would likely be expensive. The introduction of this pest may result in an increase in the cost of production by triggering specific control strategies. Additionally, costs for crop monitoring and consultant's advice to manage these pests may be incurred by the producer.
Domestic trade	**D** — Significant at the district level. The presence of this pest in commercial production areas may have a significant effect at the local level due to resulting trade restrictions between states and territories. These restrictions may lead to loss of markets.
International Trade	**D** — Significant at the district level. Globally this species is a major pest of stone fruit and is capable of dispersing by

	independent flight (EPPO 2004b; Pickel *et al.* 2006c; Bentley *et al.* 2009c; Coates and Van Steenwyck 2009). The presence of peach twig borer in commercial production areas of a wide range of horticultural commodities (e.g. apricots, nectarines, peaches, plums) may limit access to overseas markets where this pest is not present. The introduction of pesticides to control this pest in Australia would likely restrict export market access to markets that are sensitive to the use of these chemicals.
Environment	**B** — Minor at the local level. Additional pre-harvest pesticide applications would be required to contain and/or eradicate this pest and control it on susceptible crops. Although additional treatments may affect the environment, the impact of pesticide run-off from commercial operations is not likely to result in impacts significantly greater than those that occur due to current measures for the control of other pests.

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**E**', the overall consequences are considered to be **MODERATE**.

4.7.6 Unrestricted risk

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

Unrestricted risk estimate for peach twig borer	
Overall probability of entry, establishment and spread	**Low**
Consequences	**Moderate**
Unrestricted risk	**Low**

As indicated, the unrestricted risk for peach twig borer has been assessed as 'low', which is above Australia's ALOP. Therefore, specific risk management measures are required for this pest.

4.8 Leafrollers (Lepidoptera: Tortricidae)

The species examined in this risk assessment are:

Archips argyrospila (Walker, 1863)	Fruit-tree leafroller
Archips podana (Scopoli, 1763)	Great brown twist moth
Archips rosana (Linnaeus, 1758)	European leafroller
Argyrotaenia citrana (Fernald, 1889)	Orange tortrix
Choristoneura rosaceana (Harris, 1841)	Oblique banded leafroller
Pandemis pyrusana Kearfott, 1907	Pandemis leafroller
Platynota stultana Walsingham, 1884	Omnivorous leafroller

The leafroller species listed above are recognised as pests that may be found associated with stone fruit in California and the Pacific Northwest states. These species have been grouped together because of their related biology and taxonomy and are predicted to pose a similar risk and require similar mitigation measures. The species of leafrollers assessed cause similar damage to foliage and fruits, and it is difficult to differentiate between the damage caused by different species. Due to the recognised importance of the omnivorous leafroller on many different host plants, it has been used as the basis for the risk assessment.

Leafrollers are the larval (caterpillar) stages of a number of species of moths which are members of the Tortricidae family, a family which includes over 5,000 species (Meijerman and Ulenberg 2000). The larvae of leafrollers feed on leaves and fruit and derive their common name from the habit of rolling leaves together with silk to form a protective shelter (Bentley *et al.* 2006a; Bentley *et al.* 2006b; Bentley *et al.* 2006c; Bentley *et al.* 2006d; Bentley *et al.* 2009d). This shelter may also be attached to fruit, or other feeding sites, so that feeding can occur without the caterpillar leaving the safety of the shelter (Bentley *et al.* 2006a; Bentley *et al.* 2006b; Bentley *et al.* 2009d). The distribution and abundance of leafrollers in orchards is influenced by the presence of suitable alternative host plants in the vicinity of individual orchards, including other fruit trees (HortResearch 1999). The Tortricidae family also includes a number of moths that are recognised as important fruit boring moths, including oriental fruit moth and codling moth. Due to their different biology and behaviour, the fruit boring moths have been assessed in a separate risk assessment.

Leafrollers lay eggs in clusters on host leaves and fruit and the larval stages feed on leaf tissue, shoot tips and fruit. On fruit, the larvae of the species considered here principally feed externally. When the adult leafroller is at rest, only the forewings are visible, with one overlapping the other to form a bell-shaped outline. The adult omnivorous leafroller is a small, dark brown moth, 9–12 mm long with a dark band on the wing and a long snout (Bentley *et al.* 2006c; Bentley *et al.* 2009e).

Eggs are laid in overlapping rows that resemble fish scales. The first generation of eggs are usually laid on host weeds in early March, and adults from this generation emerge in late Spring (May to June) and it is this generation that move into orchards to lay eggs on leaves and fruit. Larvae that hatch from this generation of eggs can cause significant damage to stone fruits (Bentley *et al.* 2006c; Bentley *et al.* 2009e) . The orange tortrix, which is mainly found in coastal areas, is a fawn to brown coloured moth with mottled wings. The larvae are straw to light green caterpillars with brown heads. The orange tortrix overwinters as larvae, and there are two to four generations each year in coastal areas (Coats and Van Steenwyck 2007a; Bentley *et al.* 2009d). A female orange tortrix will lay on average nine cream or green coloured masses each with around 33 eggs that darken as the eggs mature (Weires and Riedl 1991).

When disturbed, many leafroller species wriggle backwards and drop from a silken thread attached to the leaf or fruit surface. Omnivorous leafroller, fruit tree leafroller, orange tortrix and oblique banded leafroller are all reported to show this behaviour (Bentley *et al*. 2006c; Pickel *et al*. 2006d; Bentley *et al*. 2009e).

The risk scenario of concern in this risk assessment is the presence of leafroller eggs or larvae being present on imported stone fruit.

4.8.1 Probability of entry

The probability of entry is considered in two parts, the probability of importation and the probability of distribution, which consider pre-border and post-border issues respectively.

Probability of importation

The probability that leafrollers will arrive in Australia on fruit that has undergone standard production and post-harvest practices in the US is estimated to be **MODERATE**.

Supporting evidence for this assessment is provided in the text below:

Harvesting fruit for export

- Leafrollers feed on leaves and fruit, fruit damage is common on stone fruit in California (Weires and Riedl 1991; Curtis *et al.* 1992; Bentley *et al.* 2006cl Bentley *et al.* 2009e).
- Young and mature larvae occasionally attach leaves to the fruit as a shelter where they feed on the surface of the fruit (Bentley *et al.* 2006c).
- Egg masses are laid in clusters on the upper surface of host leaves and fruit. All larval stages, which may total five or six depending on the species, feed on the leaves and fruit of host plants (Bentley *et al.* 2006a; Bentley *et al.* 2006b; Bentley *et al.* 2009d).
- The larvae may feed internally or externally on fruit though external feeding damage is much more common (Yokoyama and Miller 1999).
- Internally feeding larvae eject droppings (frass) outside the fruit or protective shelter (Benz 1991). Most fruit with internally feeding larvae would show damage such as entrance holes, the presence of frass or fruit rots and heavily infested fruit is likely to be rejected during harvest and grading operations (Yokoyama and Miller 1999; Curtis *et al.* 1992; Pickel *et al.* 2006d).
- Infested fruit would not be suitable for harvest; however some internal feeders may not display obvious symptoms and could still be harvested.
- Fruit are typically picked into picking bags and then transferred into buckets or bins kept on the ground in the orchard before transportation to the packing house (Yokoyama and Miller 1999). Larvae may be disturbed and removed from fruit during harvest, they may contaminate harvest bins or containers used to transport stone fruit to the packing house.

Processing of fruit in the packing house

- Eggs, larvae and adults on the external surface of the fruit are likely to be removed by washing and defuzzing/brushing of fruit. This may be less effective for eggs or larvae that are near or in the stem end cavity.
- Contaminated fruit would usually have damage or webbing that indicated the presence of larvae (Pickel *et al.* 2006d). Sorting and grading would remove some fruit that are showing these symptoms, particularly when webbing remains on the stem end of fruit where defuzzing rollers can not effectively reach.

- Although internal feeding is not common, larvae feeding internally may display the presence of frass and or webbing that may be detected during sorting and grading.
- Secondary infection by fungi and bacteria that cause rots can occur on infested fruit and such fruit may be detected during packing house procedures (Curtis *et al.* 1991; Curtis *et al.* 1992).
- Incidence of omnivorous leafroller after packing house treatments for nectarines in California was 40 per 100 000 fruit, most being in the larval stage (91%) with the rest as pupae (Curtis *et al.* 1992).

Pre-export and transport to Australia

- Fruit is stored at around 1°C (Curtis *et al.* 1992; Yokoyama and Miller 1999).
- Transport of fruit to Australia would be either by air freight or by sea freight, with the total time in transit, from orchard until arrival in Australia, expected to take from a few days to three weeks.
- Leafrollers can survive cold conditions experienced during refrigerated transport, but survival rate decreased to around 6% after two weeks at <1°C (Yokoyama and Miller 2000).
- An additional treatment of slow release sulphur dioxide pads with cold treatment was successful in achieving 100 per cent mortality of omnivorous leafroller in table grapes (Yokoyama *et al.* 1999). High CO_2 concentrations combined with high temperatures are also effective in increasing omnivorous leafroller mortality (Zhou *et al.* 2000). However, these treatments are not considered as a mandatory practice for US stone fruit.
- Leafroller larvae have been detected several times on imported fresh apricots, peaches, nectarines, cherries and avocados from New Zealand (DAFF 2003; DAFF 2006), indicating that leafroller larvae can survive cold storage and transport.

Probability of distribution

The probability that leafrollers, having entered Australia on infested fruit, will survive during the movement of fruit within Australia after it has been released from the port of entry and be transported in a reproductively viable state to a suitable host is estimated to be **MODERATE**.

Supporting evidence for this assessment is provided in the text below:

- Leafrollers are known to be associated with stone fruit in the larval and pupal life stages (Curtis *et al.* 1992).
- If the larvae were to survive cold storage and transport to Australia it would then have to complete development and find a site to pupate.
- Omnivorous leafroller pupates in a webbed shelter created between leaves, or leaves and fruit (Bohart 1942; Bentley *et al.* 2006c; Pickel *et al.* 2006d).
- Pupation may occur during transport and live adult leafrollers could emerge soon after consignments arrive in Australia, although cold storage conditions would reduce the rate of development. This would increase the ability of the leafroller to disperse and locate a suitable host plant.
- Sexual reproduction is essential for leafrollers (Weires and Riedl 1991). After successful pupation, adults would therefore need to disperse and locate a mate, which will constrain their capacity to distribute in a reproductively viable state to a suitable host.
- Uneaten fruit that is not discarded is likely to be a suitable site for larvae to complete their development. Adults would need to disperse and locate a suitable mate, which may limit their capacity to distribute in a reproductively viable state to a suitable host.

- Fruit that is discarded into household trash or compost bins is likely to degrade quickly. Such fruit is unlikely to be suitable for larvae to complete development, unless larvae were already in a late stage of development. Therefore this distribution pathway would likely have a narrow window for successful distribution.
- After successful pupation, adults would disperse and locate a host. The wide host range of leafrollers would increase the potential for this pest to distribute to a suitable host.

Overall probability of entry (importation x distribution)

The overall probability of entry for leafrollers is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for leafrollers is estimated to be **LOW**.

4.8.2 Probability of establishment

The probability that leafrollers, having been distributed in a viable state to a suitable host, will establish a persistent population into the foreseeable future is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Availability of suitable hosts, alternate hosts and vectors in the PRA area

- Caterpillars of orange tortrix and omnivorous leafrollers have been recorded on more than 200 plant species in 71 families (CABI 2007; Powell 1983).
- Some of the more important and common leafroller hosts are: kiwifruit, apples, cotton, pears, grapes, citrus varieties, walnut, lupin, ivy, tea, laurel, and berries (Atkins Jr *et al.* 1957; AliNiazee and Stafford 1972; Curtis *et al.* 1992; Yokoyama and Miller 1999).
- Many known leafroller hosts are common and widely distributed throughout Australia. These include native and naturalized plants, household and garden plants and horticultural crops.

Suitability of the environment

- The leafrollers in this assessment are found throughout California and the Pacific Northwest states and across North America where climatic conditions are similar to areas within Australia, especially southern regions. Some of the leafrollers examined, for example European leafroller, are also found in Europe.

Reproductive strategy and the potential for adaptation

- Sexual reproduction is essential for leafrollers (Weires and Riedl 1991). After mating, eggs will be laid on a suitable host plant.
- The leafrollers under consideration for this assessment may produce up to four overlapping generations a year depending on latitude and climate (AliNiazee and Stafford 1972). Generally warmer climates reduce the generation time for leafroller species and increases the number of generations per year (Solomon 1991).
- The life cycle for the omnivorous leafroller can be completed in 30–45 days in Californian conditions, with higher temperatures resulting in shorter life cycles (AliNiazee and Stafford 1972).
- Leafrollers produce distinct female sex pheromones that are released in the evening and night, but particularly around dusk, to attract males over distances up to 400 meters (Webster and Carde 1982; Webster and Carde 1984; Shorey *et al.* 1996).
- Female omnivorous leafrollers mate only once, although other leafrollers are capable of mating more times (Webster and Carde 1984).

- Variation in fecundity (between 100–600 eggs per female) is determined by weather conditions, and the quality of host plants (Smirle 1993; Safonkin and Triseleva 2005).
- Populations can start from a single mated female, for example omnivorous leafrollers lay from 100–600 eggs over five days (Kearns *et al.* 2004).
- Many of the leafrollers assessed, including fruit-tree leafroller, great brown twist moth, oblique banded leafroller and pandemis leafroller have developed resistance to many different pesticides (Vakenti *et al.* 1984; Croft and Hull 1991; Smirle *et al.* 1998; Smirle *et al.* 2002; Smirle *et al.* 2003a; Smirle *et al.* 2003b; Dunley *et al.* 2006).

Cultural practices and control measures

- The pest control practices recommended by the University of California, Davis (Bentley *et al.* 2006b), recognise the impact of chemical sprays for other pests on leafroller populations.
- Organic control can be achieved using *Bacillus thuringiensis* and *Saccharopolyspora spinosa* sprays and pheromone traps (McLaren *et al.* 1999; Pickel *et al.* 2006d; Bentley *et al.* 2006c; Bentley *et al.* 2009e).
- Conventional insecticides may be successful in controlling leafroller populations but resistance is developing to some chemicals in some areas (Vakenti *et al.* 1984; Meagher and Hull 1986; Croft and Hull 1991; Smirle *et al.* 1998; Smirle *et al.* 2002; Smirle *et al.* 2003a; Smirle *et al.* 2003b; Dunley *et al.* 2006).
- While pest control activities in commercial orchards may limit or prevent the establishment of these pests, such controls are unlikely to be applied in urban and suburban areas or for feral host trees. Thus, the potential for establishment of leafrollers would not be reduced in most of these pests' potential geographic range in Australia.

4.8.3 Probability of spread

The probability that leafrollers, having established a persistent population on a suitable host in Australia, will spread to other susceptible hosts both in the local area and more widely is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Suitability of natural and/or managed environment

- The leafrollers in this assessment are found throughout California and the Pacific Northwest states and across North America where climatic conditions are similar to those in some regions of Australia. Some of the leafrollers examined, for example European leafroller, are also found in Europe.

Presence of natural barriers

- Adult leafrollers are capable of flight, thus allowing for unassisted movement between areas. Adults of some leafroller species have been recorded flying up to 400 m (HortResearch 2007).
- The long distances existing between some of the main Australian commercial orchards may make it difficult for this moth to disperse directly from one area to another unaided due to barriers such as mountains or deserts. However, spread within orchards and between adjacent orchards is likely to occur.
- The polyphagous nature of these species may enable them to locate suitable hosts in areas between stone fruit production areas. This may allow these species to spread between growing areas.

Potential for movement with commodities, conveyances or vectors

- A mixture of adult flight and the transportation of infested host material and fruit would aid the movement of these leafrollers within orchards and into new areas. Nursery stock for which there are no restrictions could be an important pathway for long distance spread.
- There are movement restrictions for fruit within Australia due to fruit fly concerns, but these restrictions apply to fruit from specific areas and required treatments may not be effective against these leafrollers.
- Interstate restrictions on the movement of nursery stock may also limit the human assisted spread of leafrollers.

4.8.4 Probability of entry, establishment and spread

The probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive probabilities shown in Table 2.2.

The overall probability that leafrollers will enter Australia as a result of trade in stone fruit from California and the Pacific Northwest states and be distributed in a viable state to suitable hosts, establish and subsequently spread, is estimated to be **LOW**.

4.8.5 Consequences

The consequences of the establishment of exotic leafrollers in Australia have been assessed according to the methods described in Table 2.3. The justification for these ratings is provided below:

Impact scores for exotic leafrollers	
Direct Impacts	**Estimate and Justification**
Plant life or health	**E** — Significant at the regional level. These leafrollers can cause direct harm affecting fruit quality and plant health of numerous fruit crops including kiwifruit, apples, cotton, pears, grapes, citrus varieties, walnut, lupin, ivy, tea, laurel, and berries (Atkins Jr et al. 1957; AliNiazee and Stafford 1972; Curtis et al. 1992; Yokoyama and Miller 1999). Some of the leafrollers are rated as primary economic pests in North America where they damage the leaves, buds and fruit of their hosts (Weires and Riedl 1991). Many of its hosts are significant economic crops in throughout Australia. It is likely that the effect on native plant could be significant, given the polyphagous nature of these leafrollers.
Any other aspects of the environment	**B** — Minor at the local level. While there are no known consequences of leafrollers on other aspects of the environment, their introduction into a new environment may lead to competition for resources with native species.
Indirect Impacts	**Estimate and Justification**
Eradication, control, etc.	**E** — Significant at the regional level. Additional programs to minimise the impact of these pests on host plants may be necessary. Existing control programs may not be effective. Several leafroller species in California and the Pacific Northwest states have developed resistance to organophosphate pesticides (Dunley *et al* 2006). Oblique banded leafroller and pandemic leafroller have developed resistance to organophosphates such as Azinphos-methyl® and cross-resistance to insect growth regulators tebufenozide and methoxyfenozide in Washington State as well as some populations also display cross-resistance to Spinosad® and Indoxacarb® (Dunley *et al.* 2006). Thus it would be more difficult to eradicate or control these pests if the resistant leafrollers were introduced into Australia.

	These pests may potentially increase production costs by triggering specific controls. The use of insecticides for control may increase because of difficulties estimating the optimum time for insecticide application. Increased costs for crop monitoring and consultant's advice to the producer may be incurred. The wide host range for the leafrollers assessed here would also make it difficult for these species to be eradicated once established.
Domestic trade	**D** — Significant at the district level. The presence of these pests in commercial production areas of commodities, such as pome fruit and stone fruit, may have a significant impact at the local level due to resulting trade restrictions on the sale or movement of a wide range of commodities between states and territories. These restrictions may lead to loss of markets and significant industry adjustment.
International Trade	**E** — Significant at the regional level. The presence of these leafrollers in commercial production areas of a wide range of horticultural commodities (e.g. apricots, nectarines, peaches, plums) would have a significant effect at the regional level due to limitations of accessing international markets where these pests are absent. Come of these moths, for example the oblique banded leafroller, is listed as an A1 quarantine pest by EPPO and is also of quarantine significance to South American countries. Further, the reintroduction of pesticides to control these pests in Australia is likely to restrict export market access in markets that are sensitive to the use of these chemicals.
Environment	**A** — In discernible at the local level. Additional pesticide applications or other control activities would be required to contain and/or eradicate these pests and control them on susceptible crops. However, this is unlikely to impact on the environment to any greater extent than already occurs from run-off into waterways from commercial crops due to control measures already in place for other pests

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**E**', the overall consequences are considered to be **MODERATE**.

4.8.6 Unrestricted risk

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5. The unrestricted risk estimation for leafrollers is shown below.

Unrestricted risk estimate for leafrollers	
Overall probability of entry, establishment and spread	**Low**
Consequences	**Moderate**
Unrestricted risk	**Low**

As indicated, the unrestricted risk for leafrollers has been assessed as 'low', which exceeds Australia's ALOP. Therefore, specific risk management is required for these pests.

4.9 *Cydia* spp. (Lepidoptera: Tortricidae)

The species considered in this assessment are

Cydia latiferreana (Walsingham, 1879) Filbertworm

This analysis also considers the following species which is of quarantine significance to Western Australia:

Cydia pomonella (Linnaeus, 1758) Codling moth [WA, EP]

Codling moth has previous been assessed with the importation of stone fruit from New Zealand. In that assessment, the probability of entry, establishment and spread was assessed to be 'extremely low' and the consequences assessed to be 'moderate'. An important consideration in that assessment was the very poor host status of stone fruit for codling moth, which differs from the preferred host status of apples and pears. As a result, the unrestricted risk was assessed to be 'negligible' and quarantine measures were not necessary to manage the risk.

The existing policy for codling moth is adopted for the importation of stone fruit from California, Idaho, Oregon and Washington as the risks of importation and distribution are judged to be similar. Therefore codling moth, a quarantine pest for Western Australia, is not considered further in the risk assessment presented here.

Filbertworm is recognised as a pest of stone fruit production in California and the Pacific Northwest states (Curtis *et al.* 1992; APHIS 2002a; APHIS 2006a). While filbertworm is a member of the Tortricidae family which has been principally considered in the assessment for leafrollers, the biology of filbertworm was considered sufficiently different to justify a separate consideration.

The larvae of the genus *Cydia* feed and burrow internally in fruit, causing the fruit to become unmarketable (EPPO 1999). Heavy infestations in untreated orchards can result in losses of up to 80 per cent, however stone fruit are not seen as important hosts in terms of economic damage (EPPO 1999; English 2001; WSU TFREC 2009). Filbertworm is recognised as an important pest of filberts (hazelnuts) (AliNiazee 1983a). However, filbertworm can also infest stone fruit (Curtis *et al.* 1992) and needs to be considered in detail here. Information on filbertworm appears to be scarce and so some information on the biology of other moths in the *Cydia* genus has been included.

Filbertworm has four life stages, adult, egg, larvae and pupae and is known to have significant morphological variation between specimens (Dohanian 1940). Moths vary from grey to reddish with golden bands across the forewing and a wingspan of 11–20 mm (Hollingsworth 2007; CABI 2007). The female moth lays eggs singly on or near hazelnuts (Dohanian 1940). Mature larvae are whitish 12–15 mm in length (Hollingsworth 2007; CABI 2007).

Filbertworm feed internally in the fruit, causing damage by boring holes throughout the flesh. The large tunnels created by the larvae are commonly filled with excreta (frass). The damage caused by entrance holes also provide an opportunity for secondary infection with a range of bacteria and fungi. In severe cases up to 40 per cent of hazelnuts may be affected by filbertworm (AliNiazee 1983a).

The risk posed by filbertworm is the presence of eggs or larvae inside fruit that could lead to the establishment of this pest in Australia.

4.9.1 Probability of entry

The probability of entry is considered in two parts, the probability of importation and the probability of distribution, which consider pre-border and post-border issues respectively.

Probability of importation

The probability that filbertworm will arrive in Australia on fruit that has undergone standard production and post-harvest practices in the US is estimated to be **VERY LOW**.

Supporting evidence for this assessment is provided in the text below:

Harvesting fruit for export

- Information on the prevalence of filbertworm in orchards is lacking. Although filbertworm is recognised as a pest that can infest stone fruit (APHIS 2007a), and occurs in relatively low numbers (Curtis *et al.* 1992).
- Filbertworm feed inside the fruit, boring a hole towards the stone in a similar manner to codling moth (Curtis *et al.* 1992). Damage to the outside of fruit may be noticeable at harvest and result in infested fruit being culled.

Processing of fruit in the packing house

- Damage caused by filbertworm is described as similar to the damage caused by codling moth (Curtis *et al.* 1992) which bores entrance holes into the fruit that are filled with frass that exudes from the entrance hole (Hollingsworth 2007).
- Eggs, larvae or pupae on the external surface of the fruit are likely to be removed by washing and brushing/defuzzing. However, filbertworm pupae have been found in the stem cavity of nectarine in California after these processes (Curtis *et al.* 1992).
- Sorting and grading would remove some fruit that are contaminated with external larvae and some fruit containing internal larvae, as entrance holes or frass (droppings) outside the fruit would be noticeable (Curtis *et al.* 1992).
- Microbial breakdown may occur in infested fruit and such fruit may be detected during packing house procedures.
- The incidence of filbertworm on nectarine after packing house treatments was 1.8 per 100,000 fruit, with 83 per cent as larvae and the remainder being pupae (Curtis *et al.* 1992). The low prevalence of reported infections suggests these pests have a limited capacity to be transported on the pathway after packing house procedures.

Pre-export and transport to Australia

- Fruit is stored at around 1°C (Curtis *et al.* 1992; Yokoyama and Miller 1999).
- Transport of fruit to Australia would be either by air freight or by sea freight, with the total time in transit, from orchard until arrival in Australia, expected to take from a few days to three weeks.
- Complete mortality of codling moth eggs was achieved after 14 days at 0°C. Mature larvae are far more tolerant of cold temperatures, with 21 days at 0°C achieving only 30% mortality of fifth stage instars. Larvae that survive cold storage suffer no negative effects on fecundity (Yokoyama and Miller 1989).

Probability of distribution

The probability that filbertworm, having entered Australia on infested fruit, will survive during the movement of fruit within Australia after it has been released from the port of entry and be transported in a reproductively viable state to a suitable host is estimated to be **MODERATE**.

Supporting evidence for this assessment is provided in the text below:

- Filbertworm is associated with stone fruit in the larval or pupal life stages (Curtis *et al.* 1992).
- If the larvae or pupae were to survive cold storage they would need to complete development and then find a suitable site to pupate.
- While the imported fruit would be a suitable site for development, this would need to be completed before fruit is either destroyed, eaten or decomposes.
- Larvae could potentially emerge at unpacking and repacking facilities, retailers, on discarded fruit in waste, at landfills where the waste is disposed, during transportation of purchased stone fruit from retailers to households, or at the consumers' residence.
- Filbertworm pupates in the fruit, on the trees or in the soil (Dohanian 1940). Pupation of filbertworm takes at least 15 days depending on weather conditions (Dohanian 1940).
- In all cases, overwintering is accomplished by the diapausing fifth instar larvae in cocoons under the bark and in holes in the wood of host trees. These larvae develop into pupae in the spring before emerging as adult moths.
- After successful pupation, adults would disperse and look for a mate. Filbertworms appeared to be reluctant to fly in laboratory cages, but in field cages were seen to fly short, unquantified, distances (Dohanian 1940).
- Filbertworm adults are more active at dusk and early evening (AliNiazee 1983b; Howell 1991).
- Hosts for filbertworm are hazelnuts, but may infest stone fruit, oaks, walnut and pomegranate (Dohanian 1940; Michelbacher *et al*. 1956; AliNiazee 1983a; Davis *et al.* 1983; Curtis *et al.* 1992; Harper *et al.* 2000). Hazelnuts are a small commercial industry in Australia, but stone fruit is a relatively large industry and host trees such as *Prunus* and oaks may also be found in urban and suburban areas.

Overall Probability of entry (importation x distribution)

The overall probability of entry for filbertworm is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for filbertworm is estimated to be **VERY LOW**.

4.9.2 Probability of establishment

The probability that filbertworm, having been distributed in a viable state to a suitable host, will establish a persistent population into the foreseeable future is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Availability of suitable hosts, alternate hosts and vectors in the PRA area

- The filbertworm is primarily a pest of filberts (hazelnuts), but may infest stone fruit, oaks and pomegranate (Dohanian 1940; AliNiazee 1983a; Davis *et al.* 1983; Curtis *et al.* 1992; Harper *et al.* 2000).
- Suitable host species are present in Australia, with stone fruit distributed widely in both commercial production areas and in urban and suburban areas. Oaks are widespread in suburban areas, especially in southern Australia, suggesting that filbertworm adults could find hosts on which to oviposit and establish.

Suitability of the environment

- Filbertworm is found throughout California and the Pacific Northwest states and across North America where climatic conditions are similar to those of Australia.

Reproductive strategy and the potential for adaptation

- Sexual reproduction is essential for filbertworm (Dohanian 1940; Howell 1991). The female of each species produces a pheromone to attract males (Davis and McDonough 1981; Howell 1991; Vickers and Rothschild 1991; Wearing *et al.* 2001).
- The filbert worm lays eggs singly and may have 1–2 generations per year (Dohanian 1940).
- Female codling moths carry a full complement of eggs at eclosion and can begin ovipositing the day after mating, with an average of 50–100 eggs laid per female (Wearing *et al.* 2001). It is presumed that filbertworm has a similar reproductive capacity.
- Given the necessity for sexual reproduction and the number of eggs laid per reproductive event, populations could establish from a single mated female. After larvae have hatched from eggs they can develop, pupate and become adults and mate before laying their eggs to establish a new population (Dohanian 1940).

Cultural practices and control measures

- Pheromone traps are used to estimate filbert worm populations in order to maximise chemical treatment impact (AliNiazee 1983c; Hollingsworth 2007). Chemical treatment is the major method of control (AliNiazee 1983a).
- It is unlikely that suitable controls would be applied in urban or suburban areas, and chemical spray timing in rural areas is unlikely to coincide with the period when these moths are inside the fruit and therefore protected from non-systemic insecticides. Therefore, it is unlikely that current control measures would impact on the establishment of these species in Australia.

4.9.3 Probability of spread

The probability that filbertworm, having established a persistent population on a suitable host in Australia, will spread to other susceptible hosts both in the local area and more widely has been determined to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Suitability of natural and/or managed environment

- Filbertworm is found throughout California and the Pacific Northwest states and across North America where climatic conditions are similar to those in some regions of Australia. Codling moth is already established in eastern Australia.

Presence of natural barriers

- The long distances between some of the main Australian commercial orchards may make it difficult for these moths to disperse directly from one area to another unaided. However, hosts such as oaks could be found in areas and thus provide opportunities for spread between important commercial production areas.

Potential for movement with commodities, conveyances or vectors

- A mixture of adult flight and the transportation of infested stone fruit trees and fruit would aid the movement of the moths within orchards and into new areas. Nursery stock for which there are no restrictions could be an important pathway for long distance spread.
- Existing interstate quarantine control on the movement of nursery stock could reduce the rate of scope for the spread.
- Larvae that are feeding internally in stone fruit would be distributed through the wholesale or retail trade.
- The difficulty in identifying nuts infested with filbertworm would increase the chance of filbertworm being transported with harvested commodities.

4.9.4 Probability of entry, establishment and spread

The probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive probabilities shown in Table 2.2.

The overall probability that filbertworm will enter Australia as a result of trade in stone fruit from California and the Pacific Northwest states and be distributed in a viable state to suitable hosts, establish and subsequently spread is estimated to be **VERY LOW**.

4.9.5 Consequences

The consequences of the establishment of filbertworm in Australia have been assessed according to the methods described in Table 2.3. The justification for these ratings is provided below:

Impact scores for filbert worm	
Direct Impacts	**Estimate and Justification**
Plant life or health	**D** —Significant at the district level. In North America filbertworm is considered a major pest of filberts (hazelnuts) and an occasional stone fruit pest (AliNiazee 1983a; Curtis *et al.* 1992). Filbertworm is capable of causing over 50% damage to hazelnut plantations if left untreated (AliNiazee 1998). In Australia, there is an estimated 75 hectares of hazelnut production (Hazelnut Nursery Propagators 2006), but the commercial value of other potential hosts such as stone fruit is much greater. Walnuts are a known host with up to 40 per cent damage caused in bad seasons (Michelbacher *et al*. 1956). While the Australian walnut industry is small, producing around 1000 tonnes, it is a growing industry and could be significantly affected by this pest. Oaks are another host to this pest and are commonly found as amenity trees, especially in southern Australia. As damage by this pest is primarily to the fruits and nuts of hosts, the amenity value many not be significantly reduced, however feeding on twigs or shoots could cause some impact.

Any other aspects of the environment	**A** — Indiscernible at the local level. There are no known direct consequences of filbertworm on the natural or urban environment, but its introduction into a new environment may lead to competition for resources with other established species.
Indirect Impacts	**Estimate and Justification**
Eradication, control, etc.	**D** — Significant at the district level. Should filbertworm establish in Australia, additional costs would be incurred as part of the management of this pest. Eradication may be considered, but the relatively narrow host range with limited commercial production could assist with eradication programs. The costs of ongoing control measures are difficult to estimate and would be dependant on the host range of this pest in Australia.
Domestic trade	**D** — Significant at the district level. The presence of filbertworm in commercial production areas may have an effect at the local level due to any resulting interstate trade restrictions on a wide range of commodities. These restrictions could lead to a loss of markets, which in turn would be likely to require industry adjustment.
International Trade	**D** — Significant at the district level. The presence of filbertworm in Australia is expected to limit access to overseas markets while new quarantine treatments are developed and approved by importing countries.
Environment	**B** — Minor at the local level. Additional pesticide applications or other control activities may be required to contain and/or eradicate filbertworm and control them on susceptible crops. Run-off from such applications may have minor environmental impacts.

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are **‘D’**, the overall consequences are considered to be **LOW**.

4.9.6 Unrestricted risk

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5. The unrestricted risk estimation for *Cydia* fruit moths is shown below.

Unrestricted risk estimate for *Cydia* moths	
Overall probability of entry, establishment and spread	**Very Low**
Consequences	**Low**
Unrestricted risk	**Negligible**

As indicated, the unrestricted risk for filbertworm has been assessed as ‘negligible’, which meets Australia’s ALOP. Therefore, specific risk management measures are not required for these pests.

4.10 *Grapholita* spp. (Lepidoptera: Tortricidae)

The species considered in this risk assessment are:

Grapholita packardi Zeller, 1875	Cherry fruitworm
Grapholita prunivora (Walsh, 1868)	Lesser apple fruitworm

This analysis also considers the following species which is of quarantine significance to Western Australia:

Grapholita molesta (Busck, 1916)	Oriental fruit moth [EP, WA]

Oriental fruit moth has previous been assessed with the importation of stone fruit from New Zealand into Western Australia. In that assessment, the probability of entry, establishment and spread was estimated to be ‘low’ and the consequences estimated to be ‘moderate’. As a result the unrestricted risk was assessed to be ‘low’ and quarantine measures were determined to be necessary to manage the risk.

The existing policy for oriental fruit moth is adopted for the importation of stone fruit from California, Idaho, Oregon and Washington, as the risks of importation and distribution are judged to be similar. Therefore, oriental fruit moth, a quarantine pest for Western Australia, is not considered further in the risk assessment presented here.

The two remaining moths considered in this assessment are recognised as potential pests of stone fruit production in California and the Pacific Northwest states. While these species are also members of the family Tortricidae which has been largely considered in the assessment for leafrollers, the biology of these species was considered sufficiently different to justify a separate assessment. Both species considered in this assessment have been grouped together because of their related biology and taxonomy and are predicted to pose a similar risk and require similar mitigation measures.

The larvae of the genus *Grapholita* feed internally on fruit and also on twigs and their twig and fruit boring behaviour distinguishes them from other members of the Tortricidae family. Due to their direct damage to the fruit, these pests have the potential to cause serious damage to host crops and are considered to be important pests. These moths have four life stages: adults, eggs, larvae (or caterpillars) and pupae.

The lesser apple fruitworm is a species widespread in North America (Mantey *et al.* 2000). It is recognised as a pest of stone fruits in the Pacific Northwest (Brown 1953; Mantey *et al.* 2000). The adults are smaller than oriental fruit moth with a wingspan of 8 mm (Neven and Mantey 2004). Eggs are laid on fruit or on leaves (Brown 1953).

The cherry fruitworm is considered a minor pest on blueberries and apple (Tomlinson Jr 1951; Mallampalli and Isaacs 2002). It can be a serious pest on cherry (Hoerner and List 1952). The adult moth has a wingspan from 6–9.5mm (Hoerner and List 1952). In laboratory trials eggs are often laid on leaves while in the field eggs are often laid on cherry fruit (Hoerner and List 1952).

The risk scenario of concern is the presence of eggs or larvae on or in imported stone fruit, resulting in the establishment of these pests in Australia.

4.10.1 Probability of entry

The probability of entry is considered in two parts, the probability of importation and the probability of distribution, which consider pre-border and post-border issues respectively.

Probability of importation

The probability that *Grapholita* moths will arrive in Australia on fruit that has undergone standard production and post-harvest practices in the US is estimated to be **LOW**.

Supporting evidence for this assessment is provided in the text below:

Harvesting fruit for export

- *Grapholita packardi* is recorded from apple, blueberry, cherry, hawthorn, plum, peach and rose (Chapman and Lienk 1971). *Grapholita prunivora* has been reported on *Amelanchier* (serviceberry and shadbush), hawthorn, *Prunus* (apricot, cherry, peach, plum, and prune) and *Pyrus* (apple, crab apple and pear) (Moffitt and Willett 1993; Mantey *et al.* 2000). The activity of cherry and lesser apple fruitworm larvae are considered to be similar to the oriental fruit moth (Tomlinson Jr 1951; Hoerner and List 1952; Brown 1953; Barceneas *et al.* 2005).
- Infestation by oriental fruit moth in stone fruit affects both the shoots and fruit (Rothschild and Vickers 1991; Gencsoylu *et al.* 2006). Fruit infestation is caused by larvae tunnelling into the fruit (Rothschild and Vickers 1991). Secondary rots can often follow after initial tunnelling causing further damage to the fruit (Rothschild and Vickers 1991). The internal feeding by other *Grapholita* species is predicted to cause similar damage and have similar secondary rots.
- Reports of *G. packardii* in plum (as *Epinotia pyricolana*) refer back to Foster and Jones (1909), while reports in peach to Garman (1918, unsighted). The report by Heinrich (1926), notes that there is a small number of questionable records for peach and that fruit of hosts (primarily apples) are rarely attacked. The EPPO datasheet for this pest (EPPO 1997p, listed as *Cydia packardi*) further notes that *G. packardi* has not been a significant pest of either apples or peaches since the early 1900's.
- Internally feeding larvae eject gum and frass from the wound area as the larvae bore into the fruit (Chapman and Lienk 1971; Hogmire and Beavers 1998). As the gum ages, a sooty mould may develop, turning the wound area black (Hogmire and Beavers 1998). The formation of these secondary rots after tunnelling causes additional damage to the fruit. Therefore, fruit with internally feeding larvae would show obvious symptoms of infestation, and are likely be rejected during routine quality inspections throughout harvest operations. However, fruit containing early instar larvae may not always present with obvious symptoms of infestation and could potentially remain undetected.
- Reports of *G. prunivora* are also uncommon. Chapman and Lienk (1971) provide a number of references for plums being host plants, some dating back to the early 1900's. Quaintance (1908) reported it was found to feed on buds of apples and fruits of cherries. Feeding on young plums caused fruit drop, but boring into mature fruit was also recorded (Quaintance 1908). Plums and peaches are reported as hosts (Heinrich 1926), but references were not provided. While *G. prunivora* was reported to be a serious pest of plum fruit in Oregon during the 1950's (Brown 1953), there have been no reports since of it as a pest and no specific control measures are in place for this pest.
- While both of these pests historically had the potential to be associated with stone fruit production, the absence of any contemporary records indicates that they are either rare pests or effectively controlled under modern orchard management practices. However, these pests might be associated with production, or become more prevalent if management practices changed.

Processing of fruit in the packing house

- Where the fruit are attacked directly, an individual larva will usually complete its feeding period within the same fruit (Rothschild and Vickers 1991). Final instar larvae leave the shoots, stems or fruits to find an appropriate pupation site which may be in the soil, or in crevices in the tree (Rothschild and Vickers 1991).
- Sorting and grading would remove some fruit that are contaminated with external larvae and some fruit containing internal larvae as entrance holes or frass (droppings) outside the fruit would be noticeable (Curtis *et al.* 1992). However, these symptoms may not always be present.
- Microbial breakdown can occur on infested fruit and such fruit may be detected during packing house procedures (Rothschild and Vickers 1991).

Pre-export and transport to Australia

- After packing, fruit is stored at around 1°C (Curtis *et al.* 1992; Yokoyama and Miller 1999).
- Transport of fruit to Australia would be either by air freight or by sea freight, with the total time in transit, from orchard until arrival in Australia, expected to take from a few days to three weeks.
- The lesser apple fruitworm is thought to be more cold tolerant than oriental fruit moth (Neven 2004), though a direct comparison has not been made. At 2°C, 99 per cent mortality of late stage (blackhead) eggs of the lesser apple fruitworm was achieved after 52 days (Neven 2004). Larvae are more cold tolerant and 99 per cent mortality of fourth instar larvae, the most tolerant stage, is achieved after 236 days (Neven 2004), while 99 per cent mortality of the least cold tolerant larval stage, first instars, taking 46 days.
- On completion of feeding, mature larvae of these pests leave the shoots, stems or fruits of their hosts to locate suitable overwintering sites, where they spin a cocoon prior to hibernation (Hoerner and List 1952; Brown 1953; Rothschild and Vickers 1991). Given the distribution profile of these three species throughout the United States and Canada, and the temperatures through which the overwintering diapause stages must endure, they are likely to be capable of surviving cold transportation conditions.

Probability of distribution

The probability that *Grapholita* moths, having entered Australia on infested fruit, will survive during the movement of fruit within Australia after it has been released from the port of entry and be transported in a reproductively viable state to a suitable host is estimated to be **MODERATE**.

Supporting evidence for this assessment is provided in the text below:

- Cherry fruitworm and lesser apple fruitworm are recorded as laying eggs on fruit (Hoerner and List 1952; Brown 1953). Assuming eggs or larvae of these pests were to survive fruit harvesting, processing, cold and/or controlled atmosphere storage, and transport to Australia, these pests would have to find a site to complete development, and to subsequently pupate. Larvae could potentially complete their development in the fruit but development through to pupation would need to be completed before the fruit desiccates or rots. Otherwise, an alternative host would be required for the completion of development.
- Distribution of the commodity would be for retail sale as the intended use of the commodity is human consumption. Larvae could potentially emerge at unpacking and repacking facilities (if these are used), retailers, on discarded fruit in waste, at landfills where the waste is

disposed, during transportation of purchased stone fruit from retailers to households, or at the consumer's residence.

- Fruit showing obvious symptoms would likely be unmarketable and disposed of before sale. Fruit without symptoms, or with only minor infestations, are likely to be consumed. Any waste material would need to be disposed of in the environment near suitable hosts given the limited dispersal capacity of larvae. Any fruit that are discarded are likely to be in bins or composting systems. The colonisation of fruit by saprophytic fungi or bacteria would quickly rot the fruit.
- Once a suitable site has been found, such as in the soil or in crevices on the tree, the larvae pupate. Oriental fruit moth pupae (surrounded by a silk cocoon) take 10–16 days to emerge as adults, depending on temperature (Rothschild and Vickers 1991). Pupae of lesser apple fruitworm take at least nine days to emerge though in the wild it may be about 14–20 days depending on weather conditions (Brown 1953; Neven and Mantey 2004). Cherry fruitworm pupates for an average of 29 days (Hoerner and List 1952). Cherry fruitworm can pupate inside host fruit while the lesser apple fruitworm pupates outside of the fruit, usually in the soil (Hoerner and List 1952; Brown 1952).
- After successful pupation, adults emerge to disperse and look for a mate (Rothschild and Vickers 1991). Dispersal of adults is by flight. In laboratory studies, tethered female oriental fruit moths were found to fly further than males (Hughes and Dorn 2002). In these studies, the longest single flight for females moths was over 700m and the total distance flown over 10 days was approximately 4km (Hughes and Dorn 2002). Cherry fruitworm and lesser apple fruitworm are assumed to be capable of flying similar distances.
- Sexual reproduction is essential for all species under review (Rothschild and Vickers 1991; Neven and Mantey 2004). The female of each species produces a pheromone to attract males. The pheromones produced are very similar in composition across the species and extracts can be used to attract males of all the species (Roelofs *et al.* 1969; Gentry *et al.* 1974; Roelofs and Carde 1974; Pfeiffer and Killian 1988). After mating, eggs will be laid on a suitable host plant.
- The conditions in Australia may be suitable for larvae to emerge immediately after they arrive in Australia.
- Hosts for the lesser apple fruit worm include apples, pears and stone fruit while hosts for the cherry fruitworm include cherries and other stone fruit. These hosts are commonly found in suburban areas as well as in commercial production.

Overall probability of entry (importation x distribution)

The overall probability of entry for *Grapholita* moths is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for *Grapholita* moths is estimated to be **LOW**.

4.10.2 Probability of establishment

The probability that *Grapholita* moths, having been distributed in a viable state to a suitable host, will establish a persistent population into the foreseeable future has been determined to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Availability of suitable hosts, alternate hosts and vectors in the PRA area

- Although not an exhaustive list, the main collective hosts of note for these species includes apple, apricot, blueberry, cherry, crab apple, hawthorn, peach, pear, plum, prune, rose, serviceberry and shadbush (Chapman and Lienk 1971; Moffitt and Willett 1993; Mantey *et al*. 2000). Many of these hosts are widespread throughout Australia, enabling these species to establish persistent populations.

Suitability of the environment

- The moths in this assessment are found throughout California and the Pacific Northwest states as well as across North America. Many of these regions have similar climates to regions within Australia, suggesting environmental conditions are likely to be amenable to the establishment of these species in Australia.
- *Grapholita molesta* has been reported from NSW, Qld., Tas., Vic and the ACT (APPD 2009). The presence of this pest in Australia suggests the Australian environment is likely to be suitable for the establishment of the other *Grapholita* species assessed here.

Reproductive strategy and the potential for adaptation

- Populations can begin from a single mated female. After larvae have hatched from eggs they can develop, pupate and become adults and mate before laying their eggs to establish a new population.
- In oriental fruit moth, adults generally become sexually active 24–28 hours after emergence (Smith and Summers 1948; Rothschild and Vickers 1991). Sexual activities are mediated by female pheromones and the calling period (release of pheromones to attract males) extends from about three hours before to one hour after sunset (Rothschild and Vickers 1991). Males are sexually responsive over a longer period than females (Rothschild and Vickers 1991). Males usually only mate once in a 24 hour period, but may mate with different females on successive nights (Rothschild and Vickers 1991). A single mating is sufficient for a female to lay her full complement of viable eggs (Smith and Summers 1948). While similar data is not available for the specific moths considered here, they are assumed to behave similarly as they are members of the same genus.
- Egg laying usually begins 2–5 days after the females emerge and continues for 7–10 days (Rothschild and Vickers 1991). Up to 234 eggs are laid on the underside of leaves near the growing tips or on fruit (Smith and Summers 1948). The proportion of successful hatchings declines with daily maximum temperature and/or relative humidity, though leaf microclimates may offset this (Smith and Summers 1948).
- In laboratory experiments, lesser apple worm laid up to 136 eggs, though the average per female was 42 (Neven and Mantey 2004). The potential high fecundity for all three species would allow the rapid establishment of these pests in an Australian setting.

Cultural practices and control measures

- Similar pheromones used for oriental fruit moth are also effective against lesser apple fruitworm (Roelofs *et al.* 1969; Gentry *et al.* 1974; Willson and Trammel 1975; Pfeiffer and Killian 1988). Pheromone disruption is effective against lesser apple fruitworm and cherry fruitworm (Gentry *et al.* 1974; Roelofs *et al.* 1969; Willson and Trammel 1975; Pfeiffer and Killian 1988). However, such controls are not applied in urban and suburban areas and are not required in all orchards. Therefore, the establishment of these pests in Australia is unlikely to be affected.

4.10.3 Probability of spread

The probability that *Grapholita* moths, having established a persistent population on a suitable host in Australia, will spread to other susceptible hosts both in the local area and more widely is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Suitability of natural and/or managed environment

- The moths in this assessment are found throughout the Pacific Northwest states and across North America, where climatic conditions are similar to some regions in Australia, particularly southern Australia. The Australian environment is likely to be suitable for the spread of these species.
- *Grapholita molesta* is currently reported from the ACT, NSW, Qld., Tas., and Vic (APPD 2009). Given this species has demonstrated the ability to spread to most Australian states and territories, the Australian climate is likely to be amenable to the spread of the other two assessed species.

Presence of natural barriers

- The long distances between some of the main Australian commercial orchards may make it difficult for these moths to disperse directly from one area to another unaided. However, the prevalence of hosts, such as apples and *Prunus*, in the intervening areas may allow for the local spread from plant to plant, and slow spread between areas.

Potential for movement with commodities, conveyances or vectors

- Larvae that feed internally could be distributed through the wholesale or retail trade of stone fruit.
- A mixture of adult flight and facilitated transport of infested host commodities would aid the movement of these moths within orchards and into new areas. Larvae that feed internally could be distributed through the wholesale or retail trade of stone fruit. Given the obvious symptoms of infestation, any infested fruit would likely be discarded.
- Commodities infested by *Grapholita* moths primarily include fruit and nursery stock (Canadian Food Inspection Agency 2007; Virginia Tech 2009). These commodities are moved within states and between states, which would assist in the spread of these pests. While nursery stock is a potentially important means of spread for oriental fruit moth, is unlikely to be a significant mechanism for spread as the moths assessed here are rarely found boring into shoots and twigs.

4.10.4 Probability of entry, establishment and spread

The probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive probabilities shown in Table 2.2.

The overall probability that *Grapholita* moths will enter Australia as a result of trade in stone fruit from California and the Pacific Northwest states and be distributed in a viable state to suitable hosts, establish and subsequently spread, is estimated to be **LOW**.

4.10.5 Consequences

The consequences of the establishment of *Grapholita* moths in Australia have been assessed according to the methods described in Table 2.3. The justification for these ratings is provided below:

Impact scores for exotic *Grapholita* moths	
Direct Impacts	**Estimate and Justification**
Plant life or health	**E** — Significant at the regional level. These species are recorded as being capable of causing direct damage to host plants. In North America, cherry fruitworm and lesser apple fruitworm have been reported as potentially serious pests of stone fruit (Hoerner and List 1952; Brown 1953) and may have significant impacts in Australia where established natural enemies are not present and different chemical and cultural control practices are used. More important hosts for these pests include apples and cherries. Apples are a major crop in Australia with over 270 000 tonnes of production, while cherries have around 10 000 tonnes (Australian Bureau of Statistics 2007). While these pests are considered to be minor pests in the US (Chapman and Lienk 1971), their high pest potential is cause for concern.
Any other aspects of the environment	**A** — Indiscernible at the local level. There are no known consequences of *Grapholita* spp. on other aspects of the environment but their introduction into a new environment may lead to competition for resources with native moth species.
Indirect Impacts	**Estimate and Justification**
Eradication, control, etc.	**D** — Significant at the district level. The impact of these pests in their native range (North America) is of little concern and they are considered minor pests (Chapman and Lienk 1971). However, they do have a potential to become pests (Chapman and Lienk 1971) and if introduced into new areas may behave differently. The potential costs could approach those as seen for oriental fruit moth which cost several million dollars to eradicate from Western Australia in 1952 (Botha *et al.* 2000). There may be increases in the use of insecticides for control of these pests and appropriate spray timing would need to be determined for Australia. If eradication for any or all of these species is considered unfeasible, increases in production costs are expected due to activities that would be required to meet the quarantine requirements of important trading partners.
Domestic trade	**D** — Significant at the district level. The presence of the cherry fruitworm or lesser apple fruitworm in any region of Australia is likely to result in domestic movement restrictions on many commodities, particularly stone fruit and pome fruit. This may lead to the loss of domestic markets and difficulties in re-establishing trade until new regulations are established.
International Trade	**E** — Significant at the regional level. The presence of these *Grapholita* spp. in commercial production areas on a range of horticultural commodities including stone fruit and pome fruit may limit access to overseas markets where these pests are not present (Barcenas *et al.* 2005). New quarantine restrictions are likely to be imposed for both cherry fruitworm and lesser apple fruitworm. While the two pests assessed here appear to have only minor pest status in the USA, they are listed as A1 pests by EPPO.
Environment	**B** — Minor at the local level. Additional pesticide applications or other control activities would be required to contain and/or eradicate these pests and control them on susceptible crops. However, this is likely to have only minor impacts on the environment when compared to that which already occurs from run-off into waterways from commercial crops due to control measures for other pests.

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are **'E'**, the overall consequences are considered to be **MODERATE**.

4.10.6 Unrestricted risk

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5. The unrestricted risk estimation for *Grapholita* fruit moths is shown below.

Unrestricted risk estimate for *Grapholita* moths	
Overall probability of entry, establishment and spread	**Low**
Consequences	**Moderate**
Unrestricted risk	**Low**

As indicated, the unrestricted risk for *Grapholita* fruit moths has been assessed as 'low', which is above Australia's ALOP. Therefore, specific risk management is required for these pests.

4.11 Thrips (Thysanoptera: Thripidae)

The species examined in this pest risk assessment are:

Frankliniella intonsa (Trybom, 1895)	Taiwan flower thrips
Frankliniella occidentalis (Pergande, 1895)	Western flower thrips **EP**
Frankliniella tritici (Fitch, 1855)	Flower thrips
Taeniothrips inconsequens (Uzel, 1895)	Pear thrips

Western flower thrips has previous been assessed with the importation of stone fruit from New Zealand. In that assessment, the probability of entry, establishment and spread was estimated to be 'moderate' and the consequences estimated to be 'low'. As a result the unrestricted risk was estimated to be 'low' and quarantine measures were determined to be necessary to manage the risk.

The existing policy for western flower thrips is adopted for the importation of stone fruit from California, Idaho, Oregon and Washington as the risks of importation and distribution are judged to be similar. Therefore, western flower thrips is not considered further in the risk assessment presented here.

The other thrips species considered in this assessment are recognised as pests of stone fruit and are present in one or more of the exporting states. These species have been grouped together because of their related biology and taxonomy, and are predicted to pose a similar risk and to require similar mitigation measures. Unless explicitly stated, the information presented is considered as applicable to all four species assessed.

Thrips are minute, winged insects of the order Thysanoptera that are characterised by their narrow wings with distinctive hair fringe. Thrips cause direct damage to host plants through feeding and oviposition (Antonelli 2003) and indirect damage by vectoring microbial and viral pathogens, such as tospoviruses (Morse and Hoddle 2006). Thrips are commonly polyphagous with a wide range of host plants and are distributed worldwide in a variety of environments (Dreistadt *et al.* 2007b). They show a general preference for immature, succulent plant tissue and feed by puncturing host tissue and sucking the exuded cell contents (Agnello and Kain 1996; Antonelli 1996; Dreistadt *et al.* 2007b).

The reproductive biology of thrips species is often inferred from sex ratio data (Kumm 2002). Most thrips reproduce through both sexual and parthenogenetic reproduction, where unfertilised eggs produce male offspring (Lewis 1973; Kumm 2002).

The thrips species assessed here are all members of the suborder Terebrantia. This suborder of thrips has an egg stage, two feeding larval instars, two quiescent pre-pupal/pupal instars and the adult (McDonald *et al.* 2000; Hoover 2002a; Kumm 2002; Mound 2005; Frank 2009). Eggs are deposited in protected areas of the plant, such as in buds, furled leaves and the fruit and larvae usually feed in these areas after hatching (Smith and Van Driesche 2003; Dreistadt *et al.* 2007b).

Near the end of the second larval instar, the immature thrips enter the soil or leaf litter as non-feeding pre-pupae in readiness for pupation (Smith and Van Driesche 2003; Dreistadt *et al.* 2007b). Adults then emerge when soil and ambient temperatures are favourable in early spring as buds begin to swell (Hoover 2002a; Smith and Van Driesche 2003). The development of thrips is influenced by daily temperature and in temperate regions, there may be multiple breeding cycles each year. In contrast there may be only one or two generations per year in cool climates, with larval or pupal instars overwintering in the soil for a large portion of the year (Booth 1999; Hoover 2002a; Kumm 2002).

Direct damage through feeding and oviposition may scar leaf, flower, or fruit surfaces and/or deform plant growth (Booth 1999; Dreistadt *et al.* 2007b). Leaves may become mottled, dwarfed and distorted with browned or wilted leaf margins and may drop prematurely (Agnello and Kain 1996; Booth 1999; Hoover 2002a; Antonelli 2003; Smith and Van Driesche 2003; Dreistadt *et al.* 2007b). As the infestation persists, growth decline and crown die back may occur (Hoover 2002a).

The risk posed by thrips is that eggs, larvae or adult stages may be associated with imported fruit. In particular, larval and adult thrips seek sheltered areas of plants and may be found in the stem end of stone fruit (Agnello and Kain 1996). Thrips have been detected in nectarines after packing house processes in California (Curtis *et al.* 1992) and have regularly been detected in stone fruit imported from New Zealand (DAFF 2003).

4.11.1 Probability of entry

The probability of entry is considered in two parts, the probability of importation and the probability of distribution, which consider pre-border and post-border issues respectively.

Probability of importation

The probability that thrips will arrive in Australia on fruit that has undergone standard production and post-harvest practices in the US is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Harvesting fruit for export

- Pear thrips are widespread through North America, but Taiwan flower thrips and flower thrips have a more restricted distribution (EPPO/CABI 1989; EPPO/CABI 1997d; EPPO/CABI 1999; EPPO 2002). All three thrips species are associated with stone fruit production in one or more of the exporting states (EPPO/CABI 1989; Agnello and Kain 1996; EPPO/CABI 1997d; Booth 1999; EPPO/CABI 1999; APHIS 2002a).
- Adult thrips are extremely small and body colour can range from translucent white or yellow to black or brown in adults, and pale cream to translucent green in larvae (Hoover 2002a; Dreistadt *et al.* 2007b). Any thrips species present on fruit may be difficult to detect during harvesting.
- Eggs are typically deposited onto leaves or buds (Dreistadt *et al*. 2007b), but may be found in other plant parts such as fruit (Childers and Achor 1995).
- Many thrips species feed or oviposit within enclosed plant parts such as the buds, furled leaves or around fruit stems, making them difficult to detect (Dreistadt *et al.* 2007b).
- Symptoms of infestation include scarred leaf, flower and fruit surfaces (Booth 1999; Dreistadt *et al.* 2007b). Damage to fruits may be obvious, but would not be a reliable indicator when culling fruit at harvest.

Processing of fruit in the packing house

- The small size of thrips would make detection on fruit difficult. Adults and immature forms may also hide in crevices such as those found at the stem end of fruit (Agnella and Kain 1996).
- Feeding and oviposition by thrips on plant material generally results in visible morphological changes in affected tissues and affected fruit is typically scarred on the surface (Booth 1999; Dreistadt *et al.* 2007b).

- Post-harvest grading, washing, brushing and packing procedures are likely to cull symptomatic fruit and leaf material. It is likely that packing house processing will reduce the amount of adult and larval thrips and their eggs present on the commodity. However, their small size, large numbers, cryptic behaviour, inconspicuous colouring and egg deposition suggests that thrips will survive fruit processing procedures (Morse and Hoddle 2006).

Pre-export and transport to Australia

- Transport of fruit to Australia would be either by air freight or by sea freight, with the total time in transit, from orchard until arrival in Australia, expected to take from a few days to three weeks.
- Thrips are capable of overwintering but generally do so in association with protected sites which may provide some buffering from environmental conditions (McDonald *et al.* 2000). A related thrips species, *T. palmi*, has demonstrated a limited capacity to tolerate conditions comparable to those experienced during transportation of commodities with viability being proportionate to exposure times (McDonald *et al.* 2000). Adults appear to have more cold tolerance than larvae and acclimation may be observed in populations chronically exposed to colder climates (McDonald *et al.* 2000). Most thrips species favour protected environments that buffer the cold and could possibly seek shelter during transport (McDonald *et al.* 2000).
- Thrips species have been recorded on produce entering the Netherlands from 30 different countries over a thirteen year period and approximately 1000 thrips specimens are intercepted by US border inspectors annually (Morse and Hoddle 2006).
- In California, 16% of catalogued thrips species are exotic and 47% of Terebrantian thrips species are also introduced (Morse and Hoddle 2006).

Probability of distribution

The probability that thrips, having entered Australia on infested fruit, will survive during the movement of fruit within Australia after it has been released from the port of entry and be transported in a reproductively viable state to a suitable host is estimated to be **MODERATE**.

Supporting evidence for this assessment is provided in the text below:

- Distribution of the commodity would be for retail sale as the intended use of the commodity is human consumption. Waste material would be generated.
- Thrips could enter the environment directly from fruit during distribution and sale and through eggs that have hatched in discarded fruit before the fruit desiccates or decays.
- Adult thrips are winged, but are generally recognised as poor fliers (Dreistadt *et al.* 2007b). Assisted distribution with nursery stock or other commodities would be important for long distance spread (Hoover 2002a; Dreistadt *et al.* 2007b).
- The small size, inconspicuous body colouring, cryptic behaviour, oviposition in protected plant parts, and tendency to infiltrate tight spaces, allows for a favourable potential for distribution of thrips from the port of entry (Morse and Hoddle 2006; Dreistadt *et al.* 2007b).
- Although the mobility and reproductive capacity of thrips may be temporarily subdued by prolonged cold treatment, it is likely that thrips would survive and reproduce after transportation with the commodity (McDonald *et al.* 1997; McDonald *et al.* 2000).
- In California, 16% of all catalogued thrips species and 47% of terebrantian species are introduced, suggesting a favourable potential for distribution of thrips from the port of entry (Morse and Hoddle 2006).

Overall probability of entry (importation x distribution)

The overall probability of entry for thrips is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for thrips is estimated to be **MODERATE**.

4.11.2 Probability of establishment

The probability that thrips, having been distributed in a viable state to a suitable host, will establish a persistent population into the foreseeable future is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Availability of suitable hosts, alternate hosts and vectors in the PRA area

- Host records for Thysanoptera are often unreliable, with many host records based on the detection of dispersed winged adults rather than identified breeding sites (Mound 2005). However the thrips species considered under this assessment have a wide host range (Dreistadt *et al.* 2007b).
- *Frankliniella tritici* has been reported on hosts from 29 plant orders, *F. intonsa* from 146 species, and *T. inconsequens* on a wide range of fruits and ornamentals (Agnello and Kain 1996; Booth 1999).
- The worldwide distribution of thrips species, the wide host range suggest that suitable hosts would be available for colonisation by the thrips species considered here.

Suitability of the environment

- The prevalence and spread of all four species of thrips in diverse regions worldwide is testament to their capacity to adapt to a range of environmental conditions. Many of these regions have similar environments to Australia, suggesting environmental conditions are potentially amenable to the establishment or expansion of geographic range of thrips species.
- The broad host range of all four thrips species suggests the Australian environment would be amenable to the establishment of new thrips species, with many weed, crop and native hosts in Australia being potentially susceptible to infestation.
- Related thrips species such as *T. palmi* have established across northern Australia, indicating the suitability of the environment to other related thrips species (Clift and Tesoriero 2002; Morse and Hoddle 2006; APPD 2009).

Reproductive strategy and the potential for adaptation

- Female thrips lay their eggs under bud scales, in petals and sepals, on stems, or in other delicate immature plant tissues (Agnello and Kain 1996; Frank 2009; Hoover 2002a). Eggs are laid soon after an appropriate host is located and as many as 150–300 eggs may be laid by each female (Smith and Can Dreische 2003), which will favour establishment (Hoover 2002a).
- Post-embryonic development consists of two active feeding larval instars, two relatively inactive, non-feeding instars, and finally the adult (McDonald *et al.* 2000; Hoover 2002a; Kumm 2002; Frank 2009). The time taken for the development from egg to adult depends on environmental variables such as temperature, day length and food availability but is usually complete in 10–30 days (Kumm 2002). In temperate climates and greenhouse conditions, breeding may be continuous with as many as 12–15 generations produced annually (Kumm 2002). However, cooler climate species generally complete only 1–2 generations annually and overwinter in the soil as larval or pupal instars for most of the year (Booth 1999; Hoover

2002a; Kumm 2002). Adults persist for between ten days and six weeks depending on the species (Agnello and Kain 1996; Kumm 2002).

- The wide host range in a range of environments worldwide suggests all four thrips species are potentially capable of adapting to a diverse range of environments.
- Biotypes or strains of thrips species may allow for adaptation to new habitats and different hosts (Morse and Hoddle 2006).
- The high fecundity, short generation time, and capacity to reproduce by parthenogenesis suggest that minimal numbers are required for establishment of founding populations (Morse and Hoddle 2006. Under optimal conditions, thrips populations could potentially establish from a single female (Morse and Hoddle 2006).

Cultural practices and control measures

- The use and timing of chemical insecticides is difficult as thrips generally spend most of their lives concealed either under the ground or in buds where they remain unaffected by externally applied treatments (Agnello and Kain 1996; Hoover 2002a; EPPO 2004b). Insecticidal treatments are usually applied when larval stages are exposed on host foliage and protection is provided for the following growing season (Hoover 2002a).
- Identification of thrips to the species level generally requires an expert, however most thrips can be controlled by the same mitigation measures (Dreistadt *et al*. 2007b).
- The conservation of natural enemies approach in controlling thrips populations is also difficult. Multiple generalist enemies would need to be simultaneously available to affect all thrips life stages sheltering in the soil or buds (Morse and Hoddle 2006.
- Most thrips species are sensitive to broad spectrum, pre-bloom insecticides, but the short generational time and high fecundity increases the opportunity for insecticide resistance to develop. Further, growers may not be aware of infestations until much of the damage has been done (Agnello and Kain 1996).

4.11.3 Probability of spread

The probability that thrips, having established a persistent population on a suitable host in Australia, will spread to other susceptible hosts both in the local area and more widely is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Suitability of natural and/or managed environment

- All four thrips species are found in North America as well as in a range of geographic regions worldwide. Many of these regions have similar environments to Australia suggesting the thrips species could spread in Australia.
- The broad host range of the thrips considered here suggest the Australian environment would be potentially amenable to their spread, with many weed, crop and native host species in Australia being potentially capable of supporting thrips infestations.

Presence of natural barriers

- Winged adult thrips are considered weak fliers and rely on wind or distribution with commodities for long distance transport. Long distance dispersal by wind may be limited due to the presence of natural barriers such as deserts, mountains and regions lacking suitable hosts. The long distance between some of the main Australian orchards may limit the capacity for thrips spread between production areas unless they are carried on wind currents.

Potential for movement with commodities, conveyances, or by other vectors

- Facilitated transport of thrips with commodities and plant propagative material is important for long distance spread. The small size, cryptic behaviour, and tendency to infiltrate tight spaces, allows thrips to be co-transported in a variety of commodities and devices (Morse and Hoddle 2006; Dreistadt *et al.* 2007b).
- Adults and immature forms may spread undetected via the movement of fruit or infested vegetative host material.
- The international movement of some thrips species has occurred predominantly by the movement of horticultural material such as cuttings, seedlings, and potted plants.
- The small size, inconspicuous body colouring, cryptic behaviour and capacity for flight allows thrips species to be transported by wind and human conveyances (Hoover 2002a; Morse and Hoddle 2006; Dreistadt *et al.* 2007b).

4.11.4 Probability of entry, establishment and spread

The probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive probabilities shown in Table 2.2.

The overall probability that thrips will enter Australia as a result of trade in stone fruit from California and the Pacific Northwest states and be distributed in a viable state to suitable hosts, establish and subsequently spread is estimated to be **MODERATE**.

4.11.5 Consequences

The consequences of the establishment of exotic thrips in Australia have been estimated according to the methods described in Table 2.3. The justification for these ratings is provided below:

Impact scores for exotic thrips	
Direct Impacts	**Estimate and Justification**
Plant life or health	**D** — Significant at the district level. Thrips are capable of causing direct harm to its hosts through feeding and oviposition as well as by vectoring viral pathogens (Antonelli 2003). Both the thrips and vectored agents have a wide host range and can cause significant damage to susceptible hosts at the district level. Both adults and larvae feed on the cell contents of soft plant tissues and from pollen grains. In stone fruit, feeding damage can lead to the discolouration, bleaching and speckling of fruit. Damage can range from an inoffensive cosmetic blemish to a significant downgrading of fruit (Teulon and Penman 1996).
Any other aspects of the environment	**B** — Minor at the local level. There are no known direct consequences of thrips on other aspects of the natural or built environment but their introduction into a new environment may lead to competition for resources with native thrips species.

Indirect Impacts	Estimate and Justification
Eradication, control, etc.	**C** — Significant at the local level. Additional programs to minimise the impact of thrips on host plants may be necessary. Existing control programs may be effective for some species and/or hosts (e.g. broad spectrum pesticide applications) but may not be effective for all species or not be applicable to all situations (e.g. where specific integrated pest management programs are used). These pests may potentially increase production costs by triggering specific controls. The use of insecticides for control may increase because of difficulties in identifying the optimum time for insecticide application. Increased costs for crop monitoring and consultant's advice to the producer may be incurred. The extremely wide range of host species for these four thrips would also make it difficult/unlikely to completely eradicate them from the natural environment.
Domestic trade	**D** — Significant at the district level. If these thrips become established in Australia it is likely to result in intrastate and interstate trade restrictions on many commodities such as apricots, nectarines, peaches and plums, leading to a potential loss of markets and significant industry adjustment.
International Trade	**D** — Significant at the district level. The presence of these thrips in commercial production areas of a wide range of horticultural commodities (e.g. vegetables, ornamentals, apricots, nectarines, peaches, and plums) may limit access to overseas markets where these pests are not present.
Environment	**A** — Indiscernible at the local level. Additional pre-harvest pesticide applications would be required to contain and/or eradicate these pests and control them on susceptible crops. However, this is unlikely to impact on the environment to any more than already occurs from run-off into waterways from commercial crops due to control measures for other thrips pests.

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**D**', the overall consequences are considered to be '**LOW**'.

4.11.6 Unrestricted risk

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5. The unrestricted risk estimation for thrips is shown below.

Unrestricted risk estimate for exotic thrips	
Overall probability of entry, establishment and spread	**Moderate**
Consequences	**Low**
Unrestricted risk	**Low**

As indicated above, the unrestricted risk for thrips has been assessed as 'low', which is above Australia's ALOP. Therefore, specific risk management measures are required for these pests.

4.12 *Xylella fastidiosa* (Xanthomonadales: Xanthomonadaceae)

The species examined in this pest risk assessment is:

Xylella fastidiosa (Wells, Raju, Hung, Weisburg, Mandelco-Pauland, Brenner, 1987)	Cause of phoney peach disease

Xylella fastidiosa is a gram negative, rod shaped bacterium from the family Xanthomonadaceae, that infects the water conducting xylem vessels of its hosts (Bradbury 1991; Wells 1995). The bacterium can infect a wide range of plants, with 153 known susceptible species from approximately 30 dicotyledonous and monocotyledonous families (Mizell *et al.* 2003). *Xylella fastidiosa* causes diseases of economic importance including phoney peach disease, Pierce's disease, citrus variegated chlorosis, plum leaf scald, and leaf scorch of almond, coffee, elm, oak, oleander, pear and sycamore (Hendson *et al.* 2001; Mizell *et al.* 2003; Costa *et al.* 2004; Hernandez-Martinez *et al.* 2007). Different subspecies are responsible for each of these diseases and differentiation between strains that cause almond leaf scorch and Pierce's disease has been made (Hopkins and Purcell 2002; Hernandez-Martinez *et al.* 2007). The subspecies infecting species of *Prunus* are *X. fastidiosa* subsp. *multiplex* and *X. fastidiosa* subsp. *fastidiosa* (Hernandez-Martinez *et al.* 2007). The bacterium is found in tropical and subtropical regions of North, Central and South America, with limited distribution outside these areas (Hopkins 1989; Hopkins and Purcell 2002; Redak *et al.* 2004). The main factors limiting the distribution and persistence of *X. fastidiosa* are cold winter temperatures and suitable overwintering vectors (Hopkins 1989; Hopkins and Purcell 2002; Redak *et al.* 2004).

In infected hosts, *Xylella fastidiosa* is restricted to xylem tissues and replicates and spreads in the xylem vessels throughout the plant. Aggregates of bacteria, gum and tyloses, form within the xylem vessels and restrict water and nutrient transport (Hopkins 1989; Purcell and Hopkins 1996). The bacterium is acquired and transmitted by insects that feed on xylem fluid. The most important vectors for *X. fastidiosa* in North America are sharpshooters (Cicadellinae) and spittlebugs (Cercopidae) (Wichman and Hopkins 2002). The bacteria are retained in the foregut of vectors feeding on infected leaf and stem tissue, and is transmitted to new hosts upon subsequent feeds (Purcell and Hopkins 1996; Bevan 2000; Redak *et al.* 2004). The bacterium can be transmitted almost immediately after acquisition and adult vectors retain the pathogen in a virulent state for the rest of their lives. The bacterium is not passed onto progeny. In nymphs, virulence is lost after each of the moulting stages when the foregut cuticle lining is shed (Almeida *et al.* 2005; Redak *et al.* 2004).

Symptom development depends on the rate and extent of colonisation of the xylem vessels of the host (Purcell and Hopkins 1996). Commonly, symptoms are typical of water stress (Purcell and Hopkins 1996) and leaves are scorched, scalded, chlorotic, or necrotic (Purcell and Hopkins 1996; Wells 1995). Stems may mature irregularly and become stunted, and die back of twigs and branches may occur. Infections can affect fruit through reduced yield, quality and size and fruit can have more colour and ripen prematurely (Bradbury 1991; Wells 1995; Purcell and Hopkins 1996; CABI 2007). In some hosts, infected plants can become compact with umbrella like canopies, dwarfed or bloom early (Wells 1995). A general decline in productivity is observed and hosts may die within 3-8 years after initial leaf symptoms (Purcell 2006). Symptoms vary according to the host and bacterial strain and infected hosts may be asymptomatic.

The risk posed by *X. fastidiosa* is that fruit with latent or asymptomatic infections could arrive in Australia and lead to the introduction, establishment and spread of this pathogen in Australia.

4.12.1 Probability of entry

The probability of entry is considered in two parts, the probability of importation and the probability of distribution, which consider pre-border and post-border issues respectively.

Probability of importation

The probability that *X. fastidiosa* will arrive in Australia with fruit that has undergone standard production and post-harvest practices in the US is estimated to be **VERY LOW**.

Supporting evidence for this assessment is provided in the text below:

Harvesting fruit for export

- *Xylella fastidiosa* is predominantly found in tropical and subtropical regions of the Americas and its distribution corresponds to that of its principal vectors, the glassy-winged sharpshooter (*Homalodisca vitripennis*) and the blue-yellow sharpshooter (*Oncometopia nigricans*). In North America, it is mainly found in the southern states where there are warm climates and mild winters, including California. In North America, the glassy-winged sharpshooter is considered to be the most important vector due to its ability to breed up to large numbers and its efficiency in vectoring *X. fastidiosa* (Redak *et al.* 2004).
- Vectors of *X. fastidiosa* are most active at higher temperatures and ambient conditions during harvest are likely to favour mobility of vectors. Given their mobility, vectors are likely to be disturbed during harvesting. To date, the glassy-winged sharpshooter has not been intercepted on table grapes exported from California (Scott and De Barro 2000). It is therefore unlikely that infected vectors present during the harvest period would be co-transported with harvested fruit.
- *Xylella fastidiosa* is limited to the xylem vessels and can be distributed systemically through plants where ever these tissues occur. The citrus variegated chlorosis strain of *X. fastidiosa* can be carried in the peel, endocarp and seed of citrus (Li *et al.* 2003), but there is no confirmation that the strains infecting *Prunus* spp. can be spread this way.
- In peach, the bacterium colonises the roots with little to no colonisation of leaf and stem tissue (Wells 1995). In plum, the bacteria proliferate more diffusely in roots, stems and leaves (Wells 1995). Fruits with well developed continuous vessels are more likely to contain this bacterium systemically, but bacterial levels in symptomless fruit may be low (Li *et al.* 2003). The lack of evidence in the literature addressing the distribution of *X. fastidiosa* in *Prunus* spp., may suggest the capacity for *X. fastidiosa* to be associated with fruit is limited. This is strengthened by the likelihood that low bacterial numbers would be present in harvested fruit.
- Indicators in symptomatic hosts include scorching, scalding, chlorosis and necrosis of leaf tissue. Reduced quality, yield and size of affected fruit may be observed in some hosts which can be more colourful and ripen earlier. Fruit from trees with advanced symptoms may be culled during the harvesting process, but fruit from asymptomatic trees or trees with only minor symptoms would still likely be harvested.
- Temporary remission of symptoms of infection by *X. fastidiosa* has been seen in grapevines when temperatures drop to -8 to -12°C, which suggests that the pathogen is temperature sensitive (Wells 1995). Susceptibility to low temperatures may explain why *X. fastidiosa* is not known to occur in Washington (APHIS 2007a).

Processing of fruit in the packing house

- While *X. fastidiosa* is primarily present in the leaves and branches, fruit may contain the bacterium. Fruit displaying symptoms may be culled during processing, but the low level of the bacterium expected to be present suggests that symptoms may not be evident.
- Washing and defuzzing/brushing of fruit would remove any vectors that were not dislodged during harvesting operations. These activities would not have any impact on bacterium inside the fruit.

Pre-export and transport to Australia

- After packing, fruit is stored at <1°C (Curtis *et al.* 1992; Yokoyama and Miller 1999).
- Transport of fruit to Australia would be either by air freight or by sea freight, with the total time in transit, from orchard until arrival in Australia, expected to take from a few days to three weeks.
- Experimental data on the temperature-dependent growth and survival of *X. fastidiosa* in grapevine show *X. fastidiosa* to prefer temperatures between 25 and 30°C, whereas temperatures below 12-17°C and above 34°C may affect survival (Feil and Purcell 2001). Feil and Purcell (2001) also reported that the number of culturable bacteria diminishes 160-fold in grapevines after 5 days at 5°C.
- While cold temperatures can be detrimental to *X. fastidiosa* and temperatures below 10°C have been shown to reduce bacterial numbers in grapevines (Feil and Purcell 2001), it is unknown whether long periods of cold storage of stone fruit would significantly reduce or eliminate *X. fastidiosa* from fruit.

Probability of distribution

The probability that *X. fastidiosa*, having entered Australia in infested fruit, will survive during the movement of fruit within Australia after it has been released from the port of entry and be transported in a reproductively viable state to a suitable host is estimated to be **VERY LOW**.

Supporting evidence for this assessment is provided in the text below:

- For *X. fastidiosa* to be distributed to a susceptible host plant, the bacterium would need to either be vectored from an infected fruit, or infected seed would need to germinate. However, the ability of stone fruit seed to carry the bacterium and transmit it to seedlings has not been demonstrated.
- The main vectors of *X. fastidiosa* are xylem-feeding sharpshooters (subfamily Cicadellinae) and spittlebugs and froghoppers (superfamily Cercopoidea) (EPPO/CABI 1997c; Merriman *et al.* 2001). Known important vectors of *X. fastidiosa* in North America include *Carneocephala fulgida*, *Draeculacephala minerva*, *Graphocephala atropunctata* and *Homalodisca coagulata*, which are absent from Australia.
- There are 14 species in the subfamily Cicadellinae and 32 species in the Cercopoidea in Australia (Fletcher 2009). These potential vectors could enable the distribution of *X. fastidiosa*, given they are highly mobile and occur throughout the eastern states of Australia.
- The presence of the bacterium in fruit stalks may allow for the acquisition and distribution of the bacterium by opportunistic insect vectors. Little information addressing the distribution of *X. fastidiosa* in stone fruits is available, but leafhopper and spittlebug species primarily feed on living stem and leaf tissue. Endemic potential vectors of *X. fastidiosa* are not expected to feed on discarded fruit.
- *Xylella fastidiosa* has a wide host range with over 150 known species from 30 monocotyledonous and dicotyledonous families being susceptible to infection (Mizell *et al.*

2003). It is reported that 127 of 138 genera of plants affected by *X. fastidiosa* are imported into Australia in various forms (Luck *et al.* 2002). Many known hosts of *X. fastidiosa* including common weeds, shrubs and ornamental species, are widely grown in Australia, providing a greater potential for the pathogen to be distributed to a suitable host.
- Given the cold sensitivity of *X. fastidiosa* and that only low bacterial levels are likely to be present in symptomless fruit (Hopkins 1989; Wells 1995; Purcell and Hopkins 1996; Hopkins and Purcell 2002; Costa *et al.* 2004), there are potentially insufficient numbers of viable bacteria within the commodity for effective acquisition if vectors were to occur in Australia and feed on discarded fruit.

Overall probability of entry (importation x distribution)

The overall probability of entry for *X. fastidiosa* is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for *X. fastidiosa* is estimated to be **EXTREMELY LOW**.

4.12.2 Probability of establishment

The probability that *X. fastidiosa*, having been distributed in a viable state to a suitable host, will establish a persistent population into the foreseeable future is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Availability of suitable hosts, alternative hosts and vectors in the PRA area

- Even non-virulent strains are known to multiply in susceptible hosts (Hopkins 1989).
- For initial establishment, vectors would not be required as the initially infected host plant would be sufficient for initial multiplication of the bacterium.
- Known vectors for *X. fastidiosa* include sharpshooter and spittlebug (Hopkins 1989). There appears to be little specificity for vectors (Almeida *et al.* 2005) and potentially any xylem feeding insect could vector the bacterium and provide a means for the establishment of *X. fastidiosa* in Australia.
- Should additional hosts be required to establish a founding population, there would be opportunities for *X. fastidiosa* to be spread to adjacent plants.

Suitability of the environment

- *Xylella fastidiosa* proliferates in environments with warm conditions and mild winters. Many of the regions where *X. fastidiosa* is found in North America have similar environments to Australia, suggesting climatic conditions in Australia are suitable for the establishment of *X. fastidiosa*.
- *Xylella fastidiosa* is sensitive to cold temperatures and has limited distribution outside tropical and subtropical regions of the Americas. Bacterial titre is reduced at temperatures below 10°C in grape and temporary remission of Pierce’s disease symptoms was observed at -8°C to -12°C (Hopkins 1989; Hopkins and Purcell 2002). Australian winters are less severe than those in North America and therefore the Australian environment may allow for growth of the bacterium throughout the year.

Reproductive strategy and the potential for adaptation

- *Xylella fastidiosa* is able to directly reproduce inside its hosts by cell division. Persistence of the bacterium in host plants is determined by the systemic movement of the bacteria within the host xylem vessels (Hopkins 1989; Redak *et al.* 2004). Early season infections and feeding on stem tissue increase the chance of systemic spread and therefore chronic infection of the host (Redak *et al.* 2004). Late season infections and vector feeding on distal portions of the host plant are more susceptible to winter pruning, and are less likely to become systemic (Redak *et al.* 2004).

- The time for *X. fastidiosa* populations to double ranges from 12–48 hours (Hopkins 1989). Short generation times suggest that there would be potential for genetic variation to occur in short periods of time leading to adaptation to new environments.
- It is estimated that 100–200 viable virulent bacterial cells are required for successful disease transmission (Purcell and Hopkins 1996; Redak *et al.* 2004).
- After initial inoculation, maximum bacterial numbers can be observed as quickly as 10–14 days and symptoms may occur after 21–28 days (Hopkins 1989). The main factor affecting the persistence of the bacterium is systemic movement within the host vascular system (Hopkins 1989).

Cultural practices and control measures

- Current chemical controls and cultural practices in Australian stone fruit orchards, urban gardens, or native plant communities, are unlikely to have any impact on the establishment of *X. fastidiosa* in an initial host plant.
- If an infection occurred late in the season in a commercial host, the bacterium may be limited to the distal regions and thus possibly be removed during winter pruning (Redak *et al.* 2004). However, many potential hosts in urban and suburban areas, as well as weeds and wild hosts would not be subject to pruning.

4.12.3 Probability of spread

The probability that *X. fastidiosa*, having established a persistent population on a suitable host in Australia, will spread to other susceptible hosts both in the local area and more widely is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Suitability of natural and/or managed environment

- *Xylella fastidiosa* has a restricted distribution outside tropical and subtropical regions of the Americas and cold climates limit the spread of the bacterium (Hopkins 1989; Hopkins and Purcell 2002). Many of these regions have similar environments to Australia suggesting the bacterium could potentially spread in an Australian setting. Additionally, Australian winters are less severe than those in North America and thus Australian winter conditions would not hinder the spread of the bacterium all year round.
- The broad host range of *X. fastidiosa* with many host weeds, crops and native plants present in Australia, suggests the pathogen could have many potential hosts within close proximity to an infection.
- The bacterium has not been detected in Australia and known important vectors in North America are absent. The limited distribution of *X. fastidiosa* outside the Americas has been attributed to the lack of appropriate overwintering vectors to initiate early season infections, as the bacterium is likely to survive wherever host plants are grown (Almeida *et al.* 2005). However, the lack of vector specificity shown by *X. fastidiosa* enhances the potential for native insect species to acquire and transmit the bacterium.

Presence of natural barriers

- *Xylella fastidiosa* is limited to the host plant and cannot spread without either a vector, or by movement of nursery stock and other propagative material.
- Interstate quarantine controls may limit the rate of spread. However, intrastate transportation may be a potential pathway of spread.
- The most effective means of transmission of *X. fastidiosa* is by xylem feeding vectors and potential vectors include species of leafhoppers and spittlebugs. Spittlebugs have a limited capacity for dispersal. Leafhoppers are more mobile but still have limited ability to traverse long distances.

Potential for movement with commodities, conveyances or vectors

- *Xylella fastidiosa* is an obligate parasite that proliferates in xylem tissue of living plant hosts. If virulent bacteria were within transported fruit, it is unclear how long the bacterium would remain viable. *Xylella fastidiosa* may have limited time to be acquired and transmitted and would also need an efficient vector available for acquisition and transmission.
- Information regarding the presence of *X. fastidiosa* in fruit and seeds and the capacity of vectors to penetrate xylem in infected fruits is limited. In commodities with well developed and relatively continuous vasculatures throughout the fruit, transmission may be possible (Li *et al.* 2003). However, asymptomatic fruit may contain insufficient numbers of *X. fastidiosa* for effective vector acquisition (Scott and De Barro 2000).
- Long distance transmission of *X. fastidiosa* can occur through the transport of infected plant propagative material. Presumably, cultivar certification programs and rigorous testing could be implemented to prevent the spread of the bacteria.
- Facilitated distribution of nursery stock and other plant propagative material is the most important means for long distance *X. fastidiosa* transmission. Existing interstate quarantine controls regarding the commercial movement of plant propagative material may limit the transfer of the bacterium. However, the capacity for hosts to remain asymptomatic and the difficulties of diagnostic testing may reduce the efficacy of such mitigation measures.
- Xylem feeding insects acquire the bacterium from infected hosts. The bacterium adheres to and is retained in the foregut of the vector where it replicates and from which it can be transmitted to new hosts almost immediately (Hopkins 1989; Purcell and Hopkins 1996). The time between acquisition and transmission to new hosts can be as little as two hours and virulence can be maintained throughout the life of adult vectors (Redak *et al.* 2004). *Xylella fastidiosa* transmission is therefore persistent and non-latent (Almeida *et al.* 2005), thereby enabling the rapid spread of the bacterium.
- *Xylella fastidiosa* is not transmitted to vector progeny and virulence is lost during the moult as the external foregut cuticle lining is shed during these developmental processes (Almeida *et al.* 2005; Redak *et al.* 2004).
- Species identified as principle vectors of *X. fastidiosa* in North America are absent in Australia. However, species of the Cicadellinae and Cercopidae are present in Australia and could potentially vector the pathogen. Nine species of Cercopidae and thirteen species of Cicadellinae have been reported in Australia and occur in most Australian states (Fletcher 2009; Liang and Fletcher 2002). Potentially important vectors include species of *Ishidaella* and *Cofana,* given their broad host range, mobility, and prevalence throughout the eastern states of Australia.

4.12.4 Probability of entry, establishment and spread

The probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive probabilities shown in Table 2.2.

The overall probability that *X. fastidiosa* will enter Australia as a result of trade in stone fruit from California and the Pacific Northwest states and be distributed in a viable state to suitable hosts, establish and subsequently spread, is estimated to be **EXTREMELY LOW**.

4.12.5 Consequences

The consequences of the establishment of *X. fastidiosa* in Australia have been assessed according to the methods described in Table 2.3. The justification for these ratings is provided below:

Impact scores for *Xylella fastidiosa*	
Direct Impacts	**Estimate and Justification**
Plant life or health	**F** — Significant at the national level. *Xylella fastidiosa* is capable of causing direct harm to its hosts and is considered as one of the greatest potential threats to a number of Australia's horticultural industries. Direct damage to plant health includes potential impacts on leaves, stem and fruit and eventually death of affected hosts. Infected hosts can remain symptomless and serve as an inoculum source for the bacterium.
Any other aspects of the environment	**A** — Indiscernible at the local level. There are no known direct consequences of *X. fastidiosa* on other aspects of the environment.
Indirect Impacts	**Estimate and Justification**
Eradication, control, etc.	**E** — Significant at the regional level. *Xylella fastidiosa* mitigation measures have not been effective and rely on early detection, removal of affected hosts and potential wild host reservoirs, and the use of insecticides for vector removal. Prophylactic measures include controls on the transport of nursery stock and other plant propagative material. The potential costs for large scale removal of host material and vector control activities would be substantial and ongoing.
Domestic trade	**C** — Significant at the local level. The presence of *X. fastidiosa* in commercial production areas may result in some domestic movement restrictions, but fruit are not recognised as an important means of spread of this pathogen, so any fruit quarantine measures are likely to have only limited impacts. Movement restrictions on nursery stock material and other living plant material is likely to be the greatest impact on domestic trade.
International Trade	**C** — Significant at the local level. *Xylella fastidiosa* is known only from North and South America, although unconfirmed records exist in Asia. The presence of *X. fastidiosa* in Australia could lead to quarantine restrictions on a range of Australian fruit exports
Environment	**A** — Indiscernible at the local level. Indirect consequences of *X. fastidiosa* establishment would be minimal and would involve isolation of affected areas, destruction of affected stock, and the use of insecticides to remove potential vectors.

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**F**', the overall consequences are considered to be **HIGH**.

Unrestricted risk

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

Unrestricted risk estimate for *Xylella fastidiosa*	
Overall probability of entry, establishment and spread	**Extremely Low**
Consequences	**High**
Unrestricted risk	**Very low**

As indicated, the unrestricted risk for *X. fastidiosa* has been assessed as ‘very low’, which meets Australia’s ALOP. Therefore, specific risk management measures are not required for this pathogen.

4.13 *Blumeriella jaapii* (Helotiales: Dermateaceae)

The species examined in this risk assessment is:
Blumeriella jaapii (Rehm) Arx Cause of cherry leaf spot

Cherry leaf spot primarily affects leaves. It causes significant damage to sour cherry in the eastern states of the US and Europe (Jones 1995a). *Blumeriella jaapii* is recorded in California, Idaho, Oregon and Washington (Farr *et al.* 1989). Other *Prunus* species such as plum and apricot can be infected, but peach is considered to be resistant (Smith *et al.* 1988; Farr and Rossman 2010).

Symptoms of cherry leaf spot initially appear as small purple coloured spots on the upper surfaces of leaves in late spring or early summer (Smith *et al.* 1988). Later the spots develop into necrotic regions that may fall out of the leaf (Smith *et al.* 1988). A small number of infections per leaf can cause chlorosis and leaf drop thus leading to potentially serious defoliation, and in severe cases of this disease, tree death may result where severe cold proceeds from midsummer defoliation and causes winter injury (Jones 1995a). Fruit pedicles can be infected when weather conditions are optimum, but infection of the fruit is considered rare and only in the case of severe epidemics (Jones 1995a).

The fungus overwinters in fallen leaves and fruiting structures (apothecia) develop during spring as the temperature increases (Jones 1995a). During rainy periods, ascospores are discharged from the apothecia for distances up to half a metre (Keitt *et al.* 1937). Ascospores can germinate within a few hours if moist conditions are present (Smith *et* al. 1988). Leaves are infected through stomata on the underside of the leaf surface when they unfold. After an initial period of high susceptibility, leaves become increasingly resistant with age (Jones 1995a). Soon after the germinated ascospores have penetrated the stomata, small spots or lesions develop on the leaf surface. As the lesions develop, conidia are produced on the underside of infected leaves and are another important infective stage of this fungus (Travis *et al*. 2009). Conidia are spread by rain splash and wind blown mists (Smith *et al.* 1988), so wet conditions are important for secondary infections and the spread of this fungus to other plant parts such as pedicels and fruit.

Cherry leaf spot has been previously considered in the risk assessment for cherries from California and the Pacific Northwest states. While cherry leaf spot is known to occur in California and the Pacific Northwest, there is existing policy for the importation of cherries from the US that recognises area freedom from this pest in specific counties in California and the Pacific Northwest. These counties are all located in inland stone fruit growing regions and only cherries grown in these counties may be exported to Australia. In this assessment, it is assumed that stone fruit would be sourced from any region in the exporting states and thus the susceptibility of these stone fruit varieties is considered.

The risk posed by *Blumeriella jaapii* is that infected fruit or stem material might enter Australia and result in the establishment of this fungus into Australia. Cherry leaf spot has previously been recorded and eradicated from New South Wales (APPD 2010) and South Australia (Cook and Dubé 1989).

4.13.1 Probability of entry

The probability of entry is considered in two parts, the probability of importation and the probability of distribution, which consider pre-border and post-border issues respectively.

Probability of importation

The probability that *B. jaapii* will arrive in Australia on fruit that has undergone standard production and post-harvest practices in the US is estimated to be **EXTREMELY LOW**.

Supporting evidence for this assessment is provided in the text below:

Harvesting fruit for export

- *Blumeriella jaapii* is known to occur in California and the Pacific Northwest states (Farr *et al.* 1989; Pscheidt 2009).
- The primary host for *B. jaapii* is cherries, and peach is reported as being resistant to *B. jaapii* infection (Smith *et al.* 1988). It is considered extremely unlikely that commercially grown fruit, other than cherries, would be infected with *B. jaapii*.
- Despite the potential economic importance of this fungus, no controls are recommended in the 2006 Crop Protection Guide for Tree Fruit in Washington for the main host cherry, nor for any hosts (Washington State University 2009).
- No mention is made of cherry leaf spot by the University of California for commercial growers. Only limited mention is made of cherry leaf spot for home gardens and only on the fungi's primary host, cherries (University of California 2009a).
- Previous BA policy has allowed for the importation of cherries from specified US counties into Australia since 1997, based on survey data supporting area freedom from cherry leaf spot. Access for additional counties from California, Idaho, Washington and Oregon was granted in 1999 as these counties were considered to also be free from cherry leaf spot.
- The area freedoms and lack of recommended control measures indicates that *B. jaapii* is, at most, a relatively uncommon pathogen in the commercial production regions.
- Cherry leaf spot is primarily a leaf pathogen and fruit infection rarely occurs (Jones 1995a). Fruit are only susceptible to infection for a short period of time (Jones 1995a).

Processing of fruit in the packing house

- Fruit may be infected, or contaminated with conidia. However, contamination with conidia would only occur if wet periods had occurred immediately before harvest as conidia are spread by water splash and wind blown mists. As stone fruit is generally grown in hot, dry locations and harvested during summer, such conditions are unlikely to have occurred.
- Post-harvest washing and defuzzing/brushing of fruit is likely to remove surface contamination of conidia. Fruit are subsequently air dried and cool stored, thus not providing the free moisture and warm conditions required for conidial germination.
- Sorting and grading operations may remove fruit that has disease symptoms as these cause physical blemishes. However, fruit without symptoms or with only minor symptoms may pass through grading operations.

Pre-export and transport to Australia

- After packing, fruit is stored at <1°C (Curtis *et al.* 1992; Yokoyama and Miller 1999).
- Transport of fruit to Australia would be either by air freight or by sea freight, with the total time in transit, from orchard until arrival in Australia, expected to take from a few days to three weeks.
- *B. jaapii* survives through the winter on leaves on the ground and it is likely that this fungus would survive cold storage.

Probability of distribution

The probability that *B. jaapii*, having entered Australia on infested fruit, will survive during the movement of fruit within Australia after it has been released from the port of entry and be transported in a reproductively viable state to a suitable host is estimated to be **LOW**.

Supporting evidence for this assessment is provided in the text below:

- Fruit would be harvested in the US during Australia's winter. Therefore, fruit would arrive in Australia through winter and spring. This would present a narrow window, late in the US export season, when Australian trees may have the first leaves that would be susceptible to infection. However, young leaf material may be available as early as July in the warmer low chill stone fruit production regions in Australia, thereby presenting a broader window of potential exposure.
- Most imported fruit would be eaten, thus minimising the quantity of waste material disposed of into the environment. Stone fruit are usually eaten with the skin.
- Any fruit that are discarded are likely to be in bins or composting systems. The colonisation of the fruit by saprophytic fungi and bacteria would quickly rot the fruit.
- Imported fruit contaminated with conidia would require the conidia to infect the fruit or to be transferred to a susceptible host at a suitable stage of development.
- Fruit are only susceptible for a limited period of time (Jones 1995a), and not when fully ripened. It is therefore considered unlikely that any contaminating conidia in a consignment of stone fruit would be able to infect fruit and therefore result in fungal growth during transit.
- For conidia to be transferred to a suitable host, rain splash or mechanical transfer would be required to deposit the conidia onto a susceptible host. However, conidia would need to survive until wet conditions are available for germination and infection.
- *Blumeriella jaapii* has a narrow host range, primarily limited to cherries, although some other *Prunus* spp. are reported to be susceptible (Farr *et al.* 1989; Jones 1995a). Cherries may be grown in suburban areas and ornamental *Prunus* species are sold by nurseries in Australia as amenity plants. These include host species such as sour cherries.

Overall probability of entry (importation x distribution)

The overall probability of entry for *B. jaapii* is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for *B. jaapii* is estimated to be **EXTREMELY LOW**.

4.13.2 Probability of establishment

The probability that *B. jaapii*, having been distributed in a viable state to a suitable host, will establish a persistent population into the foreseeable future is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Availability of suitable hosts, alternative hosts and vectors in the PRA area

- *Blumeriella jaapii* is capable of infecting several cultivated, ornamental and wild *Prunus* species (Jones 1995a; Farr and Rossman 2010). Cherry species are primary hosts, and while other *Prunus* species such as apricot and plum are noted as being potentially susceptible, they are reported to be less seriously affected.

- All commercially grown cultivars of cherry are susceptible to *B. jaapii*, although sour cherry is the most susceptible (Jones 1995a).

Suitability of the environment

- *Blumeriella jaapii* is found throughout the US and in Europe where climatic conditions are similar to those of Australia. The pathogen is capable of surviving in these environments and infecting trees annually.
- *Blumeriella jaapii* has previously been recorded as having established in Australia and was subsequently eradicated (Cook and Dubé 1989). This demonstrates that the environments in regions of Australia are suitable for this fungus to establish.
- Cool climatic conditions are optimal for *B. jaapii* establishment and spread, with optimal development of fruiting bodies being 16.5°C (Jones 1995a).

Reproductive strategy and the potential for adaptation

- The fungus overwinters on infected leaves on the ground. Apothecia develop on these leaves in spring and release ascospores to cause primary infection on new leaves, stems and fruit (Jones 1995a).
- Populations can start from a single conidiospore or ascospore providing it is able to infect a host.
- Ascospores gain entry into the leaf through stomata and colonise the leaf on the underside, producing conidia. Secondary spread occurs through several successive generations of conidia. Even small initial infections can result in large inoculum levels within a few generations (Keitt *et al.* 1937).
- Leaves are not susceptible until they have unfolded and stomata have developed. While older leaves are resistant, they are still potentially susceptible (Jones 1995a).

Cultural practices and control measures

- The use of fungicides is effective in controlling *B. jaapii* provided resistance does not develop (Jones 1995a; McManus *et al.* 2007). Copper fungicides are especially useful in controlling *B. jaapii* (Jones 1995a; McManus *et al.* 2007). Such fungicides may be applied to commercial orchards, but would need to be 100 per cent effective to prevent *B. jaapii* establishing. Trees in urban or suburban areas are unlikely to have any fungicide applications.
- *Blumeriella jaapii* has developed resistance to some fungicides in some parts of Michigan (McManus *et al.* 2007).

4.13.3 Probability of spread

The probability that *B. jaapii*, having established a persistent population on a suitable host in Australia, will spread to other susceptible hosts both in the local area and more widely is estimated to be **MODERATE**.

Supporting evidence for this assessment is provided in the text below:

Suitability of natural and/or managed environment

- *Blumeriella jaapii* is found throughout the US and in Europe (CABI 2007).
- The environment (for example, suitability of climate, soil, pest and host competition) in Australia in regions where *Prunus* is grown is likely to be suitable for the spread of *B. jaapii*.
- Warm, wet conditions are required for the overwintering fungus to ripen. Ascospores are usually released at the end of a wet period (Keitt *et al.* 1937) and can infect new host tissue

providing that water is available. A temperature range from 4°C to 32°C is suitable for infection (Keitt *et al.* 1937).
- Suitable conditions are likely to be found in many Australian *Prunus* orchards, urban and suburban areas, and where naturalised *Prunus* is growing.

Presence of natural barriers

- *Blumeriella jaapii* is dispersed by air-borne ascospores and water splashed and wind blown conidia.
- The long distances existing between some of the main Australian commercial orchards and production areas may make it difficult for *B. jaapii* to disperse directly from one production area to another unaided.

Potential for movement with commodities, conveyances or other vectors

- The transportation of infested nursery stock or plant products and fruit would aid the movement of *B. jaapii* within and between orchards and suburban areas.
- Inoculum overwinters in fallen, infected leaves. The movement of leaf material would present an opportunity for long distance spread.
- Interstate and intrastate quarantine controls on the movement of nursery stock could reduce the rate of spread.

4.13.4 Probability of entry, establishment and spread

The probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive probabilities shown in Table 2.2.

The overall probability that *B. jaapii* will enter Australia as a result of trade in stone fruit from California and the Pacific Northwest states and be distributed in a viable state to suitable hosts, establish and subsequently spread, is estimated to be **EXTREMELY LOW**.

4.13.5 Consequences

The consequences of the establishment of *B. jaapii* in Australia have been assessed according to the methods described in Table 2.3. The justification for these ratings is provided below:

Impact scores for *Blumeriella jaapii*	
Direct Impacts	**Estimate and Justification**
Plant life or health	**D** — Significant at the district level. Cherry leaf spot can be a serious disease of sour cherry (*Prunus cerasus*) and potentially sweet cherry (*P. avium*). Other *Prunus* species, while potentially susceptible, are less seriously affected. Seriously affected trees may be defoliated, which results in fruit that fails to mature normally. Trees death may result from winter injury where severe cold periods follow midsummer defoliation (Jones 1995a). However, the host range of *B. jaapii* is limited and the effects of this fungus will be restricted. Crop losses of cherries attributed to defoliation may be around 42 per cent (CABI 2007). Defoliation of amenity tree in suburban areas may also be noticeable.
Any other aspects of the environment	**A** — Insignificant at the local level. There are no known direct consequences on other aspects of the environment that would be caused by *Blumeriella jaapii* establishing in Australia.

Indirect Impacts	Estimate and Justification
Eradication, control, etc.	**E** — Significant at the regional level. *Blumeriella jaapii* has previously been eradicated from Australia. Should this fungus enter and establish again, significant restrictions on the movement of host material, coupled with an intensive eradication campaign is likely. Removal of trees and extensive chemical sprays during susceptible periods are likely to be required. If eradication were not considered feasible, ongoing control costs would include additional chemical sprays, particularly early in the season, to suppress *B. jaapii* and minimise any impact. Such control program would represent a significant cost to the cherry growing industry and costs may also be incurred by other stone fruit industries.
Domestic trade	**D** — Significant at the district level. The presence of *B. jaapii* in restricted areas of Australia would result in domestic quarantine regulations being imposed to prevent the spread of this fungus.
International Trade	**E** — Significant at the regional level. While *B. jaapii* is present in Europe and North America, other important markets for Australian stone fruit are currently free of this fungus. There would likely be new quarantine restrictions on Australian stone fruit exports which would cause a significant disruption to trade.
Environment	**A** — Indiscernible at the local level. Additional control measures may be applied to limit the impact of *B. jaapii* in Australia, but controls such as sulphur or copper fungicides are already used in Australia for other fungi. The effect of additional sprays, if any, are unlikely to lead to any discernable impacts in the environment.

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are 'E', the overall consequences are considered to be **MODERATE**.

4.13.6 Unrestricted risk

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

Unrestricted risk estimate for *Blumeriella jaapii*	
Overall probability of entry, establishment and spread	**Extremely Low**
Consequences	**Moderate**
Unrestricted risk	**Negligible**

As indicated, the unrestricted risk for *B. jaapii* has been assessed as 'negligible', which meets Australia's ALOP. Therefore, specific risk management measures are not required for this pathogen.

4.14 *Passalora circumscissa* (Dothideales: Mycosphaerellaceae)

The species examined in this risk assessment is:
Passalora circumscissa (Sacc.) U. Braun Cause of cercospora leaf spot [WA]

Passalora circumscissa primarily causes disease on *Prunus* hosts, with late maturing stone fruit varieties being particularly susceptible (Little 1987). The fungus is most prevalent on cherry but is also found on almonds, blackthorn, peaches and plums (Little 1987; Sztejnberg 1995). Generally, the following season's crops are most affected and losses of up to 40% have been recorded (Little 1987). *Passalora circumscissa* is found in many temperate and subtropical environments around the world. However, in some regions, its presence is limited and it is of little economic significance (Sztejnberg 1995).

Passalora circumscissa spores infect susceptible hosts through leaf stomata. Symptoms generally appear early in the growing season on young leaves as red-brown necrotic spots (Little 1987). As lesions continue to enlarge they coalesce causing the necrotic tissue to drop out, leaving characteristic 'shot hole' symptoms (Little 1987; Sztejnberg 1995). As the disease progresses, leaf tissue continues to be degraded and leaves of the host become densely perforated with holes, giving the leaves a ragged appearance (Little 1987). Early defoliation can occur and in severe cases complete defoliation may be seen by the start of summer (Little 1987; Sztejnberg 1995. Further debilitation of the host may occur as premature defoliation stimulates new growth (Sztejnberg 1995).

The fungus overwinters as substomatal stroma or as the teleomorph in leaf debris on the orchard floor (Sztejnberg 1995). During the spring when conditions are favourable, overwintered stroma produce conidia which function as a primary inoculum source and are dispersed by wind and water splash to nearby susceptible hosts to mediate secondary cycles of infection (Little 1987; Sztejnberg 1995).

Passalora circumscissa has been detected in both the US and Australia. In Australia, the fungus has been reported on *Prunus* hosts in New South Wales, Queensland, South Australia, and Victoria (APPD 2009). Consequently, *P. circumscissa* is only considered as a quarantine pest for Western Australia. The Department of Agriculture and Food, Western Australia has previously assessed the risk posed by *P. circumscissa* on apricots from South Australia and Tasmania and concluded that there was a negligible unrestricted risk. While some additional information is presented in this assessment, the conclusions are the same.

4.14.1 Probability of entry

The probability of entry is considered in two parts, the probability of importation and the probability of distribution, which consider pre-border and post-border issues respectively.

Probability of importation

The probability that *P. circumscissa* will arrive in Australia on fruit that has undergone standard production and post-harvest practices in the US is estimated to be **VERY LOW**.

Supporting evidence for this assessment is provided in the text below:

Harvesting fruit for export

- *Passalora circumscissa* primarily affects *Prunus* hosts and is associated with peach and plum commodities in production regions of California, Idaho, Oregon and Washington (APHIS 2002b). Late maturing stone fruit varieties are more susceptible to infection and severe outbreaks have been reported in Coastal California (Little 1987).
- *Passalora circumscissa* is primarily a leaf pathogen. Necrotic spots may form on branch and fruit (Little 1987). *Passalora circumscissa* infection causes reddish brown necrotic spots on both leaf surfaces (Sztejnberg 1995). As they enlarge, necrotic regions may coalesce and fall out, giving leaves the typical 'shot-hole' symptoms (Sztejnberg 1995). Early defoliation may occur, and in severe cases, complete defoliation may be observed in early summer (Little 1987; Sztejnberg 1995).
- Symptomatic fruit is likely to be removed during routine harvesting operations due to the distinct symptoms.

Processing of fruit in the packing house

- Post-harvest washing and brushing/defuzzing may remove some spores present on the surface of fruit. However, infections in the fruit would not be affected by this process.
- Grading and packing procedures are likely to result in culling of symptomatic fruit and other infected plant material.

Pre-export and transport to Australia

- Transport of fruit to Australia would be either by air freight or by sea freight, with the total time in transit, from orchard until arrival in Australia, expected to take from a few days to three weeks.
- *Passalora circumscissa* can overwinter as substomatal stroma or as the teleomorph in leaf debris on the orchard floor (Little 1987; Sztejnberg 1995). Therefore, cold storage treatment during transport is unlikely to eliminate infections.

Probability of distribution

The probability that *P. circumscissa*, having entered Australia on infested fruit, will survive during the movement of fruit within Australia after it has been released from the port of entry and be transported in a reproductively viable state to a suitable host is estimated to be **VERY LOW**.

Supporting evidence for this assessment is provided in the text below:

- Distribution of the commodity would be for retail sale as the intended use of the commodity is human consumption. Fungi present on the surface of fruit could potentially be distributed via wholesale and retail trade and waste material would also be generated.
- Stone fruit with obvious symptoms are unmarketable and would not be sold within Western Australia.
- Fruit without symptoms, or with only minor symptoms, are likely to be consumed. As stone fruit are usually eaten with the skin, there will be limited amounts of waste material. The limited amount of waste material disposed of in the environment would need to remain as a suitable host for *P. circumscissa* and colonisation by saprophytic fungi may decompose fruit before conidia develop.

- For *P. circumscissa* to enter and successfully be distributed requires the fungi to overwinter on any discarded fruit and multiply in the following Australian spring season due to the off-set seasons and timing of stone fruit importation. Late season arrivals of stone fruit in Australia in late August may shorten the period of dormancy required for successful reproduction.

Overall probability of entry (importation x distribution)

The overall probability of entry for *P. circumscissa* is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for *P. circumscissa* is estimated to be **EXTREMELY LOW**.

4.14.2 Probability of establishment

The probability that *P. circumscissa*, having been distributed in a viable state to a suitable host, will establish a persistent population into the foreseeable future is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Availability of suitable hosts, alternate hosts and vectors in the PRA area

- *Passalora circumscissa* has previously been detected in New South Wales, Queensland, Victoria and South Australia (APPD 2009). Suitable hosts would be present in Western Australia.
- *Passalora circumscissa* has a relatively narrow host range with detections almost entirely on *Prunus* species (Little 1987; Sztejnberg 1995). Disease symptoms have been most prevalent on cherry species, but almonds, blackthorn, plums and peaches have also been found to be susceptible (Sztejnberg 1995). Many of these hosts are present in Western Australia in both naturalised and cultivated forms. The prevalence of *Prunus* hosts could potentially provide a means for establishment of the fungus in Western Australia.

Suitability of the environment

- The detection of *P. circumscissa* in diverse regions worldwide is testament to its capacity to adapt to a range of environmental conditions. Many of these regions have similar environments to Australia, suggesting environmental conditions are potentially amenable to the establishment of the fungus in Western Australia.
- *Passalora circumscissa* favours temperate and subtropical environments and proliferates in high humidity conditions with an optimal temperature range of 20-25^{o}C (Farr *et al.* 1989; Sztejnberg 1995). The temperate Western Australian environment would potentially be suitable for the establishment of the fungus.
- *Passalora circumscissa* has been reported in New South Wales, Queensland, Victoria and South Australia (APPD 2009). As the fungus has already established in these states, it is likely to be capable of establishing in Western Australia.

Reproductive strategy and the potential for adaptation

- The distribution of *P. circumscissa* worldwide suggests that the fungus is capable of adapting to a diverse range of environments.
- *Passalora circumscissa* can potentially produce large numbers of spores, thereby increasing the potential for adaptation.
- The detection of *P. circumscissa* and its teleomorph in most Australian states (New South Wales, Queensland, Victoria and South Australia (APPD 2009)) demonstrates the fungus has

been able to adapt to the Australian environment and are therefore likely to be capable of broadening its geographic range to Western Australia.

- The role of ascospores in the epidemiology of the disease is unknown. Conidia are considered to be the primary source of inoculum (Sztejnberg 1995). This may limit the genetic diversity of founding populations given the haploid nature of conidia, thereby reducing the potential for adaptation.
- *Passalora circumscissa* overwinters as substomatal stroma or as the teleomorph in leaf debris on the orchard floor (Sztejnberg 1995).
- Under favourable conditions in the spring, characteristic conidia are produced from overwintered stroma and function as a primary inoculum source for dispersal by wind and water splash (Sztejnberg 1995).
- Disease development is favoured by high humidity, rain, dew, and optimal at temperature ranges of 20-25^{o}C (Sztejnberg 1995).
- *Passalora circumscissa* fungi are likely to be capable of producing large numbers of spores from overwintered dormant fungi on infected plant material.
- The worldwide distribution and capacity for wind and rain dispersal suggest that minimal numbers of founding populations are required for establishment.

Cultural practices and control measures

- Effective control measures for *P. circumscissa* leaf spot use multiple fungicidal treatments applied at regular intervals starting from leaf burst (Sztejnberg 1995).
- Fungicide sprays as leaf burst may be applied for other pathogens in some commercial areas, but are unlikely to be applied in all areas, particularly in suburban areas.

4.14.3 Probability of spread

The probability that *P. circumscissa*, having established a persistent population on a suitable host in Australia, will spread to other susceptible hosts both in the local area and more widely is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Suitability of natural and/or managed environment

- *Passalora circumscissa* is found in a range of geographic regions worldwide. Favourable environments are present in parts of Western Australia.
- The fungus prefers temperate and subtropical environments and proliferates in higher humidity conditions with optimal temperatures of 20-25^{o}C (Farr *et al.* 1989; Sztejnberg 1995). The Western Australian climate is therefore likely to be suitable for the spread of *P. circumscissa*.
- *Passalora circumscissa* has already been detected in Victoria, New South Wales, Queensland and South Australia (APPD 2009).
- *Passalora circumscissa* has only been detected on *Prunus* hosts in Australia. This narrow host range may limit the spread of the fungus.

Presence of natural barriers

- *Passalora circumscissa* spores are dispersed by wind and water splash. Long distance spread to Western Australia by wind is unlikely due to the presence of natural barriers such as deserts and regions lacking suitable hosts.

Potential for movement with commodities, conveyances or vectors

- Conidia serve as the primary source of inoculum and are distributed by wind or water splash to nearby susceptible hosts (Little 1987).
- The transportation of infected nursery stock or plant products would aid the movement of *P. circumscissa* within and between orchards and suburban areas.
- Inoculum overwinters in fallen, infected leaves. The movement of leaf material would present an opportunity for long distance spread.
- The fungus is most prevalent on leaf material but may also infect fruit. Severely infected fruit would likely exhibit distinct symptoms and would not likely be distributed as it would be unmarketable. This would limit the opportunities for spread of this fungus.

4.14.4 Probability of entry, establishment and spread

The probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive probabilities shown in Table 2.2.

The overall probability that *P. circumscissa* will enter Australia as a result of trade in stone fruit from California and the Pacific Northwest states and be distributed in a viable state to suitable hosts, establish and subsequently spread, is estimated to be **EXTREMELY LOW**.

4.14.5 Consequences

The consequences of the establishment of *P. circumscissa* in Western Australia have been assessed according to the methods described in Table 2.3. The justification for these ratings is provided below:

Impact scores for *Passalora circumscissa*	
Direct Impacts	**Estimate and Justification**
Plant life or health	**D** — Significant at the district level. *Passalora circumscissa* is capable of causing direct harm to *Prunus* hosts. The fungus generally affects the leaves however branch and fruit material may also develop symptoms. Symptoms are typified by necrotic spots on leaves which cause 'shot hole' symptoms as they enlarge and in severe cases, defoliation and decline in tree vigour occur (Little 1987; Sztejnberg 1995).
Any other aspects of the environment	**A** — Indiscernible at the local level. There are no known direct consequences of this pathogen on the natural or built environment.
Indirect Impacts	**Estimate and Justification**
Eradication, control, etc.	**C** — Significant at the local level. A regime of multiple fungicidal application treatments have been effective in controlling *P. circumscissa* disease (Sztejnberg 1995). Additionally, orchard hygiene practices that minimise the inoculum potential of the fungus on leaf debris aids in controlling *P. circum*scissa (Sztejnberg 1995). While current practices may offer some control of this fungi, additional controls are likely to be required in Western Australia.
Domestic trade	**A** — Indiscernible at the local level. The presence of this pathogen in the commercial stone fruit production areas of Western Australia is not expected to have any consequences to domestic quarantine as this fungi is already present in the eastern states.

International Trade	**B** — Minor at the local level. The presence of this fungus in the commercial stone fruit production areas of Western Australia is estimated to have only minor consequences for international quarantine. It is doubtful there would be any limitations in access to overseas markets.
Environment	**A** — Indiscernible at the local level. Fungicides required to control *P. circumscissa* are not expected to have any impacts on the environment beyond any impacts already occurring through the use of controls of other pathogens of concern

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**D**', the overall consequences are considered to be **LOW**.

4.14.6 Unrestricted risk

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

Unrestricted risk estimate for *Passalora circumscissa*	
Overall probability of entry, establishment and spread	**Extremely Low**
Consequences	**Low**
Unrestricted risk	**Negligible**

As indicated, the unrestricted annual risk for *P. circumscissa* has been assessed as 'negligible', which meets Australia's ALOP. Therefore, specific risk management are not required for this pathogen.

4.15 *Podosphaera clandestina* (Erysiphales: Erysiphaceae)

The species examined in this pest risk assessment is:

Podosphaera clandestina (Wallr.:Fr) Lev. The cause of hawthorn powdery mildew

Anamorph: *Oidium crataegi* Grognot

This analysis also considers the following species which is of quarantine significance to Western Australia:

Podosphaera tridactyla (Wallr.) de Bary The cause of cherry powdery mildew [WA EP]

Anamorph: *Oidium passerinii* Bertol.

Podosphaera tridactyla has previous been assessed with the importation of stone fruit from New Zealand. In that assessment, the probability of entry, establishment and spread was assessed to be 'very low' and the consequences assessed to be 'low'. As a result the unrestricted risk was assessed to be 'negligible' and quarantine measures were not required to manage the risk.

The existing policy is adopted for the importation of stone fruit from California, Idaho, Oregon and Washington as the risks of importation would be similar, and therefore *P. tridactyla* is not considered in the risk assessment presented here.

Podosphaera species are fungal pathogens that cause powdery mildew on foliage, stems and fruits of many types of plants, including apricot, plum, peach, cherry and nectarine (Grove 1995). Stone fruits are susceptible to powdery mildew and losses of economic importance have occurred in a wide range of geographic regions, causing reduced yields and increased production costs, and it has been particularly problematic in the semi-arid climates of California, the Pacific Northwest, and Eastern Europe (Grove 1995).

Powdery mildews reproduce both sexually and asexually (Cooperative Research Centre for Viticulture 2005), and require living plant tissue to grow and survive (Moorman 2007). Fungi can overwinter in infected buds as conidia or as cleistothecia on plant detritus (Grove 1995; Khairi and Preece 1975). Overwintered cleistothecia release ascospores from asci during spring rains that initiate new infections in spring (Teviotdale *et al.* 2001; Gubler and Koike 2008). Conidiophores grow on the outside of infected tissue and release conidia that infect young tissues and mediate secondary infection cycles (Teviotdale *et al.* 2001). Conidia or ascospores produced from primary infections are dispersed by wind or water splash (Grove 1995; Teviotdale *et al.* 2001; Xu and Robinson 2000). Conidia can initiate infections on leaf surfaces in the absence of water under relative humidity conditions as low as 50% (Xu and Robinson 2000) Generally, the time from the establishment of new powdery mildew infections to production of new conidia can be 5-12 days (CooperativeResearch Centre for Viticulture 2004). Cleistothecia take approximately 90 days to mature and are present during the more advanced stages of infection (CooperativeResearch Centre for Viticulture 2004). They produce ascospores when wet which are dispersed by wind and water splash (CooperativeResearch Centre for Viticulture 2004).

Symptoms occur as white weblike growths on leaves and stems and new growth can often be stunted and/or distorted (Grove 1995). Most powdery mildew fungi grow on the surface of affected hosts as a thin mycelium layer (Teviotdale *et al.* 2001). Chlorosis and necrosis on severely affected leaves may be observed, and affected leaves may roll upward, pucker, blister and abscise as the disease progresses (Grove 1995). As the disease progresses, numerous cleistothecia are formed which are initially yellow but gradually turn brown and black (Grove 1995; Cooperative Research Centre for Viticulture 2005). Affected fruits also typically develop a white powdery growth roughly circular in shape during the spring that can later become scabby and dry (Teviotdale *et al.* 2001).

Podosphaera clandestina is widely distributed in the US and is associated with commodities in production areas. In Australia, *P. clandestina* has only been recorded on *Crataegus* hosts in NSW, Tas. and Vic. (APPD 2009). The North American strain of *P. clandestina* on cherries has not been identified on *Prunus* hosts in Australia and is of concern to all states and territories. *Podosphaera tridactyla* is more widely distributed throughout Australia (ACT, NSW, SA, Tas., Vic. and Qld.) and detections have all been on *Prunus* hosts (APPD 2009). Based on its distribution in Australia, *P. tridactyla* is of concern to Western Australia.

The risk posed by *P. clandestina* is that imported fruit may be contaminated or infected by the fungi and result in its establishment in Australia.

4.15.1 Probability of entry

The probability of entry is considered in two parts, the probability of importation and the probability of distribution, which consider pre-border and post-border issues respectively.

Probability of importation

The probability that *P. clandestina* will arrive in Australia on fruit that has undergone standard production and post-harvest practices in the US is estimated to be **LOW**.

Supporting evidence for this assessment is provided in the text below:

Harvesting fruit for export

- *Podosphaera clandestina* is found in the US with powdery mildews being particularly prevalent in semi-arid areas of California and the Pacific Northwest (Grove 1995) and has caused severe financial losses to growers in Washington (Grove and Boal 1991).
- *Podosphaera clandestina* is associated with peach, plum, nectarine and apricot stone fruits in the California, Idaho, Oregon and Washington production regions (APHIS 2002b; Farr *et al.* 1989).
- Conidia of *P. clandestina* have been found in cherry orchards from early May until mid-autumn and are most prevalent post-harvest in late June (Grove 1995).
- Powdery mildew commonly affects shoots and leaves but fruit can also be affected (Grove 1995). Infections occur throughout fruit development but usually peak at the end of the harvest season and beyond (Grove 1995; Grove 1998).
- Powdery mildew produces characteristic web-like white powdery growths or brown/black spots on affected tissues (Grove 1995). Symptomatic host material is likely to be removed during routine harvesting and grading operations due to obvious symptoms.

Processing of fruit in the packing house

- Post-harvest washing and brushing/defuzzing is likely to reduce the presence of contaminant fungal mycelium, conidiospores, and cleistothecia on the surface of fruit.
- Grading and packing procedures are likely to cull symptomatic fruit.

Pre-export and transport to Australia

- After packing, fruit is stored at $<1°C$ (Curtis *et al.* 1992; Yokoyama and Miller 1999).

- Transport of fruit to Australia would be either by air freight or by sea freight, with the total time in transit, from orchard until arrival in Australia, expected to take from a few days to three weeks.
- *Podosphaera* species can overwinter as mycelium or cleistothecia and therefore cold storage during transport is unlikely to have any effect on the fungus should it be present.

Probability of distribution

The probability that powdery mildew fungi, having entered Australia on infested fruit, will survive during the movement of fruit within Australia after it has been released from the port of entry and be transported in a reproductively viable state to a suitable host is estimated to be **LOW**.

Supporting evidence for this assessment is provided in the text below:

- Mycelium, conidiophores, conidia and cleistothecia of *P. clandestina* may be transported with fruit and distributed via wholesale and retail trade.
- Spores and mycelium of powdery mildews are sensitive to extreme heat and direct sunlight, with some mortality reported at leaf temperatures of 32°C (Gubler and Koike 2008). Mycelium, conidiophores and conidia on discarded fruit may be damaged or killed if exposed to similar conditions.
- The fungus is an obligate parasite and requires living plant tissue in order to grow and reproduce (Moorman 2007). This may limit the ability of the fungus to survive and spread to new hosts from the point of entry.
- The germination rate of conidia decreases as the soluble solid (brix) content increases (Grove 1995) and therefore ripe fruit may not be suitable for germination and growth of conidia. It is reported that a brix level above 12–15 per cent decreases infection of fruit by *P. clandestina* (Grove 1995).
- In *P. clandestina*, latency of conidia of between 5–16 days has been reported at constant temperatures between 10–28°C (Xu and Robinson 2000). The shortest latency period occurred at temperatures from 21°C to 25°C, while the longest latency occurred at 11°C (Xu and Robinson 2000).
- The distribution of *P. clandestine* to a susceptible host would require the dispersal of spores by water splash and wind from infected fruit waste to leaves, shoots or fruit of hosts. This would need to occur before fruit waste desiccates and the fungus dies. In many regions of Australia, imported fruit would be distributed when host trees are dormant and susceptible tissue is not available for infection. However, in warmer areas, particularly where low chill stone fruit varieties are grown, susceptible hosts may be available during the import period.

Overall probability of entry (importation x distribution)

The overall probability of entry for *P. clandestina* is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for *P. clandestina* is estimated to be **VERY LOW**.

4.15.2 Probability of establishment

The probability that *P. clandestina*, having been distributed in a viable state to a suitable host, will establish a persistent population into the foreseeable future is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Availability of suitable hosts, alternate hosts and vectors in the PRA area

- *Podosphaera clandestina* has a wide host range worldwide with susceptible hosts in the genera *Amelanchier*, *Crataegus*, *Cydonia*, *Diospyros*, *Holodiscus*, *Malus*, *Prunus*, *Pyracantha*, *Pyrus*, *Sanguisorba*, *Spiraea*, *Symphoricarpos* and *Vaccinium* (Farr *et al.* 1989), some of which are widely distributed in Australia. Cherries are known to be particularly susceptible to the North American strain of *P. clandestina*.
- *P. clandestina* has currently only been detected on *Crataegus* (Hawthorn) hosts in Victoria, New South Wales and Tasmania and no records for infections on Prunus have been documented (APPD 2009).

Suitability of the environment

- *Podosphaera clandestina* is associated with stone fruits throughout the California, Idaho, Oregon and Washington regions in the US (APHIS 2002b; Farr *et al.* 1989) where conditions are similar to those in parts of Australia.
- Powdery mildews proliferate in warmer climates and prefer low relative humidity conditions during the day and high relative humidity at night (Moorman 2007). Germination of conidia can occur in temperature ranges of 5–25^{o}C and down to 50% relative humidity, with the rate increasing as relative humidity rises (Khairi and Preece 1979). The Australian environment is therefore likely to be suitable for the establishment of these species.
- Other powdery mildews have established in Australia, indicating the suitability of the environment to other members of this genus.
- *Podosphaera clandestina* has been recorded in NSW, Tas. and Vic., but only is association with hawthorn (*Crataegus* spp.)(APPD 2009), demonstrating that the Australian environment is suitable for the establishment of this species.

Reproductive strategy and the potential for adaptation

- Powdery mildews can overwinter as mycelium in infected buds or as cleistothecia (Grove 1995; Xu and Robinson 2000). Overwintered powdery mildews infect newly emerging leaves in spring (Xu and Robinson 2000). Conidia or ascospores are dispersed by wind and germinate on leaf, stem or fruit surfaces on susceptible hosts, which initiate secondary mildew cycles and increase the pathogen's inoculum potential (Grove 1995; Xu and Robinson 2000; Teviotdale *et al*. 2001).
- *Podosphaera clandestina* on hawthorn can germinate in conditions with a temperature range of 5-2^{5o}C down to 50% relative humidity (Khairi and Preece 1979). Germination on fruit is greatest when fruit are immature and decreases as the fruit soluble solid content increases (Grove 1995).
- Powdery mildew fungi require living plant tissue to grow and survive (Moorman 2007) and therefore the conidia have a limited timeframe for spread and the infection of new hosts.
- Powdery mildews are capable of producing large numbers of spores from overwintered cleistothecia on infected plant material. Visible colonies can form as quickly as 5 days after conidia come in contact with host material and sporulation within 48 hours after visible colonies are present (Xu and Robinson 2000).

Cultural practices and control measures

- Mitigation measures implemented to stem the spread of powdery mildews include: ensuring adequate air circulation, keeping humidity low at nights, optimising spray penetration and sunlight exposure, using appropriately timed fungicidal treatments, limiting irrigation, avoiding over-fertilisation, and adequate timing of planting and pruning regimes (Grove 1995; Teviotdale *et al.* 2001; EPPO 2004b; Moorman 2007).

- Specific fungicides are required to control powdery mildew fungi (Teviotdale *et al.* 2001).
- Fungicides are applied to control *Podosphaera tridactyla* and *Podosphaera pannosa* in apricot, nectarine, peach and plum orchards in Australia. No fungicide applications are required for powdery mildew control in Australian cherry orchards.
- Fungicide applications may reduce the opportunity for *P. clandestina* to establish in commercial stone fruit orchards in Australia. However, fungicides would not be applied in all areas, particularly in suburban back-yards to amenity *Prunus* species.

4.15.3 Probability of spread

The probability that *P. clandestina*, having established a persistent population on a suitable host in Australia, will spread to other susceptible hosts both in the local area and more widely is estimated to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Suitability of natural and/or managed environment

- *Podosphaera clandestina* is recorded on *Crataegus* species in NSW, Tas., and Vic. (APPD 2009) and could spread in temperate areas of Australia.

Presence of natural barriers

- Powdery mildew spores are dispersed by wind to adjacent trees and orchards (Grove 1995). Long distance spread by wind is unlikely, due to the presence of natural barriers such as deserts, mountains and regions lacking suitable hosts. The long distances between some of the main Australian commercial orchards would therefore limit the capacity for the natural spread of *P. clandestina*.
- The fungus is an obligate parasite, requiring living tissue to grow and survive (Moorman 2007). Therefore, long distance dispersal by natural means is limited.

Potential for movement with commodities, conveyances or vectors

- Facilitated distribution of powdery mildew is required for long distance spread. This may occur through the movement of fruit, nursery stock or other propagative material. Interstate quarantine controls may limit the rate of spread. However, intrastate transportation would be a potential pathway for spread.
- *Podosphaera clandestina* on the surface of infected fruit could be distributed via wholesale and retail trade.
- Powdery mildews are obligate parasites that require living plant tissue to grow and reproduce (Moorman 2007). Any fungus on infected fruit would therefore have limited time available for growth and sporulation and would need an efficient means of rapidly dispersing to susceptible hosts.

4.15.4 Probability of entry, establishment and spread

The probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive probabilities shown in Table 2.2.

The overall probability that *P. clandestina* will enter Australia as a result of trade in stone fruit from California and the Pacific Northwest states and be distributed in a viable state to suitable hosts, establish and subsequently spread, is estimated to be **VERY LOW**.

4.15.5 Consequences

The consequences of the establishment of *P. clandestina* in Australia have been assessed according to the methods described in Table 2.3. The justification for these ratings is provided below:

Impact scores for *Podosphaera clandestina*	
Direct Impacts	**Estimate and Justification**
Plant life or health	**D** — Significant at the regional level. *Podosphaera clandestina is* capable of causing direct harm to their hosts (Grove 1995). Areas of white powdery fungal growth, roughly circular in shape, develop on the fruit. These infected areas later become scabby and dry. Control measures, where implemented, may reduce the impact of this fungus. However, control may not be implemented to all susceptible crops. Any impact of this fungus is likely to be reduced by current fungal control programs in commercial orchards.
Any other aspects of the environment	A — Indiscernible at the local level. There are no known direct consequences of this pathogen on the natural or built environment.
Indirect Impacts	**Estimate and Justification**
Eradication, control, etc.	C — Significant at the local level. Programs to minimise the impact of this disease on host plants are unlikely to be required as existing management measures are in place to control other powdery mildew pathogens. Fungicide applications are specific to powdery mildew infections and thus additional spray programs may be necessary in orchards where powdery mildews do not occur, especially in cherry orchards.
Domestic trade	B — Minor significance at the local level. The establishment of *P. clandestina* in regions of Australia may result in some quarantine restrictions.
International Trade	C — Significant at the local level. The presence of *P. clandestina* in Australia may result in some quarantine restriction for produce sent to countries where this pathogen is not established. However, *P. clandestina* already occurs in other countries so the impacts may be restricted in magnitude.
Environment	**A** — Indiscernible at the local level. Fungicides required to control powdery mildew are not expected to have any incidental impacts on the environment beyond those already occurring due to fungicide applications for other pathogens.

Based on the decision rules described in Table 23.4, that is, where the consequences of a pest with respect to one or more criteria are '**D**', the overall consequences are considered to be **LOW**.

4.15.6 Unrestricted risk

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5. The unrestricted risk estimation for powdery mildew fungi is shown below.

Unrestricted risk estimate for powdery mildew fungi	
Overall probability of entry, establishment and spread	**Very Low**
Consequences	**Low**
Unrestricted risk	**Negligible**

As indicated, the unrestricted risk for *P. clandestina* has been assessed as ‘negligible’, which meets Australia’s ALOP. Therefore, specific risk management measures are not required for this pathogen.

4.16 *Taphrina pruni* (Taphrinales: Taphrinaceae)

This analysis considers the following species which is of quarantine significance to Western Australia:

Taphrina pruni Tul. Plum pockets **WA EP**

The pathogen *T. pruni* has previously been assessed with the importation of stone fruit from New Zealand. In that assessment, the probability of entry, establishment and spread was assessed to be 'extremely low' and the consequences assessed to be 'low'. As a result the unrestricted risk was assessed to be 'negligible' and no specific quarantine measures were determined to be necessary.

The existing policy for *T. pruni* is adopted for the importation of stone fruit from California, Idaho, Oregon and Washington as the risks of importation and distribution are judged to be similar. Therefore *T. pruni* is not considered further here.

4.17 *Plum pox potyvirus*

The pathogen considered in this risk assessment is
Plum pox potyvirus Plum pox

Plum pox potyvirus (PPV) causes plum pox (sharka) disease. Plum pox is considered one of the most economically important diseases of stone fruit (Németh 1994; EPPO/CABI 2004). The disease reduces fruit quality and can cause premature fruit drop, resulting in large yield losses (Németh 1994; EPPO/CABI 2004). PPV infected trees were found in Pennsylvania in 2000, and in Michigan and New York State in 2006. In 2000, the virus was also found in the Canadian provinces of Nova Scotia and Ontario (CFIA 2008). Ontario neighbours New York State and Michigan. In association with state inspection agencies, APHIS has implemented measures to trace, eradicate and monitor PPV in the affected US regions. However, the incursions of this pathogen in the US and concerns over US domestic movement restrictions justified a detailed risk assessment.

PPV is a member of the genus *Potyvirus* in the Potyviridae family. The virus particles are flexuous rods about 700 x 11nm (EPPO/CABI 2004). The genome is a single-stranded positive sense RNA molecule about 9.7 kilobases long (López-Moya *et al.* 2000), which encodes 9 or 10 proteins.

Most PPV isolates are transmitted in a non-persistent manner during feeding by aphids (Labonne *et al.* 1995; Gildow *et al.* 2004; Glasa *et al.* 2004). Flights of aphids transmit the virus within and between orchards and can transmit after feeding on infected fruit (Labonne and Quiot 2001; Labonne and Quiot 2006; Gildow *et al.* 2004a; Gildow *et al.* 2004b). PPV is probably not transmitted through seed (Dulić Marković and Ranković 1996; Myrta *et al.* 1998; Pasquini *et al.* 2000; Thomidis and Karajiannis 2003). PPV isolates are also transmitted by grafting and mechanical inoculation.

Several distinct strains of PPV are recognised (Glasa *et al* 2004; Myrta *et al.* 2006). The Dideron strain (PPV-D) and the Marcus strain (PPV-M) are most frequently reported and are widespread in Europe. PPV-D mainly infects apricot and plum and occasionally peach, whereas PPV-M is known for the damaging disease it causes in peach (Pasquini and Barba 1996). The Cherry strain (PPV-C) is the only known strain to infect cherry species systemically, including sour and sweet cherries (Nemchinov and Hadidi 1996; Fanigliulo *et al.* 2003). The Winona strain (PPV-W) has only been found in two plum trees in Ontario, Canada (James *et al.* 2003). The El Amar strain (PPV-EA) was from apricot (Pasquini and Barba 1996) and has only been found in Egypt (Glasa *et al.* 2006; Myrta *et al.* 2006).

Apart from the two trees found with PPV-W, all North and South American isolates of the virus are considered to be PPV-D (Levy *et al.* 2000b). When compared, PPV-D is considered to spread more slowly and be less efficiently transmitted by aphids than PPV-M (Pasquini and Barba 1996; Gildow *et al.* 2004).

The risk posed by PPV is that infected fruit and/or seed may enter Australia and result in the establishment of this virus in hosts in Australia. The strain of the virus that is present on stone fruit in some areas of the US is the D strain (Levy *et al.* 2000b).

4.17.1 Probability of entry

The probability of entry is considered in two parts, the probability of importation and the probability of distribution, which consider pre border and post border issues respectively.

Probability of importation

The probability that PPV will arrive in Australia on fruit that has undergone existing production and post-harvest practices in the US has been determined to be **EXTREMELY LOW**.

Supporting evidence for this assessment is provided in the text below:

- PPV has only been confirmed from restricted areas in the states of Pennsylvania, Michigan and New York. The virus was declared eradicated from Michigan and Pennsylvania in 2009, but may still exist in a restricted area in New York State (Holton 2009; NAPPO 2010).
- A national survey started in the US in 2000 ran for three years (Hughes *et al*. 2002) and from 2004 surveys continued in some states including California and Oregon (Levy 2006; Osterbauer *et al*. 2006). No reports of PPV in California and the Pacific Northwest states were found.
- Prior to eradication of PPV from Michigan and Pennsylvania in 2009, official controls were in place for the movement of nursery stock of host species from Pennsylvania, Michigan and New York and legislated in the *Code of Federal Regulations* (Johanns 2007; USDA 2009). Controls did not extend to the sale of fruit from areas where the virus had been detected (APHIS 2009).
- Aphids transmit PPV from infected fruit (Labonne and Quiot 2001; Gildow *et al.* 2004a; Gildow *et al*. 2004b). However, the risk of distribution through fruit is considered to be a lower than the risk of distribution through nursery stock (APHIS 2009; USDA 2009).
- There is a small possibility that the virus could enter the exporting states in fruit and aphids could transmit the virus to fruit trees. However, California and the Pacific Northwest states are major producers of stone fruit and the total volume of stone fruit entering these states from the eastern US is expected to be small.

Harvesting fruit for export

- Infected fruits can show chlorotic spots or yellow rings or line patterns, and fruit can become deformed or irregular in shape and develop brown or necrotic areas (EPPO/CABI 2004). Diseased fruit have browned flesh and may drop prematurely (EPPO/CABI 2004).
- While plums are recognised as one of the best indicator plants for PPV, symptoms may not always be present. The strain of the virus present in Pennsylvania has been detected in symptomless fruit (Gildow *et al.* 2004).
- While a proportion of infected fruit is likely to be culled during harvest, asymptomatic fruit or fruit with mild symptoms are likely to escape detection.

Processing of fruit in the packing house

- Stone fruit would be washed and brushed/defuzzed prior to grading operations. However, this would have no effect on the presence of virus particles inside the fruit or seed.
- Symptomatic fruit is likely to be culled during sorting and grading operations. However, some infected fruit might pass through this process and be packed for export to Australia and asymptomatic fruit or fruit with mild symptoms are likely to escape detection.

Pre-export and transport to Australia

- After packing, fruit is stored at <1°C (Curtis *et al.* 1992).

- Transport of fruit to Australia would be either by air freight or by sea freight, with the total time in transit, from orchard until arrival in Australia, expected to take from a few days to three weeks.
- PPV can be recovered from fruit stored for a month or less at 4°C (EPPO/CABI 2004; Gildow *et al.* 2004). Cold storage treatment during transport will not eliminate the virus.

Probability of distribution

The probability that PPV, having entered Australia in infected fruit, will survive during the movement of fruit within Australia after it has been released from the port of entry and be transported in a reproductively viable state to a suitable host has been determined to be **LOW**.

Supporting evidence for this assessment is provided in the text below:

- Stone fruit will be imported for human consumption. Fruit will be distributed to many localities by wholesale and retail trade and by individual consumers. Fruit may be distributed to all states in unrestricted trade.
- Most fruit waste will be discarded into managed waste systems and will be disposed of in municipal tips. Consumers will discard small quantities of fruit waste in urban, rural and natural localities. Small amounts of fruit waste will be discarded in domestic compost. Fruit waste may be discarded near host plants.
- Distribution of the virus to a susceptible host could occur in two ways. Firstly, aphids that are vectors of PPV could feed on infected fruit and transmit the virus to a host plant. Secondly, infected seed could germinate and give rise to an infected plant.
- Plum pox virus is probably not seed transmitted (Dulić Marković and Ranković 1996; Myrta *et al.* 1998; Pasquini *et al.* 2000; Thomidis and Karajiannis 2003; Zagrai and Zagrai 2008). The virus has been detected in seed, suggesting it is possible that some strains are transmitted through seed at very low rates (Nemeth and Kolber 1982; James *et al.* 2003) that are below the rates that are detected in transmission experiments.
- The aphids *Aphis craccivora*, *Aphis gossypii, Brachycaudus helichrysi*, *Brachycaudus persicae* and *Myzus persicae* transmit PPV and are present in all states of Australia (DEWHA 2009; Levy *et al.* 2000a). *Aphis spiraecola* and *Hyalopterus arundinis* are vectors of PPV that are present in all Australian states, except WA (DEWHA 2009; Levy *et al.* 2000a).
- *Myzus persicae* and *Aphis spiraecola* that have fed on peach fruit infected with PPV can transmit the virus (Labonne and Quiot 2001; Gildow *et al.* 2004a; Gildow *et al*. 2004b). Potyvirus particles can be acquired and transmitted by an aphid in a few seconds or minutes of feeding (Gibbs and Harrison 1976).
- Aphids will probe inappropriate plants to test their suitability as a food source, and if a plant is not suitable, winged aphids will fly in search of a suitable plant. This behaviour probably assists virus spread (Matthews 1991; Powell *et al*. 2006; Moorman and Gildow 2008).
- The primary hosts of PPV, *Prunus* spp., are only likely to have suitable tissue for aphid feeding during a portion of the stone fruit import season from the United States. However, the warmer conditions in the low-chill stone fruit production regions that include the northern areas of New South Wales, Queensland and parts of Western Australia may see trees reach bud break while significant quantities of stone fruit are arriving from the US. Good volumes of Californian stone fruit are reported in New Zealand stores in mid September (California Tree Fruit Agreement 2007b).
- The limited opportunities for aphid feeding on fruit waste and transmission to a susceptible host mean that distribution through this pathway is unlikely. For this scenario to occur, fruit waste would need to be discarded in a place where aphids are likely to feed on the waste.

This could occur in urban or suburban gardens, but would represent a very small proportion of all imported fruit. There is a greater chance that this could occur through the importation of bulk bins that imported and then repacked in Australia.

- The importance of weed hosts is not clear. A number of weed species are reported as natural hosts of PPV, including: *Solanum nigrum*, *Taraxacum officinale* and *Trifolium* sp. (Virscek *et al*. 2004). Woody weed hosts include *Euonymus europaea*, *Juglans regia*, *Ligustrum vulgare*, *Prunus spinosa* (Polak *et al*. 2003; Polak 2006). The PPV strains that infect the weeds have not been reported. While the weed species are less important than mature stone fruit trees in the case of outbreaks, they may act as an intermediate host for the distribution of PPV to primary hosts in Australia.

Overall probability of entry (importation x distribution)

The overall probability of entry for PPV is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for PPV is assessed to be **EXTREMELY LOW**.

4.17.2 Probability of establishment

The probability that PPV, having been distributed in a viable state to a suitable host, will establish a persistent population into the foreseeable future has been determined to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Availability of suitable hosts, alternative hosts and vectors in the PRA area

- PPV infects *Prunus* species. The D strain present in the US infects almond, apricot and plum and occasionally infects peach (Pasquini *et al.*2000; Wallis *et al.* 2005). It is not capable of infecting cherry.
- Almond, apricot, nectarine, peach and plum are common trees in Australia.
- PPV has been transmitted experimentally to 60 plant species including species from eight families and has been found naturally infecting some weed species (Polak *et al*. 2003; Virscek *et al*. 2004; Polak 2006). Weed host species might act as intermediate or reservoir hosts allowing the establishment of PPV in Australia.
- Aphid species present within Australia that are capable of transmitting the virus from infected fruit to host plants and between host plants including: *Aphis craccivora*, *Aphis gossypii*, *Aphis spiraecola*, *Brachycaudus helichrysi*, *Brachycaudus persicae*, *Hyalopterus arundinis* and *Myzus persicae*.(Gildow et al. 2004b; DEWHA 2009; APPD 2010). Other endemic aphids may also be able to transmit PPV.

Suitability of the environment

- PPV has been found within the Eastern and Great Lake states of the US (Michigan, Pennsylvania and New York State). PPV is also found in Europe, North Africa, India, Central Asia, and Chile. The climate in these regions is similar to that in temperate parts of Australia and would not prevent the virus from establishing in Australia.

Reproductive strategy and the potential for adaptation

- The virus multiplies in growing host plants.
- *Myzus persicae* is capable of acquiring 40-2000 PPV particles by feeding on infected plants (Olmos *et al.* 2005).

- Potyvirus particles can be acquired and transmitted by an aphid in a few seconds or minutes of feeding (Gildow *et al*. 2004a). Aphids usually retain particles for no more than an hour, and many will not transmit the virus after a few minutes (Matthews 1991). Under some conditions, particles of some potyviruses may be retained for longer, possibly up to 24 hours (Shukla 1994).
- PPV is estimated to fix mutations at a high rate, 1.4×10^{-4} substitutions per site per year (Gibbs *et al*. 2008), and so PPV strains may have the capacity to adapt to vectors and hosts present in Australia.
- The generation of recombinant viral strains is also evidence of adaptation of strains of the virus (Glasa *et al.* 2004).

Cultural practices and control measures

- Spread of the virus is controlled by destroying infected trees, but this is an action taken after PPV has established and the infection has been detected.
- Systemic spread within a tree may take several years (CABI-EPPO 2007). Infected trees may be symptomless (USDA 2009).
- No measures would be applied in Australia until symptoms of PPV were detected, so there would be no actions taken to prevent the establishment of PPV.
- Quarantine conditions restrict the movement of fruit between certain Australian states, but there is no routine monitoring or testing that would detect fruit infected with PPV.

4.17.3 Probability of spread

The probability that PPV, having established a persistent population on a suitable host in Australia, will spread to other susceptible hosts both in the local area and more widely has been determined to be **HIGH**.

Supporting evidence for this assessment is provided in the text below:

Suitability of natural and/or managed environment

- PPV has been found within the Eastern and Great Lake states of the US (Michigan, Pennsylvania and New York State) (Johanns 2007).
- PPV is also found in Europe, North Africa, India, Central Asia and Chile (USDA 2009).
- The Dideron strain of PPV infects *Prunus* species including almond, apricot, peach and plum (Pasquini *et al.*2000; Wallis *et al.* 2005) and these host trees are common in Australia in orchards and in residential areas.
- The climate, vector and host numbers in temperate areas of Australia are probably similar to those in areas where the virus is prevalent and would therefore be suitable for the spread of this virus.

Presence of natural barriers

- PPV is limited to the host plant and cannot spread without either a vector, or by movement of the fruit or plant commodity.
- Interstate quarantine controls may limit the rate of spread. However, intrastate transportation may be a potential pathway of spread.
- The most effective means of transmission of PPV is by aphid vectors which have a limited capacity for dispersal.

Potential for movement with commodities, conveyances or by other vectors

- If it established, PPV would be spread by aphid species that are found in Australia including: *Aphis craccivora*, *Aphis gossypii, Aphis spiraecola*, *Brachycaudus helichrysi*, *Brachycaudus persicae, Hyalopterus arundinis* and *Myzus persicae*.(Gildow *et al.* 2004b; DEWHA 2009; APPD 2010). Other endemic aphids may also be able to transmit PPV.
- Transport by aphid vectors would be most important for short range spread. Aphids can acquire the virus in 30 seconds of feeding and transmit the virus for minutes or hours (Levy *et al*. 2000a).The total distance aphids move while infectious is usually limited and they are most likely to spread the virus between nearby hosts (USDA 2009). Aphids may fly with prevailing winds and might infrequently transport the virus over several kilometres.
- The Dideron strain is considered less virulent than other strains and is less efficiently transmitted by aphids than other strains present in Europe (Pasquini and Barba 1996).
- The transportation of infected nursery stock would be the most important means of long distance spread of PPV. Infected fruit may also play a role.
- Preventing the movement of nursery stock would be one of the most important ways of preventing PPV from spreading within Australia. However, unless an outbreak is identified, restrictions on nursery stock movement may not be applied and specific testing for PPV may not be carried out.

4.17.4 Conclusion – probability of entry, establishment and spread

The probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods shown in Table 2.2.

The overall likelihood that PPV will enter Australia as a result of trade in stone fruit from California and the Pacific Northwest states and be distributed in a viable state to suitable hosts in Australia, establish and subsequently has been assessed as **EXTREMELY LOW**.

4.17.5 Consequences

The consequences of the establishment of PPV in Australia have been assessed according to the methods described in Table 2.3. The justification for these ratings is provided below:

Impact scores for plum pox virus	
Direct Impacts	**Estimate and Justification**
Plant life or health	**F** — Major significance at the regional level. This virus is considered to cause one of the most important diseases affecting stone fruit (Németh 1994). Symptoms vary depending on the virus strain, host cultivar and environment conditions. Some cultivars may be symptomless (USDA 2009). The leaves of infected symptomless trees become distorted or develop blotches, chlorotic rings, chlorotic spots or vein chlorosis (EPPO/CABI 2004). Petals may show colour breaking (USDA 2009). Fruit may fall prematurely or may become deformed or develop blotches, rings or distinct depressions on their surfaces. Depending on the host species, fruit flesh may become brown or necrotic in some areas and they may be saturated with gum through to the seed (EPPO/CABI 2004). Apricot fruit can develop a lumpy appearance. The bark of infected sensitive plum cultivars may split and the trees may decline in a few years (Kegler and Hartmann 1998). Crop losses from susceptible cultivars can be as high as 90–100% (Kegler and Hartmann 1998). Replanting is the only option and it may take six years for trees to reach productive capacity. During quarantine, affected orchards are not replanted with susceptible species and the resulting delay or change in fruit production will reduce

	income over several years.
Any other aspects of the environment	**B** — minor significance at the local level. Plum pox virus may infect non-commercial hosts, such as ornamental plums and apricots, present in urban and suburban areas as amenity plants. However, the impact on these alternative hosts is likely to be small as the trees will be replaced.
Indirect Impacts	**Estimate and Justification**
Eradication, control, etc.	**E** — Minor significance at the national level. Eradication efforts to eliminate PPV will rely on the early detection, quarantine and ability to remove all host trees in the vicinity. The United States Department of Agriculture reported costs of US $40 million for the destruction of trees over 1600 acres (approximately 650 hectares) of commercial orchards in Pennsylvania following the detection in four counties (USDA 2007). A national survey will be carried out if PPV is detected in an orchard or nursery in Australia. The survey would include nurseries, orchards and residential areas with host plants and would probably continue for more than a year. Very large numbers of samples would tested, which would be costly. Surveys would continue in districts where the pathogen is found until two successive years of survey yield no positive results.
Domestic trade	**E** — Significant at the regional level. The presence of PPV in commercial production areas would result in quarantine regulations on the movement of risk material, including fruit. Currently, stone fruit may move between Australian states with specific quarantine measures for insect pests. It is likely that fruit movement would be restricted if PPV established in any region of Australia.
International Trade	**E** — Significant at the regional level. While PPV is recorded from Europe, important Australian markets for stone fruit would be expected to introduce new quarantine restrictions on Australian stone fruit. The potential loss of trade and difficulty in re-establishing markets is likely to be significant at the regional level.
Environment	**B** — Minor at the local level. Aphids are important vectors of PPV and the establishment of the virus in Australia would likely increase the use of various treatments for aphids. Heavy use of insecticides, particularly those with systemic and/or persistent effects may have some impact on other insects in and around orchards, including beneficial and native species.

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**F**', the overall consequences are considered to be **HIGH**.

4.17.6 Unrestricted risk

Unrestricted risk is the result of combining probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5. The unrestricted risk estimation for PPV is shown below.

Unrestricted risk estimate for plum pox virus	
Overall probability of entry, establishment and spread	**Extremely Low**
Consequences	**High**
Unrestricted risk	**Very low**

As indicated, the unrestricted risk for plum pox virus has been assessed as 'very low', which meets Australia's ALOP. Therefore, specific risk management measures are not recommended for plum pox virus.

4.18 Tobacco necrosis viruses

The pathogens considered in this risk assessment is:
Tobacco necrosis virus A, *Tobacco necrosis virus D*, tobacco necrosis virus Nebraska isolate and related viruses

The taxonomy of 'tobacco necrosis virus' (TNV) has been revised. *Tobacco necrosis virus A* (TNV-A) and *Tobacco necrosis virus D* (TNV-D) have been recognised as distinct species in the *Necrovirus* genus (Meulewaeter *et al*. 1990; Coutts *et al*. 1991), as have *Chenopodium necrosis* virus (ChNV) and *Olive mild mosaic virus* (OMMV), which were previously considered TNV isolates (Tomlinson *et al*. 1983; Cardoso *et al*. 2005). TNV isolates from Nebraska and Toyama (TNV-NE and TNV-Toyama) represent another species in the genus, as yet not officially recognised (Zhang *et al*. 1993; Saeki *et al*. 2001) and molecular sequence data indicates some other necroviruses called 'tobacco necrosis virus' are also distinct species (NCBI 2009).

Necroviruses are transmitted through soil. ChNV, TNV-A and TNV-D are transmitted by the root-infecting chytrid fungus Olpidium brassicae (Wor.) Dang (Rochon *et al*. 2004) and at least one TNV strain is transmitted by the related chytrid *Olpidium virulentus* (Sasaya and Koganezawa 2006). Virus particles released from roots and other plant matter are acquired in soil water by fungal zoospores and transmitted when the spores infect the roots of a suitable host. TNV particles are stable and relatively long lived. Transmission probably only occurs when there is sufficient soil water for *Olpidium* zoospore activity (Uyemoto 1981; Spence 2001). TNVs cause sporadic disease in some vegetable crops, strawberry, tulip and soybean. TNVs have been detected in apricot causing symptomless systemic infections (Uyemoto and Gilmer, 1972) and in plum (Zitikaite and Staniulis 2009). The necrovirus species involved in the infections of apricot in the USA were not identified but in the case of plum tree infection in Lithuania and Germany the necrovirus species has been identified as TNV-D (Staniulis 2003). A different species of TNV has been recorded in the Czech Republic on plum as TNV-B2 (Paulechova and Baumgartnerova 1980). In both the Lithuanian and Czech Republic cases, TNV was identified during initial detections of Plum pox potyvirus (PPV) in both these countries, where it was identified in a mixed infection with PPV. Although TNVs have been reported in Queensland and Victoria (Findlay and Teakle 1969; Teakle 1988), it is not known if the species or strains that infect *prunus* sp in the USA are present in Australia. TNV was thought to be ubiquitous and have a world-wide distribution (Uyemoto 1981; Brunt and Teakle 1996), but this status has not been reviewed since the taxonomic revision of the viruses. A satellite virus replicates with some strains of TNV.

A pathway is considered where the particles of foreign TNV species or strains are released from fruit waste, acquired in soil by a vector and transmitted to suitable host plants. TNVs may enter Australia in hyacinth (*Hyacinthus* sp.), lily (*Lilium* sp.) and tulip (*Tulipa* sp.) bulbs imported for planting under current conditions (ICON 2009). It is not known if the species and strains infecting monocots are the same as those infecting stonefruit.

4.18.1 Probability of entry

The probability of entry is considered in two parts, the probability of importation and the probability of distribution, which consider pre border and post border issues respectively.

Probability of importation

The probability that tobacco necrosis viruses will arrive in Australia in fruit that has undergone standard production and post-harvest practices in the US is estimated to be **MODERATE**.

Supporting information for this assessment is provided below:

- TNVs are widely prevalent in Oregon (APHIS 2007b) and TNVs are probably present in all states of the PNW. TNVs likely to be strains of TNV-A and TNV-D have been detected in the US (Babos and Kassanis, 1963; Grogan and Uyemoto 1967) and TNV-NE was first described in Nebraska (Zhang *et al*. 1993).
- Strains of TNV were found naturally infecting plum trees in Lithuania (Zitikaite and Staniulis 2009). The taxonomy, incidence and distribution of the stonefruit-infecting TNVs in the US are not known.
- Apricot trees infected with TNV in the USA showed no symptoms (Uyemoto and Gilmer 1972; Nemeth, 1986).
- TNV's have a broad host range (Staniulis 2003).

Probability of distribution

The probability that tobacco necrosis viruses, having entered Australia in infected fruit, will survive during the movement of fruit within Australia after it has been released from the port of entry and be transported in a reproductively viable state to a suitable host is estimated to be **MODERATE**.

Supporting information for this assessment is provided below:

- Imported stonefruit is intended for human consumption. Fruit will be distributed to many localities by wholesale and retail trade and by individual consumers. Stonefruit may be distributed to all states in unrestricted trade.
- Most stonefruit waste will be discarded into managed waste systems and will be disposed of in municipal tips. Consumers will discard small quantities of stonefruit waste in urban, rural and natural localities. Small amounts of stonefruit waste will be discarded in domestic compost.
- Fruit waste may be discarded near host plants.
- TNV particles are moderately to highly stable and survive for long periods in plant debris. TNV particles survive in soil containing infected roots for up to 130 days (18.5 weeks) and remain viable *in vitro* at 20°C for one to eight weeks, depending on the strain, and up to several years *in vitro* at -20°C (Smith *et al*. 1969; Kassanis 1970; Gibbs and Harrison 1976; Brunt and Teakle 1996; Nemeth 1986).
- TNV particles tolerate temperatures as high as 95oC (Brunt and Teakle 1996), so the temperatures achieved by composting and soil pasteurization may not eliminate the viruses.
- Virus particles are released from roots and plant debris (CABI 2009).
- TNVs are transmitted by the zoospores of the chytrid fungi *Olpidium brassicae* and *Olpidium virulentus* (Rochon *et al*. 2004; Sasaya and Koganezawa 2006). The chytrids probably occur throughout Australia. *Olpidium brassicae* has been recorded in New South Wales and Western Australia (APPD 2009). *Olpidium virulentus* has been recorded in Western Australia (Maccarone *et al*. 2008).
- *Olpidium brassicae* is an efficient vector of TNV-D and can acquire particles from very dilute solutions and transmit the virus to susceptible hosts in short time periods (Kassanis and

MacFarlane 1964). If infected fruit waste is discarded in areas where *Olpidium* zoospores are active, then zoospores may acquire particles and transmit the virus.

- Species of *Olpidium* form resting spores through sexual reproduction (Spence 2001; Herrera-Vesquez *et al*. 2009). Resting spores resist dessication, are long lived and may be distributed in dust, soil and roots. They germinate to produce zoospores.
- Zoospores need water to germinate and move and they are only active when there is sufficient soil moisture (Spence 2001). During drought and dry weather, zoospores are unlikely to be active in some areas because of dry conditions.
- Only certain *Olpidium brassicae* biotypes will transmit particular TNV strains (Uyemoto 1981). Some isolates of *Olpidium brassicae* will parasitize a wide range of host plants whereas others are more specific (Campbell 1996).
- TNV strains typically have wide experimental host ranges (Uyemoto 1981). TNVs have been found collectively to naturally infect apple (*Malus pumila*), apricot (*Prunus armeniaca*), adzuki bean (*Vigna angularis*), beetroot (*Beta vulgaris*), cabbage (*Brassica oleracea*), carrot (*Daucus carota*), citrus (*Citrus* spp.), common bean (*Phaseolus vulgaris*), crab apple (*Malus sylvestris*), cucumber (*Cucumis sativus*), European pear (*Pyrus communis*), grapevine (*Vitis vinifera*), hyacinth (*Hyacinthus* sp.), lettuce (*Lactuca sativa*), lily (*Lilium* sp.) olive (*Olea europaea*), passionfruit (*Passiflora edulis*), pea (*Pisum sativum)*, plum (*Prunus domestica*), potato (*Solanum tuberosum*), sour cherry (*Prunus cerasus*), soybean (*Glycine max*), strawberry (*Fragaria* × a*nanassa*), tomato (*Solanum esculentum*) tulip (*Tulipa gesneriana*) and zucchini (*Cucurbita pepo*) (Kassanis 1970; Brunt and Teakle 1996; Pham *et al*. 2007a, b; CABI 2009; Zitikaite and Staniulis 2009). Commercial crops of some of these plants are grown in every Australian state and territory and others are grown commercially in several states (HAL 2004; SAI 2009). Many of the plants are grown in domestic gardens and tulip is grown as an ornamental in Tas., Vic. and parts of NSW.
- TNVs are also found in some wild plants, weeds and forest trees including birch (*Betula* spp.), European ash (*Fraxinus excelsior*), European beech (*Fagus sylvatica*), Norway spruce (*Picea abies*), pedunculate oak (*Quercus robur*), poplar (*Populus* spp.) and potato weed (*Galinsoga parviflora*) (Hibben *et al*. 1979; Teakle 1988; Nienhaus and Castello 1989; Bos, 1999).
- It is unlikely that the TNV strains that infect stonefruit will also infect all of the species recorded as hosts of TNVs collectively. The host ranges of many strains and the newly recognised species are largely unknown. The TNVs were considered to be a single species when most host range studies were done (Brunt and Teakle 1996).

Overall probability of entry (importation x distribution)

The overall probability of entry for tobacco necrosis viruses is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for tobacco necrosis viruses is estimated to be **LOW**.

4.18.2 Probability of establishment

The probability that tobacco necrosis viruses, having been distributed in a viable state to a susceptible host, will establish a persistent population into the foreseeable future is estimated to be **HIGH**.

Supporting information for this assessment is provided below:

Availability of suitable hosts, alternative hosts and vectors in the PRA area

- Commercial crop, ornamental plant and fruit tree hosts of TNVs are common throughout Australia.
- *Olpidium brassicae* and *Olpidium virulentus*, the vectors of TNVs, probably occur throughout Australia. Evidence of the widespread nature of *Olpidium virulentus* comes from knowledge of lettuce big-vein disease that occurs throughout Australia and is caused by *Mirafiori Lettuce Big-Vein Virus* (MLBVV) which is transmitted by *Olpidium virulentus* (McDougall 2006; Maccarone *et al.* 2008).
- When infected by TNVs many plant species appear symptomless (Uyemoto 1981). Many hosts of TNVs appear not to be systemically infected (Bawden 1956). TNV infections may not be detected.

Suitability of the environment

- The presence of TNVs in many countries (CABI 2009) suggests these viruses can become established in places with widely differing conditions.
- TNV-NE and its close relative TNV-Toyama were isolated in Nebraska and Japan (Zhang *et al*. 1993; Saeki *et al*. 2001) and a closely related TNV has been detected in Europe (Zitikaite and Staniulis 2009).
- Viruses likely to be strains of TNV-A and TNV-D have been recorded in Victoria and in three sites in Queensland (Findlay and Teakle 1969; Teakle 1988). TNV incidence in Queensland varies from year to year depending on rainfall (Teakle 1988). Conditions exist in Australia that will suit other necrovirus species and strains.
- In the United Kingdom, TNVs produce greater levels of disease in glasshouse grown plants in winter than in summer (Bawden 1956). The infectivity of TNVs present in the United Kingdom, as measured by mechanical inoculation of leaves, is reduced when plants are exposed to higher light intensities (Bawden 1956).
- In general, plants that are growing vigorously are more likely to be infected by viruses (Bawden 1956; Gibbs and Harrison 1976). In Australia, potential hosts of TNVs will be growing during most of the year depending on temperature and rainfall.

Reproductive strategy and the potential for adaptation

- *Olpidium* zoospores acquire TNV particles within a few minutes of mixing *in vitro* in solution (Kassanis and MacFarlane 1964; Gibbs and Harrison 1976). Zoospores can drift and swim in films of soil water to a root surface, where they form a cyst and then penetrate the root epidermal cells and infect the plant (Gibbs and Harrison 1976).
- Transmission only occurs when there is sufficient soil water for *Olpidium* activity (Uyemoto 1981; Spence 2001). Drought and long dry spells may limit the opportunity for TNVs to establish by limiting zoospore activity, whereas high rainfall may favour TNVs as it favours zoospore activity.

4.18.3 Probability of spread

The likelihood that tobacco necrosis viruses, having established a persistent population on a suitable host in Australia, will spread to other susceptible hosts both in the local area and more widely is estimated to be **HIGH**.

Supporting information for this assessment is provided below:

Suitability of natural and/or managed environment

- Climatic conditions that favour plant growth may increase the chance of a TNV spreading in Australia. Rainfall will favour zoospore activity, as may cool conditions because of reduced evaporation.

Presence of natural barriers

- It is not known how long *Olpidium* zoospores remain infective, but the zoospores may only live for a few days (Gibbs and Harrison 1976; Spence 2001).

Potential for movement with commodities, conveyances or by other vectors

- TNVs are transmitted by the zoospores of *Olpidium brassicae* and *Olpidium virulentus*. These chytrids probably occur throughout Australia. (Rochon *et al*. 2004; McDougall 2006; Sasaya and Koganezawa 2006; Maccarone *et al.* 2008; APPD 2009).
- The viruses are transmitted to the roots of susceptible plants and to leaves that are touching the ground (Bawden 1956; Uyemoto 1981).
- No measurements of the rate at which TNV spreads through fields have been found.
- In moist soil and without physical assistance, zoospores only move very short distances (10-20 mm) (Dixon 2009). Rain splash will disperse the fungus. Sporagia and zoospores will be dispersed in runoff water, irrigation channels and waterways.
- TNVs spread through soil with the movement of soil water (Smith *et al*. 1988) and can be found in waterways (Tomlinson *et al*. 1983). Drainage water from contaminated soil contains infectious TNV particles as does runoff. However, a report of TNV spreading from waterways has not been found.
- TNVs are spread in a glasshouse if an irrigation source is contaminated with the virus (Bawden 1956; Harrison 1960) or viruliferous zoospores.
- *Olive latent virus 1*, another necrovirus, is probably transmitted through soil water without the aid of a vector (Lommel *et al*. 2005) and it is possible some TNVs may be transmitted in this way.
- TNV particles are probably spread in dust by wind (Harrison 1960), although drying prevents transmission. They are probably also spread by splashing.
- Root-infecting viruses are spread to new sites by movement of soil, root fragments and drainage water and by transplanting infected plants (Harrison 1977). Soil-borne viruses may be spread to new localities by the transfer of soil on agricultural implements and possible also on the boots of farm workers (Harrison 1960).

The presence of chytrid vectors in Australia and the likely spread of TNVs in soil and water supports a spread risk rating of ‘high’.

4.18.4 Probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of ‘rules’ for combining descriptive probabilities shown in Table 2.2.

The overall probability that tobacco necrosis viruses will enter Australia as a result of trade in stone fruit from California and the Pacific Northwest states and be distributed in a viable state to susceptible hosts, establish and subsequently spread, is estimated to be **LOW**.

4.18.5 Consequences

The consequences of the establishment of tobacco necrosis viruses in Australia have been estimated according to the methods described in Table 2.3. The justification for these ratings is provided below:

Impact scores for tobacco necrosis viruses	
Direct Impacts	**Estimate and Justification**
Plant life or health	**C** – Minor significance at the district level. Among the hosts in which TNVs cause disease, carrot, potato and strawberry are the most economically important in Australia, with the estimated value in 2002 of the carrot crop being $198.5 million, the potato crop being $485.4 million and the strawberry crop being $107.72 million (HAL 2004). The sporadic diseases caused by TNVs are economically important in some vegetable and ornamental crops in some years (Kassanis 1970; Uyemoto 1981; Nemeth 1986; Smith *et al*. 1988; Zitikaite and Staniulis 2009). No reports of adverse effects on fruit trees have been found (Nemeth 1986). A deterioration disease in trembling aspen (*Populus tremuloides*) may be caused by TNVs (Hibben *et al*. 1979). TNVs cause rusty root disease of carrot, Augusta disease of tulip, stipple streak disease of common bean, necrosis diseases of cabbage, cucumber, soybean and zucchini and ABC disease of potato (Uyemoto 1981; Smith *et al.* 1988; Zitikaite and Staniulis 2009). Losses as high as 50% have been recorded in tulips and glasshouse grown cucumbers (CABI 2009). No estimates of losses in carrot, potato and strawberry have been found. Symptomless viral infections of plants, in general, may cause no yield loss, but they may cause yield losses as high as 15% (Gibbs and Harrison 1976; Bos 1999). Naturally infected vegetable crops show a range of symptoms including spots, flecks, streaks, necrosis and stunting. In strawberry in the Czech Republic, TNV has caused dwarfing and leaf and root necrosis (Martin and Tzanetakis 2006). Stipple streak disease has been reported in Queensland causing small yield losses (Teakle 1988), but no reports of TNVs causing other diseases in Australia have been found, suggesting the combinations of virus strain, vector biotype and host plant cultivar that result in disease have not occurred in Australia. Strains have been distinguished by various characteristics including the symptoms they cause, their host ranges and genetic sequences (Kassanis 1970). The diseases recorded in common bean and cucumber are probably caused by distinct TNV strains (Brunt and Teakle 1996; Zitikaite and Staniulis 2009). No report of further investigation of their disease causing potential was found. A satellite virus replicates with some strains of TNV (Kassanis, 1970; Uyemoto 1981) but no report has been found indicating greater disease when the satellite virus is present. Given the wide host range of TNVs and their chytrid vectors it is likely that some native plants will be susceptible, although no supporting evidence was found.
Any other aspects of the environment	**A** – Indiscernible at the local level. Plum pox virus may infect non-commercial hosts, such as ornamental plums and apricots, present in urban and suburban areas as amenity plants. However, the impact on these alternative hosts is likely to be small as the trees will be replaced.
Indirect Impacts	**Estimate and Justification**
Eradication, control, etc.	**C** – Significant at the local level. Virus control measures in fields are limited and eradication may not be possible unless an outbreak is detected at an early stage. Resistant cultivars may be planted, if they are available, and crop rotations may be altered to reduce incidence (CABI 2009). Establishment and spread in a glasshouse may be controlled by reducing or eliminating Olpidium infestation of soil by chemical treatment or by heating by composting or soil pasteurization (Asjes and Blom-Barnhoorn 2002; CABI 2009). This may add significantly to costs. TNVs tolerate temperatures as high as 95oC (Brunt and Teakle 1996), so the temperatures achieved by composting and pasteurization may not eliminate the viruses. Propagation of virus free plants and careful sanitation may reduce the chance of outbreaks (Smith et al. 1988; CABI 2009).

Domestic trade	**C** – Minor significance at the district level. Australian states are unlikely to set up restrictions on interstate trade if a foreign TNV becomes established unless it causes significant disease, which is unlikely.
International Trade	**C** – Minor significance at the district level. If a damaging foreign TNV became established in Australia additional restrictions might be introduced on the international trade of some vegetables or ornamentals that might lead to the loss of markets and some industry adjustment.
Environment	**A** –Indiscernible at the local level. No report was found that could indicate an effect.

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**C**', the overall consequences are considered to be **VERY LOW**.

4.18.6 Unrestricted risk

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the estimate of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5. The unrestricted risk estimation for tobacco necrosis viruses is shown below.

Unrestricted risk estimate for tobacco necrosis viruses	
Overall probability of entry, establishment and spread	**Low**
Consequences	**Very low**
Unrestricted risk	**Negligible**

As indicated, the unrestricted risk estimate for tobacco necrosis viruses has been assessed as 'negligible', which achieves Australia's ALOP. Therefore, specific risk management measures are not required for these viruses.

4.19 Risk assessment conclusion

As stated previously, pests for which policy already exists have not been re-assessed in this risk analysis. A summary of those pests, and the outcome of the previous assessment is presented in Table 4.2.

The unrestricted risk estimates for all of the quarantine pests that were assessed in detail in this final IRA report for fresh, mature stone fruit California, Idaho, Oregon and Washington are presented in Table 4.3.

Any pests with an unrestricted risk estimated as ‘low’, ‘moderate’, ‘high’, or ‘extreme’ does not meet Australia’s Appropriate Level of Protection (ALOP) and requires risk management measures in addition to the existing commercial production and post-harvest processing practices.

Table 4.2 Summary of pests considered in previous policy and their unrestricted risk

Pests considered in previous policy	Probability of entry, established and spread	Consequences	Unrestricted risk
Diaspidiotus ostreaeformis WA	Very low	Low	Negligible
Pseudococcus calceolariae WA	Moderate	Low	Low
Cydia pomonella WA	Extremely Low	Moderate	Negligible
Grapholita molesta WA	Low	Moderate	Low
Frankliniella occidentalis	Moderate	Low	Low
Podosphaera tridactyla WA	Very Low	Low	Negligible
Taphrina pruni WA	Extremely Low	Low	Negligible
WA: a species identified as a quarantine pest only for the state of Western Australia only			

Table 4.3: Summary of unrestricted risk assessment for quarantine pests associated with stone fruit from California, Idaho, Oregon and Washington

Pest name	Probability of					Overall probability of entry, establishment and spread	Consequences	Unrestricted risk
	Entry			Establishment	Spread			
	Importation	Distribution	Overall (importation x distribution)					
Acari (mites)								
Tetranychidae (Spider mites) *Tetranychus canadensis* *Tetranychus mcdanieli* *Tetranychus pacificus* *Tetranychus turkestani*	Moderate	Moderate	Low	High	High	Low	Low	Very Low
Diptera (fruit flies)								
Rhagoletis completa	Very Low	Low	Very Low	High	Moderate	Very Low	Low	Negligible
Rhagoletis pomonella	Moderate but peaches and nectarines Negligible	Moderate	Low but peaches and nectarines Negligible	High	Moderate	Low but peaches and nectarines Negligible	High	Moderate but peaches and nectarines Negligible
Hemiptera (mealybugs, plant bugs, scales)								
Lygus elisus *Lygus Hesperus* *Lygus lineolaris* *Closterotomus norvegicus* WA	Very Low	Moderate	Very Low	High	Moderate	Very Low	Moderate	Very Low
Diaspidiotus forbesi *Diaspidiotus juglansregiae* *Parlatoria oleae* WA *Pseudaulacaspis pentagona* WA *Pseudaulacaspis prunicola* WA	Low	Low	Very Low	High	Moderate	Very Low	Low	Negligible
Pseudococcus comstocki *Pseudococcus maritimus* *Phenacoccus aceris*	High	Moderate	Moderate	High	High	Moderate	Low	Low

Lepidoptera (butterflies, moths)								
Anarsia lineatella	Moderate	Low	Low	High	High	Low	Moderate	Low
Archips argyrospila *Archips podana* *Archips rosana* *Argyrotaenia citrana* *Choristoneura rosaceana* *Pandemis pyrusana* *Platynota stultana*	Moderate	Moderate	Low	High	High	Low	Moderate	Low
Cydia latiferreana	Very Low	Moderate	Very Low	High	High	Very Low	Low	Negligible
Grapholita packardi *Grapholita prunivora*	Low	Moderate	Low	High	High	Low	Moderate	Low
Thysanoptera (thrips)								
Frankliniella tritici *Frankliniella intonsa* *Taeniothrips inconsequens*	High	Moderate	Moderate	High	High	Moderate	Low	Low
Bacteria								
Xylella fastidiosa	Very Low	Very Low	Extremely Low	High	High	Extremely Low	High	Very Low
Fungi								
Blumeriella jaapii	Extremely Low	Low	Extremely Low	High	Moderate	Extremely Low	Moderate	Negligible
Passalora circumscissa WA	Very Low	Very Low	Extremely Low	High	High	Extremely Low	Low	Negligible
Podosphaera clandestina	Low	Low	Very Low	High	High	Very Low	Low	Negligible
Viruses								
Plum pox potyvirus	Extremely Low	Low	Extremely Low	High	High	Extremely Low	High	Very Low
Tobacco necrosis viruses	Moderate	Moderate	Low	High	High	Low	Very Low	Negligible
WA: a species identified as a quarantine pest for the state of Western Australia only								

5 Pest risk management

5.1 Pest risk management measures and phytosanitary procedures

In addition to the existing commercial production practices for fresh stone fruit in California, Idaho, Oregon and Washington, and minimum border procedures in Australia, specific pest risk management measures, including operational systems, are recommended to achieve Australia's ALOP. These are:

- a systems approach for peach twig borer that includes infield control measures, orchard surveys and fruit cutting in the packing house
- fruit cutting in the packing house to detect cherry fruitworm and lesser apple fruitworm
- sourcing fruit from pest free areas, or areas of low pest prevalence for oriental fruit moth (exports to Western Australia only)
- sourcing and packing fruit in areas recognised as free from apple maggot (for apricots, plums and their interspecific hybrids)
- visual inspection of all consignments for mealybugs, leafrollers and thrips and remedial action when these pests are detected
- supporting operational systems to maintain and verify the phytosanitary status of consignments.

The specific pest risk management measures and operational systems recommended for fresh stone fruit from California, Idaho, Oregon and Washington are summarised in Table 5.1.

Specific pest risk management measures and operational systems recommended for fresh stone fruit from California, Idaho, Oregon and Washington for those pests of regional concern to Western Australia are summarised in Table 5.2.

Table 5.1: Phytosanitary measures recommended for quarantine pests for fresh stone fruit from California, Idaho, Oregon and Washington

Pest	Common name	Measures
Fruit flies [Diptera: Tephritidae]		• For peaches and nectarines, no measures required
Rhagoletis pomonella	Apple maggot	• For apricots and plums, and interspecific hybrids containing these species, fruit must be sourced from an area verified as free from apple maggot
Mealybugs [Hemiptera: Pseudococcidae]		
Phenacoccus aceris	Apple mealybug	• Inspection and, if required, remedial action
Pseudococcus comstocki	Comstock mealybug	
Pseudococcus maritimus	Grape mealybug	
Fruit boring moths [Lepidoptera: Gelechiidae]		• A systems approach for peach twig borer including infield monitoring, control through the growing season, pre-harvest orchard inspections and fruit cutting, and cutting of fruit culled during packing house procedures. If *A. lineatella* is detected during orchard fruit cutting or cull fruit cutting, the lots will not be eligible for export unless an approved treatment is applied
Anarsia lineatella	Peach twig borer	
Leafrollers [Lepidoptera: Tortricidae]		
Archips argyrospila	Fruit-tree leafroller	
Archips podana	Great brown twist moth	
Archips rosana	European leafroller	• Inspection and, if required, remedial action
Argyrotaenia citrana	Orange tortrix	
Choristoneura rosaceana	Oblique banded leafroller	
Pandemis pyrusana	Pandemic leafroller	
Platynota stultana	Omnivorous leafroller	
Fruit boring moths [Lepidoptera: Tortricidae]		• Pre-harvest orchard inspections and fruit cutting, and cutting of fruit culled during packing house procedures. Only lots found free of *G. packardi* and *G. prunivora* will be eligible for export
Grapholita packardi	Cherry fruitworm	
Grapholita prunivora	Lesser apple fruitworm	
Thrips [Thysanoptera: Thripidae]		
Frankliniella intonsa	Taiwan flower thrips	
Frankliniella occidentalis	Western flower thrips	• Inspection and, if required, remedial action
Frankliniella tritici	Flower thrips	
Taeniothrips inconsequens	Pear thrips	

Table 5.2: Phytosanitary measures recommended for quarantine pests for fresh stone fruit from California, Idaho, Oregon and Washington for those pests of regional concern to Western Australia only

Pest	Common name	Measures
Mealybugs [Hemiptera: Pseudococcidae] *Pseudococcus calceolariae*	Citrophilus mealybug	• Inspection and, if required, remedial action
Fruit boring moths [Lepidoptera: Tortricidae] *Grapholita molesta*	Oriental fruit moth	• Sourcing of lots from pest free areas, or areas of low pest prevalence consistent with the import policy for stone fruit from New Zealand or • Methyl bromide fumigation of all lots

5.1.1 Management of apple maggot

As detailed in the risk assessment, peaches and nectarines have not been recorded as hosts of apple maggot. The unrestricted risk estimate for these two commodities was therefore negligible and risk management measures are not required.

However, apricots and plums have been recorded as hosts of apple maggot and the unrestricted risk estimate was moderate, so risk management measures are required for these two species and interspecific hybrids containing these species.

As fruit fly larvae feed internally, visual inspection alone is not considered adequate to address the risk. Puncture wounds from oviposition (egg laying) may not be easily seen and internal feeding may not present clear symptoms, particularly if fruit has only recently been infested. If infested fruit is not detected, apple maggot could enter, establish and spread within Australia.

To address this risk, pest free areas are recommended for apple maggot.

Pest free areas

The requirements for establishing pest free areas or pest free places of production are set out in ISPM 4: *Establishment of pest free areas* (FAO 1996), ISPM 10: *Requirements for the establishment of pest free places of production and pest free production sites* (FAO 1999) and more specifically in ISPM 26: *Establishment of pest free areas for fruit flies (Tephritidae)* (FAO 2006).

The USA proposed that pest free areas be accepted as one of the mitigation measures for apple maggot in affected stone fruit varieties. There are specific counties and other areas in California, Idaho, Oregon and Washington that are regulated as pest free areas for apple maggot for the USA.

Biosecurity Australia is currently considering the USA's request for recognition of these counties and areas for area freedom for apple maggot, based on a system of trapping and regulations on the movement of risk material. If area freedom for apple maggot is accepted by Biosecurity Australia, the USA would be required to maintain these measures.

Should an outbreak of apple maggot occur in regions exporting under pest free areas, trade of apricots, plums and interspecific hybrids that include these species under area freedom arrangements from the outbreak areas, would immediately cease. Trade under area freedom arrangements would resume only when an eradication process had been completed, and Biosecurity Australia was satisfied that area freedom status requirements had been regained.

The objective of this measure is to reduce the likelihood of importation for apple maggot to at least 'extremely low'. The restricted risk would then be reduced to at least 'very low', which would achieve Australia's ALOP.

5.1.2 Management of peach twig borer

Peach twig borer was assessed to have an unrestricted risk estimate of low, so risk management measures are required.

Peach twig borer bores holes into the surface of the fruit and feeds on the fruit flesh. Typical feeding damage can include breaks in the skin of fruit and subsequent development of fruit rots. Fully grown larvae are around 12 mm long (Pickel *et al.* 2006c), while eggs are minute and may be laid on the fruit. Visual inspection by trained quarantine inspectors are expected to detect late-stage infestations by peach twig borer, but may not reliably detect eggs or early stage infestations.

To address this risk, the systems approach for peach twig borer proposed by APHIS is recommended for all fresh stone fruit imported from California, Idaho, Oregon and Washington.

Systems approach for peach twig borer

The systems approach proposed by APHIS consists of a dormant spray and bloom spray, grower-lot monitoring and treatment, pre-harvest surveys, pre-harvest fruit cutting, fruit cutting in the packing house and regulatory inspection. An overview of the recommended measures is included in Table 5.3.

Table 5.3: Overview of the systems approach for peach twig borer

Dormant and bloom sprays
• A dormant or delayed dormant spray targeted at peach twig borer to be applied before first bloom • A bloom spray targeted at peach twig borer to be applied prior to the one-inch leaf growth stage
Orchard monitoring and treatment
• Peach twig borer specific pheromone traps to be used in orchards to determine when the adult flight season for each generation of peach twig borer commences • The flight season be determined to have commenced when two peach twig borer moths are caught in any of the traps in a variety lot[3] • Control measures (insecticide sprays) to be applied for peach twig borer between 400 and 500 degree-days after the flight season commences • If fruit has begun to colour, control measures to be applied at 300 degree-days
Pre-harvest monitoring
• A specified number of trees in the orchard to be selected for sampling according to the size of the orchard • Each tree selected for sampling to be checked for any evidence of shoot strikes (symptom) • If there is more than an average of two shoot strikes per tree, the variety lot to be ineligible for export under this systems approach for the remainder of the season
Pre-harvest fruit cutting
• For each of the trees selected for sampling (above), five fruit will be taken from the tree and cut open to examine for peach twig borer larvae • If any peach twig borer larvae are found during the fruit cutting, the variety lot to be ineligible for export under this systems approach for the remainder of the season

[3] A variety lot is defined as "a contiguous planting of a single stone fruit cultivar that is not separated by a recognizable separate (for example: ranch road, canal or highway)". An orchard is comprised of one or more variety lots under the management of a single grower at a specific location.

Fruit cutting in the packing house
• A total of 300 fruit per variety lot per day to be cut and examined for peach twig borer larvae. The fruit may be taken from the "cull" fruit • If any peach twig borer larvae are detected during the fruit cut, the variety lot to be suspended from exporting fruit to Australia under this systems approach for the remainder of the season • Regardless of whether any peach twig borer larvae are found, the entire 300 unit cut must be completed, unless the grower elects to remove the variety lot from the export program for the season
Regulatory inspection
• Two per cent of boxes in each consignment to be randomly selected for inspection • All of the fruit in each box to be inspected and 5 % of those fruit, plus any fruit showing signs of insect infestation, to be cut to look for internal feeding pests • If any peach twig borer is found during regulatory inspection, the variety lot to be suspended from exporting fruit to Australia under this systems approach for the remainder of the season

Fruit will also be subject to inspection by AQIS, either during pre-clearance activities, or during on-arrival clearance. The detection of a single peach twig borer larvae by AQIS will result in the variety lot being suspended from exporting fruit to Australia under this systems approach for the remainder of the season.

The objective of this measure is to reduce the likelihood of importation for peach twig borer to at least 'very low'. The restricted risk would then be reduced to at least 'very low', which would achieve Australia's ALOP.

5.1.3 Management of cherry fruitworm and lesser apple fruitworm

Cherry fruitworm and lesser apple fruitworm were assessed to have an unrestricted risk estimate of low, so risk management measures are required.

The larvae of these moths feed internally on the fruit and while infestations may be accompanied by visible entrance holes and the ejection of excreta (frass), these symptoms are not always present. Entrance holes can be difficult to see and thus infested fruit may not be reliably detected by quarantine inspectors.

To address this risk, pre-harvest monitoring and cutting of culled fruit, or methyl bromide fumigation are recommended for cherry fruitworm and lesser apple fruitworm.

Pre-harvest monitoring and cutting of culled fruits

Biosecurity Australia considers that the system of fruit cutting and regulatory inspection recommended for peach twig borer, would also be effective in identifying fruit infested by either cherry fruitworm or lesser apple fruitworm. Biosecurity Australia therefore recommends that these systems-based operational requirements be accepted for both cherry fruitworm and the lesser apple fruitworm.

Specifically, the pre-harvest fruit cutting, packing house cutting of 300 fruit per variety lot per day and the regulatory inspection of 2% of boxes will be required for these pests. The detection of one or more cherry fruitworm or lesser apple fruitworm larvae during these inspections will rule the variety lot ineligible for export for the remainder of the season, unless an effective treatment, which has been approved by Biosecurity Australia, is applied to all consignments.

The objective of this measure is to reduce the likelihood of importation for cherry fruitworm and lesser apple fruitworm to at least ‘very low’. The restricted risk would then be reduced to at least ‘very low’, which would achieve Australia’s ALOP.

Methyl bromide fumigation

Methyl bromide fumigation is recommended as an alternative to pre-harvest monitoring and cutting of culled fruit for cherry fruit worm and lesser apple fruitworm. The fumigation treatment schedules set out below are those currently applied to reduce the risk of importation of oriental fruit moth, another species of *Grapholita*, on stone fruit from New Zealand.

It is recommended that when fumigation with methyl bromide is utilised as the measure for cherry fruitworm and lesser apple fruitworm, it must be carried out for a duration of 2 hours according to the specifications below:

- $32 g/m^3$ at a fruit pulp temperature of 21ºC or greater
- $40 g/m^3$ at a fruit pulp temperature of 16ºC or greater or
- $48 g/m^3$ at a fruit pulp temperature of 10ºC or greater.

The objective of this measure is to reduce the likelihood of importation for cherry fruitworm and lesser apple fruitworm to at least ‘very low’. The restricted risk would then be reduced to at least ‘very low’, which would achieve Australia’s ALOP.

5.1.4 Management of leafrollers, mealybugs and thrips

Leafrollers, mealybugs and thrips were all assessed to have an unrestricted risk estimate of low, so risk management measures are required. Of the three mealybug species identified, one species, citrophilus mealybug, is considered a quarantine pest only for Western Australia. Therefore, quarantine actions for citrophilus mealybug need only be applied for exports destined for Western Australia.

Leafrollers, mealybugs and thrips may still be present on fruit that has been packed for export. To address this risk, visual inspection and remedial action is recommended for these pests.

Visual inspection and remedial action

Various leafroller, mealybug and thrips species have been considered in previous import risk analyses and policy extensions undertaken by Biosecurity Australia. These external pests can be detected by trained quarantine inspectors using satisfactory optical enhancement such as a binocular microscopes where necessary. Therefore, the standard 600-unit quarantine inspection undertaken by AQIS would be effective at identifying consignments infested with any of these pests.

The objective of visual inspection is to ensure that consignments of stone fruit from California, Idaho, Oregon and Washington infested with these pests are identified and subjected to appropriate remedial action. The remedial action will reduce the risk associated with these pests to a ‘very low’ level to achieve Australia’s ALOP.

Remedial action, if required, could include any treatment known to be effective against the target pests. Currently, standard methyl bromide fumigation rates for external pests are recognised. However, Biosecurity Australia would also consider any other treatment that APHIS proposes, providing that it offers an equivalent level of protection. The consignment would not be released from quarantine until the remedial action has been undertaken.

The objective of this measure is to reduce the likelihood of importation for leafrollers, mealybugs and thrips to at least 'very low'. The restricted risk would then be reduced to at least 'very low', which would achieve Australia's ALOP.

5.1.5 Management of oriental fruit moth (Western Australia only)

Oriental fruit moth is a quarantine pest only for Western Australia. It was assessed to have an unrestricted risk estimate of low, so risk management measures are required.

Oriental fruit moth feeds internally on the fruit and while infestations may be accompanied by visible entrance holes and the ejection of excreta (frass), these symptoms are not always present. Entrance holes can be difficult to see and thus infested fruit may not be reliably detected by quarantine inspectors.

This pest has been considered previously for the importation of stone fruit from New Zealand and the same measures are recommended for stone fruit from the USA.

Areas of low pest prevalence or pest free areas

For oriental fruit moth, pest free areas, pest free places of production and pest free production sites were accepted, with supporting data, as mitigation options in the policy for New Zealand stone fruit entering Western Australia. Should information be presented in support of pest free areas, it would be considered by Biosecurity Australia.

Low pest prevalence is a measure that might be applied to manage the risk posed by oriental fruit moth to Western Australia. The requirements for establishing areas of low pest prevalence are set out in ISPM 22: *Requirements for the establishment of areas of low pest prevalence* (FAO 2005).

Application for recognition of areas of low pest prevalence for oriental fruit moth in the exporting states would be assessed by Biosecurity Australia in consultation with DAFWA.

Methyl bromide fumigation

Methyl bromide fumigation is a measure that is recommended to manage the risk posed by oriental fruit moth. The fumigation treatment schedules set out below are those currently applied to reduce the risk of importation of oriental fruit moth on stone fruit from New Zealand.

It is recommended that where fumigation with methyl bromide is utilised, it must be carried out for duration of 2 hours according to the specifications below:

- $32 g/m^3$ at a fruit pulp temperature of 21ºC or greater
- $40 g/m^3$ at a fruit pulp temperature of 16ºC or greater or
- $48 g/m^3$ at a fruit pulp temperature of 10ºC or greater.

The objective of this measure is to reduce the likelihood of importation for oriental fruit moth to at least 'very low'. The restricted risk would then be reduced to at least 'very low', which would achieve Australia's ALOP.

5.1.6 General conditions for fumigation

Where fumigation treatments are required, either as quarantine measures or as remedial actions, it is recommended that fruit not be fumigated if the pulp temperature is below 10ºC and that fumigations be carried out in accordance with AQIS fumigation standards as set out in *AQIS Quarantine Treatments Aspects and Procedures version 1.0.* All pre-shipment (off-shore) fumigation certificates would need to contain the following fumigation details:

- the name of the fumigation facility
- the date of fumigation
- rate of methyl bromide used, that is initial dosage (g/m^3)
- the fumigation duration (hours)
- ambient air temperature during fumigation (°C)
- minimum fruit pulp temperature during fumigation (°C) and
- the concentration time (CT) product of methyl bromide achieved by the fumigation (g/ m^3).

5.1.7 Consideration of alternative treatments

Consistent with the principle of equivalence detailed in ISPM 2: *Framework for pest risk analysis* (FAO 2007), Biosecurity Australia will consider any alternative treatment proposed by APHIS, providing that it achieves an equivalent level of quarantine protection. Evaluation of such treatments will require a technical submission from APHIS that details the proposed treatment and includes data from treatment trials.

5.2 Operational systems for maintenance and verification of phytosanitary status

A system of operational procedures is necessary to maintain and verify the phytosanitary status of fresh stone fruit from California, Idaho, Oregon and Washington. This is to ensure that the recommended risk management measures have been met and are being maintained.

It is recommended that APHIS, or other relevant agencies nominated by APHIS, prepare a documented work plan for approval by Biosecurity Australia and AQIS that describes the phytosanitary procedures for the pests of quarantine concern for Australia and the various responsibilities of all parties involved in meeting the quarantine requirements.

Details of the operational system, or equivalent system, will be determined by agreement between Biosecurity Australia and APHIS.

5.2.1 Recognition of the competent authority

The United States Department of Agriculture, Animal and Plant Health Inspection Service (APHIS) is the competent authority for the USA.

The objectives of the competent authority are to:

- inspect plants and plant products moving in international trade
- issue certificates relating to phytosanitary condition and origin of consignments of plants and plant products
- ensure that all relevant agencies participating in this program meet the recommended service and certification standards and recommended work plan procedures
- ensure that administrative processes are established to meet the requirements of the program.

Operational components and the development of risk management procedures may be delegated by APHIS to an accredited agent under an agency arrangement as appropriate. This delegation must be approved by AQIS and is to be subject to the requirements of the pre-clearance system. APHIS is responsible for auditing all delegated risk management procedures.

Orchard surveys and fruit cutting requirements must be undertaken by APHIS or persons accredited by APHIS. Accredited persons are to be assessed and audited as being competent in the recognition of disease symptoms of concern in the field. Accredited persons may include APHIS officers, agency staff, plant pathologists, commercial crop monitors/scouts, or other accredited persons. There should be documented criteria upon which accreditation is based and this is to be available for audit by APHIS and AQIS. AQIS reserves the right to audit these systems before commencement of trade.

5.2.2 Registration of export orchards

The objectives of this recommended procedure are to ensure that:

- stone fruit is sourced from APHIS registered export orchards producing export quality fruit, as the pest risk assessments are based on existing commercial production practices
- export orchards from which stone fruit is sourced can be identified so investigation and corrective action can be targeted rather than applying it to all contributing export orchards in the event that live pests are intercepted during pre-clearance inspection.

All export orchards and variety lots[3] supplying stone fruit for export to Australia are to be registered with APHIS before the start of each stone fruit season. This is to allow verification of the pre-season control required for pests of quarantine concern.

Growers are to provide APHIS with sufficient detail that clearly identifies the boundaries of the orchard and variety lots. This may be identified by maps or physical landmarks that can be used to define boundaries. Growers are to retain copies of orchard descriptions/maps for audit purposes.

APHIS are to allocate each export orchard and variety lot a unique registration number to enable traceback.

Growers/packing houses are to have approved documented systems, including appropriate records, in place ensuring that stone fruit destined for Australia is only harvested from orchards that are registered for export to Australia.

Growers must provide access to registered orchards and variety lots for the purpose of monitoring/surveillance for compliance with the quarantine requirements.

APHIS is responsible for ensuring that export stone fruit growers are aware of pests of quarantine concern to Australia, field sanitation and control measures. The hygiene of export orchards is to be maintained by appropriate pest management options that have been approved by APHIS to manage pests of quarantine concern to Australia. Registered growers are to be required to keep records of control measures for auditing purposes. If required, the details of the pest control program would need to be provided to Biosecurity Australia by APHIS before trade commenced.

5.2.3 Registration of packing houses and treatment facilities and auditing of procedures

The objectives of this recommended procedure are to ensure that:

- stone fruit is sourced only from APHIS registered packing houses, processing export quality fruit, as the pest risk assessments are based on existing commercial packing activities
- reference to the packing house and the orchard source (by name or a number code) are clearly stated on cartons of fresh stone fruit destined for export to Australia for traceback and auditing purposes.

All stone fruit for export to Australia is to be processed by registered packing houses.

All packing houses intending to export stone fruit to Australia are to be registered with APHIS before commencement of harvest each season. APHIS is to allocate each export packing house a unique registration number or code to enable traceback. The list of registered packing houses is to be kept by APHIS and provided to AQIS prior to exports commencing, with updates provided if packing houses are added or removed from the list.

Each packing house is to have an approved documented system for traceability, including keeping records of receipt, orchard and/or orchard block registration numbers, storage, packing and load-out records.

APHIS is responsible for ensuring that packing house operators are aware of pests of quarantine concern to Australia, packing house sanitation and control measures. Registered packing house operators are to be required to keep records of control measures for auditing purposes.

APHIS is to inspect packing houses during the packing and storage of export stone fruit to monitor and verify that the necessary requirements are met, including measures to prevent contamination of fruit and packing materials with quarantine pests and other regulated articles.

APHIS is to conduct audit checks on registered packing houses to monitor the measures taken to prevent mixing or substituting stone fruit destined for export to Australia with other fruit.

APHIS is to immediately suspend exports from packing houses found to be non-compliant and notify AQIS of the suspension.

Suspended packing houses may only be reinstated for processing of stone fruit for export to Australia when APHIS and AQIS are satisfied that non-compliance issues have been adequately addressed.

APHIS is to make available to AQIS, on request, information on its supervisory activities in relation to packing houses.

5.2.4 Packaging and labelling

The objectives of this recommended procedure are to ensure that:

- stone fruit proposed for export to Australia is not contaminated by quarantine pests and other regulated articles (including soil, animal and plant debris)
- unprocessed packing material (which may vector pests identified as not on the pathway and pests not known to be associated with stone fruit) is not imported with the stone fruit
- all wood material used in packaging of stone fruit complies with the AQIS conditions, e.g. those in *Cargo containers: quarantine aspects and procedures* (AQIS 2009)
- all cartons are labelled with the orchard/variety lot registration number, packing house registration number and date of packing
- palletised product is identified by attaching a uniquely numbered pallet card to each pallet or part pallet to enable traceback to registered orchards/variety lots and packing houses
- the pre-cleared status of stone fruit is clearly identified by pallet card number
- export lots that are rejected are withdrawn from the Australian program. Failed lots are identified with an appropriate label or sticker and are kept separate from other passed product awaiting inspection.

5.2.5 Specific conditions for storage and movement

The objective of this recommended procedure is to ensure that the phytosanitary status of the product is maintained during storage and movement.

Packed product and packaging is to be protected from pest contamination during and after packing, during storage and during movement between locations (that is, packing house to cool storage/depot, to inspection point, to export point). Product for export to Australia that has been inspected and certified by APHIS is to be maintained in secure conditions that will prevent mixing with fruit for domestic consumption or for export to other destinations. Security of the consignment is to be maintained until release from quarantine in Australia.

Arrangements for secure storage and movement of produce are to be developed by APHIS in consultation with Biosecurity Australia/AQIS.

5.2.6 Freedom from trash

All stone fruit for export must be free from trash, foreign matter and pests of quarantine concern to Australia. Freedom from trash will be confirmed by the inspection procedures. APHIS must provide details of how inspection for trash will occur before trade commences.

5.2.7 Pre-export phytosanitary inspection and certification by APHIS

The objective of this recommended procedure is to provide formal documentation to AQIS verifying that the relevant measures have been undertaken offshore.

APHIS is to issue a phytosanitary certificate for each consignment after completion of the pre-export phytosanitary inspection consistent with ISPM 7: *Export Certification Systems* (FAO 1997).

The inspection undertaken by APHIS is to provide a confidence level of 95% that not more than 0.5% of the units are infested/infected in the consignment. Detection of live quarantine pests, dead quarantine pests for which area freedom or non-host status was claimed, or other regulated articles will result in failure of the consignment. If a consignment fails inspection by APHIS, the exporter will be given the option of treatment and re-inspection of the consignment or removal of the consignment from the export pathway.

Detection of any pests for which area freedom, pest free places of production, pest free production sites, areas of low pest prevalence, or non-host status have been established will result in the loss of the relevant pest status. Records of the interceptions made during these inspections (live quarantine pests, dead quarantine pests and regulated articles) are to be maintained by APHIS and made available to Biosecurity Australia and AQIS as requested or upon the detection of any pest, dead or alive, for which area freedom, pest free places of production, pest free production sites, areas of low pest prevalence or non-host status is claimed.

This information will assist in future reviews of this import pathway and consideration of the appropriateness of the phytosanitary measures that have been applied.

Each phytosanitary certificate is to contain the following information:

- reference to the shipping container number and container seal number
- full description of the consignment, including registered packing house number, and registered orchard/block number/s
- an additional declaration that '*the fruit in this consignment have been produced in <state> in accordance with the conditions governing the entry of fresh stone fruit from the USA to Australia*'
- for consignments of apricots, plums and interspecific hybrids containing these varieties, an additional declaration that '*the fruit in this consignment have been produced and packed in <county/area> that is free of apple maggot (Rhagoletis pomonella)'*.

5.2.8 Phytosanitary inspection by AQIS

The objective of this procedure is to verify that the required measures have been undertaken.

A phytosanitary inspection of lots covered by each phytosanitary certificate issued by APHIS will be undertaken by AQIS either in the USA as a pre-clearance, or on arrival of the consignment in Australia. The inspection will be conducted using the standard AQIS inspection protocol for the type of commodity using satisfactory optical enhancement such as binocular microscope where necessary. The sample size for inspection of stone fruit is given below.

Consignment size	Sample size
1–450 stone fruit	100% of the consignment
451–1000 stone fruit	450 stone fruit
1001 or more stone fruit	600 stone fruit

The sample will be drawn proportionally from each grower contributing to the inspection lot.

The detection of live quarantine pests, or dead pests from pest free areas, pest free places of production, pest free production sites, areas of low pest prevalence, on hosts for which non-host status was claimed, or other regulated articles, will result in the failure of the inspection lot. Detection of pests from pest free areas, pest free places of production, pest free production sites, areas of low pest prevalence, or on hosts for which non-host status was claimed will also result in the loss of the relevant pest status.

Phytosanitary inspection by AQIS may be undertaken either in the USA (under pre-clearance arrangements) or on-arrival in Australia.

Pre-clearance of consignments by AQIS

Under these arrangements, AQIS officers would inspect and clear consignments in the USA prior to export. The involvement of AQIS officers in pre-clearance would also facilitate auditing of other arrangements including registration procedures, applications of standard commercial practices, verification of packing house procedures, traceability of consignment, and handling of export fruit in a secure manner.

Under the pre-clearance arrangement, on-arrival procedures would provide verification that the consignment received was the pre-cleared consignment and that the integrity of the consignment had been maintained.

Consignments inspected under pre-clearance arrangements in the USA would generally only undergo on-arrival verification in Australia. AQIS would examine documents for compliance, verification that the consignments received were those pre-cleared, and that the integrity of the consignments had been maintained, prior to their release from quarantine. AQIS may open the containers to verify the contents but does not usually carry out on-arrival quarantine inspection of the fruit. However, Australia maintains the right to select containers for random quarantine inspection.

Any consignment with incomplete documentation, certification that does not conform to specifications, or with seals on the containers that are damaged or missing, would be held pending clarification by APHIS and determination by AQIS, which would include the options of re-export, destruction or treatment. AQIS would inform APHIS of action taken including any intention to suspend importation.

On-arrival inspection of consignments by AQIS

Under these arrangements, AQIS officers would inspect and clear consignments when they arrive in Australia. AQIS will undertake a documentation-compliance examination for consignment verification purposes, followed by inspection before release from quarantine. The following conditions will apply:

- the importer has a valid import permit
- the shipment has a phytosanitary certificate that identifies registered orchards/blocks and registered packing houses and bears the additional declaration
- no land bridging of consignments will be permitted unless the goods have cleared quarantine
- any shipment with incomplete documentation or certification that does not conform to conditions may be refused entry, with the option of re-export or destruction. AQIS would notify APHIS immediately of such action, if taken
- subject to the specific risk management measures used, consignments will be subject to appropriate inspection by AQIS.

5.2.9 Remedial action(s) for non-compliance

Where inspection lots are found to be non-compliant with requirements, remedial action is to be taken. The remedial actions for consignments (subject to pre-clearance or on-arrival inspection) where quarantine pests are detected will depend on the type of pest and the mitigation measure that the risk assessment has determined for that specific pest.

Remedial actions could include:

- withdrawing the consignment from export (if quarantine pests are detected during pre-clearance inspection)
- re-export of the consignment (if quarantine pests are detected during on-arrival inspection)
- destruction of the consignment (if quarantine pests are detected during on-arrival inspection)

or

- treatment of the consignment and re-inspection to ensure that the pest risk has been addressed (if quarantine pests are detected during either pre-clearance or on-arrival inspection).

Separate to the corrective measures mentioned above, there may be other breach actions necessary depending on the specific pest intercepted and the risk management strategy put in place against that pest in the protocol.

If product continually fails inspection, Biosecurity Australia/AQIS reserves the right to suspend the export program and conduct an audit of the risk management systems in California, Idaho, Oregon and/or Washington. The program will recommence only after Biosecurity Australia/AQIS (in consultation with the relevant state departments if required) is satisfied that appropriate corrective action has been taken.

5.2.10 Audit and verification

The objectives of the recommended requirement for audit and verification is to ensure that:

- an effective approved documented system is in operation for the orchard, the packing house and during transport.

The phytosanitary system for stone fruit production, certification of export orchards, pre-export inspection and certification is subject to audit by AQIS. Audits may be conducted at the discretion of AQIS during the entire production cycle and as a component of any pre-clearance arrangement.

AQIS orchard audits are to measure compliance with orchard registration and identification, pest/disease management including maintenance of a spray diary/monitoring, record management, the administration and verification of area freedom status for apple maggot and any other relevant pests.

AQIS packing house audits of participants involved in pre-clearance arrangements will include the verification of compliance with packing house responsibilities, traceability, labelling, segregation and product security, and the APHIS/agency certification processes.

5.3 Review of policy

5.3.1 Audit of protocol

Prior to the first season of trade, a representative from Biosecurity Australia and/or AQIS will visit areas in California, Idaho, Oregon and/or Washington that produce stone fruit for export to Australia. They will audit the implementation of agreed import conditions and measures including registration, operational procedures and fumigation facilities.

5.3.2 Review of policy

Biosecurity Australia reserves the right to review the import policy after the first year of trade or when there is reason to believe that the pest and phytosanitary status either in the USA or in the exporting areas has changed.

APHIS must inform Biosecurity Australia/AQIS immediately on detection in California, Idaho, Oregon or Washington of any new pests of stone fruit that are of potential quarantine concern to Australia.

5.3.3 Pests for which area freedom is claimed

The pest categorisation tables (Appendix A) and the risk assessments (Chapter 4) take into account the historic absence or limited distribution of a number of pests of quarantine concern. These included outbreaks of fruit flies in California that are subject to eradication, and the restricted distribution of plum pox virus.

Plum pox virus

Plum pox virus (PPV) was found in Pennsylvania in 1999 and in New York State and Michigan in 2006 (USDA 2009). On September 14, 2009, the Michigan Department of Agriculture declared PPV eradicated from Michigan and on October 29, 2009, the Animal and Plant Health Inspection Service (APHIS) declared PPV eradicated from Pennsylvania (Holton 2009; NAPPO 2010). These declarations were based on three years of negative results from surveys of host plants in orchards and residential properties within the quarantined areas.

A national survey started in the USA in 2000 ran for three years (Hughes et al. 2002). From 2004, PPV surveys continued in some states including California, Maryland, Michigan, New Jersey, New York State, Oregon and Virginia (Levy 2006; Osterbauer *et al.* 2006). PPV has not been confirmed in California and the Pacific Northwest states.

PPV may still be present in New York State. Positive trees were identified at five locations in three counties in the state in 2008 (Cornell 2010). A detection and eradication campaign was conducted by the New York State Department of Agriculture and Markets and the New York State Agricultural Experimental Station (Carnes 2010; Cornell University 2010).

The USA Secretary of Agriculture is authorised to control and prevent PPV infections using measures that include quarantine of any region, destruction of plant material and prohibition of movement of any plant or plant product (Johanns 2007). In practice, measures have included detecting and delimiting surveys, district quarantine, certification of nursery stock and the removal and destruction of trees from nurseries, orchards and residential areas (USDA 2009).

Australia recognises that PPV is under quarantine and control in the USA and has assessed the risk posed by the pathogen on this basis. Australia reserves the right to review and amend the import policy if circumstances change. If the pathogen is detected outside of New York State, Australia expects that it will be rapidly reported. The USDA, or other relevant agency nominated by the NPPO, must inform AQIS immediately of any change in the distribution of PPV as this virus is of quarantine concern to Australia.

Fruit fly outbreaks

To mitigate the risk of establishment and spread of fruit flies in the USA, APHIS operates a system that incorporates surveillance, control programs and regulatory actions. Considered as a whole, these fruit fly programs provide a level of confidence that the USA, or areas within the USA are free from specific fruit flies that are of quarantine concern for Australia. These fruit fly freedoms are already recognised by Australia for the export of a range commodities including citrus, strawberries, cherries, figs and pomegranates.

Information on APHIS's strategic plan for managing exotic fruit flies and details on specific response plans for particular species of fruit flies is available on APHIS's website at www.aphis.usda.gov/plant_health/plant_pest_info/fruit_flies/index.shtml.

The IRA has taken into consideration that a number of species of fruit flies that have been recorded from the USA, or the exporting areas, have since been eradicated. Therefore, maintenance of the fruit fly programs is considered essential. Should APHIS's fruit fly programs cease, or substantially change, it may be necessary for Biosecurity Australia to reassess the risks poses by exotic fruit flies.

Should outbreaks of fruit flies of quarantine concern to Australia occur within the USA, regulatory action will need to be undertaken to provide assurance that exports will remain free of these pests. These measures may include delimiting surveys, restrictions on the movement of host material, and eradication campaigns. In addition to this, fruit grown and/or packed in an area regulated due to an outbreak of fruit flies must not be exported to Australia unless consignments have been subjected to a quarantine measure agreed between Biosecurity Australia and APHIS.

5.4 Uncategorised pests

If an organism is detected on mature fresh stone fruit, either during pre-clearance inspection in the USA or on-arrival in Australia, that has not been categorised, it will require assessment by Biosecurity Australia to determine its quarantine status and if phytosanitary action is required. Assessment is also required if the detected species was categorised as not likely to be on the import pathway. If the detected species was categorised as on the pathway but assessed as having an unrestricted risk that achieves Australia's ALOP due to the rating likelihood of importation, then it would require reassessment.

The detection of any pests of quarantine concern not already identified in the analysis may result in remedial action and/or temporary suspension of trade while a review is conducted to ensure that existing measures continue to provide the appropriate level of protection for Australia.

Appendices

Appendix A. Categorisation of arthropods, bacteria, fungi and viruses associated with stone fruit production in California and the Pacific Northwest and status in Australia

Table A1: Organisms associated with the production of apricots, nectarines, peaches and plums in California, Idaho, Oregon and Washington and their presence in Australia

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
ACARI (Mites)				
Aculus fockeui (Nalpela & Trouessart, 1891) Synonym: *Aculus cornutus* Banks, 1905 [Acari: Eriophyidae]	Peach silver mite; Plum rust mite	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	Yes (Halliday 1998; Poole 2008)	No
Brevipalpus phoenicis (Geijskes, 1939) [Acari: Tenuipalpidae]	False spider mite	N, Pe, Pl (APHIS 2002a)	Yes. NSW, NT, WA (APPD 2009) WA (Poole 2008)	No
Bryobia rubrioculus (Scheuten, 1857) [Acari: Tetranychidae]	Brown mite	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	Yes. NSW, SA, Tas., Vic. (APPD 2009) WA (Poole 2008)	No
Diptacus gigantorhynchus (Nalepa, 1892) [Acari: Eriophyidae]	Big-beaked plum mite	N, Pe, Pl (Rice *et al.* 1976)	Yes. Vic. (APPD 2009)	Yes[4]
Eotetranychus carpini (Oudemans, 1905) [Acari: Tetranychidae]	Yellow spider mite	Pl, *Prunus* sp. (Migeon and Dorkeld 2006)	No records	Yes
Eotetranychus pruni (Oudemans, 1931) [Acari: Tetranychidae]		Pe, Pl (Migeon and Dorkeld 2006)	No records	Yes
Eriophyes insidiosus (Keifer & Wilson, 1955) [Acari: Eriophyidae]	Peach bud mite	Pe (Oldfield 1970)	No records	Yes

[4] While a single record is known from Australia, this pest may be considered to have a limited distribution and was therefore considered futher.

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Oligonychus mangiferus (Rahman & Sapra, 1940) [Acari: Tetranychidae]	Mango spider mite	N, Pe, Pl (APHIS 2002a)	Yes (Halliday 1998)	No
Panonychus ulmi (Koch, 1836) [Acari: Tetranychidae]	European red mite	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	Yes. NSW , SA, Tas., Vic., WA (APPD 2009)	No
Panonychus citri (McGregor, 1916) [Acari: Tetranychidae]	Citrus red mite	(CABI 2007) lists peach and plum as a major host, but no reference to this pest on any stone fruit in the US was found.	Yes. NSW (APD 2009) Absent from WA (Poole 2008)	No
Tarsonemus smithi Ewing, 1939 [Acari: Tarsonemidae]	Tarsonemid mite	N, Pe, Pl (APHIS 2002a)	No records	Yes
Tetranychus canadensis (McGregor, 1950) [Acari: Tetranychidae]	Four-spotted spider mite	A, Pe, Pl (Midgeon and Dorkeld 2006)	No records	Yes
Tetranychus mcdanieli McGregor, 1931 [Acari: Tetranychidae]	McDaniel spider mite	Pl (Anthon and Smith 1975) A (APHIS 2006a)	No (Poole 2008)	Yes
Tetranychus neocaledonicus (Andre, 1933) [Acari: Tetranychidae]	Vegetable spider mite	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	Yes. NSW, NT, Qld., WA (APPD 2009) WA (Poole 2008)	No
Tetranychus pacificus (McGregor, 1919) [Acari: Tetranychidae]	Pacific spider mite	N, Pe, Pl (APHIS 2002a)	No (Poole 2008)	Yes
Tetranychus turkestani Ugarov & Nikolski, 1937 [Acari: Tetranychidae]	Strawberry spider mite	N, Pe, Pl (APHIS 2002a)	No (Poole 2008)	Yes
Tetranychus urticae Koch, 1836 [Acari: Tetranychidae]	Two spotted spider mite	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	Yes. ACT, NSW, NT, Qld., SA, Tas., Vic., WA (APPD 2009) WA (Poole 2008)	No
COLEOPTERA (Beetles, Weevils)				
Adaleres ovipennis Casey, 1895 [Coleoptera: Curculionidae]	Weevil	Pl (Beers *et al.* 2003)	No records	Yes
Agriotes lineatus (Linnaeus, 1767) [Coleoptera: Elateridae]	Lined click beetle	A recent invader in Washington State and listed as a pest of peaches (LaGasa *et al.* 2001; CABI 2007).	No records	Yes
Ambrosiodmus rubricollis (Eichhoff, 1875) [Coleoptera: Scolytidae]	Bark beetle	N, Pe, Pl (APHIS 2002a)	Yes. Introduced to Australia (Rabaglia *et al.* 2006). Distribution uncertain.	Yes

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Ambrosiodmus tachygraphus (Zimmermann, 1868) [Coleoptera: Scolytidae]	Bark beetle	N, Pe, Pl (APHIS 2002a)	No records	Yes
Amotus setulosus (Schönherr, 1847) [Coleoptera: Curculionidae]	Weevil	Pe (Beers *et al.* 2003)	No records	Yes
Anametis granulata (Say, 1831) [Coleoptera: Curculionidae]	Gray snout beetle	Pe (Beers *et al.* 2003)	No records	Yes
Anthonomus quadrigibbus Say, 1831 [Coleoptera: Curculionidae	Apple curculio weevil	Pe, Pl (Beers *et al.* 2003) Pe (CABI 2007)	No records	Yes
Carpophilus freemani Dobson, 1856 [Coleoptera: Nitidulidae]	Nitidulid beetle	Pe (CABI 2007) N, Pe (Guo 1999)	No records	Yes
Carpophilus hemipterus (Linnaeus, 1758) [Coleoptera: Nitidulidae]	Dried fruit beetle	A, Pl (CABI 2007) N, Pe (Guo 1999)	Yes. NSW, Vic, Tas, WA, NT, Qld. (APPD 2009)	No
Carpophilus humeralis (Fabricius, 1798) [Coleoptera: Nitidulidae]	Pineapple beetle	A, Pe (CABI 2007)	Yes. NT, WA (APPD 2009)	No
Carpophilus mutilatus Erichson, 1843 [Coleoptera: Nitidulidae]	Flower beetle	A, Pe (CABI 2007)	Yes. NSW, Qld, WA (APPD 2009)	No
Cercopedius artemisiae (Pierce, 1910) [Coleoptera: Curculionidae]	Lesser sagebrush weevil	Pe (Beers *et al.* 2003)	No records	Yes
Chrysobothris femorata (Oliver, 1790) [Coleoptera: Buprestidae]	Flat headed apple tree borer	Reported to attack all fruit trees (Drees *et al.*1994)	No records	Yes
Chrysobothris mali Horn, 1886 [Coleoptera: Buprestidae]	Pacific flatheaded borer	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	No records	Yes
Cleonidius canescens (LeConte, 1875) [Coleoptera: Curculionidae]	Weevil	Pe (Beers *et al.* 2003)	No records	Yes
Coccotorus scutellaris (LeConte, 1858) [Coleoptera: Curculionidae]	Plum gouger	Pl (Beers *et al.* 2003)	No records	Yes
Conotrachelus anaglypticus (Say, 1831) [Coleoptera: Curculionidae]	Cambium curculio	Pe, Pl (Beers *et al.* 2003)	No records	Yes

Scientific Name	**Common Name(s)**	**Association with stone fruit production in California, Idaho, Oregon or Washington (Apricot, Nectarine, Peach, Plum)**	**Presence in Australia**	**Consider Further ?**
Conotrachelus nenuphar (Herbst, 1797) [Coleoptera: Curculionidae]	Apple curculio; plum curculio	N, Pe, Pl (APHIS 2002a)	No records (Poole 2008)	Yes
Cotinis mutabilis (Gory & Percheron, 1833) [Coleoptera: Scarabaeidae]	Peach beetle	N, Pe, Pl (APHIS 2002a)	No records (Cassis *et al.* 1992)	Yes
Cotinis nitida (Linnaeus, 1764) [Coleoptera: Scarabaeidae]	Green June beetle	N, Pe, Pl (APHIS 2002a)	No records (Cassis *et al.* 1992)	Yes
Dyslobus nigrescens (Pierce, 1913) [Coleoptera: Curculionidae]	Weevil	Pe (Beers *et al.* 2003)	No records	Yes
Elaphidionoides villosus (Fabricius, 1792) Synonym: *Anelaphus villosus* Fabricius [Coleoptera: Cerambycidae]	Twig pruner	N, Pe, Pl (APHIS 2002a)	No records	Yes
Epicaerus imbricatus (Say, 1824) [Coleoptera: Curculionidae]	Imbricated snout beetle	Pe, Pl (Beers *et al.* 2003)	No records	Yes
Magdalis aenescens LeConte, 1876 [Coleoptera: Curculionidae]	Bronze apple tree weevil	Pl (Beers *et al.* 2003)	No records	Yes
Magdalis gracilis (LeConte, 1857) [Coleoptera: Curculionidae]	Black fruit tree weevil	Pe, Pl (Beers *et al.* 2003)	No records	Yes
Melalgus confertus (LeConte, 1856) [Coleoptera: Bostrichidae]	Prune branch borer	Pl (Pickel *et al*. 2006e) A (APHIS 2006a)	No records	Yes
Monarthrum fasciatum (Say, 1826) [Coleoptera: Scolytidae]	Peach bark beetle	N, Pe, Pl (APHIS 2002a)	No records	Yes
Omias saccatus (LeConte, 1857) [Coleoptera: Curculionidae]	Sagebrush weevil	Pe (Beers *et al.* 2003)	No records	Yes
Omileus epicaeroides Horn, 1876 [Coleoptera: Curculionidae]	Weevil	Pe (Beers *et al.* 2003)	No records	Yes
Ophryastes cinerascens (Pierce, 1913) [Coleoptera: Curculionidae]	Weevil	Pl (Beers *et al.* 2003)	No records	Yes

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Ophryastes geminatus (Horn, 1876) [Coleoptera: Curculionidae]	White bud weevil	N, Pe, Pl (Beers *et al.* 2003)	No records	Yes
Otiorhynchus cribricollis Gyllenhal, 1834 [Coleoptera: Curculionidae]	Cribrate weevil; Apple curculio	Pe (Beers *et al.* 2003) A (APHIS 2006a)	Yes. NSW, Qld., SA, Vic., WA (APPD 2009) WA (Poole 2008)	No
Otiorhynchus ligneus (Olivier, 1807) [Coleoptera: Curculionidae]	Weevil	Pe (Beers *et al.* 2003)	No records	Yes
Otiorhynchus ovatus (Linnaeus, 1758) [Coleoptera: Curculionidae]	Strawberry root weevil	Pe (Beers *et al.* 2003)	No records	Yes
Otiorhynchus singularis (Linnaeus, 1767) [Coleoptera: Curculionidae]	Claycolored weevil	Pe (Beers *et al.* 2003)	No records	Yes
Panscopus aequalis (Horn, 1876) [Coleoptera: Curculionidae]	Weevil	Pe (Beers *et al.* 2003)	No records	Yes
Pantomorus cervinus (Boheman, 1840) Synonyms: *Asynonychus cervinus* (Boheman, 1840) *Naupactus cervinus* (Boheman, 1840) [Coleoptera: Curculionidae]	Fuller's rose weevil	N, Pe, Pl (APHIS 2002a)	Yes. Tas., WA (APPD 2009) Qld., NSW, Vic., WA (Poole 2008) WA, SA, NSW, Vic., Tas., Qld. (CSIRO 2004)	No
Paraptochus sellatus (Boheman, 1859) [Coleoptera: Curculionidae]	Apricot leaf weevil	Pl (Beers *et al.* 2003)	No records	Yes
Phloeotribus liminaris (Harris, 1852) [Coleoptera: Scolytidae]	Ambrosia beetle; Peach tree bark beetle	N, Pe, Pl (APHIS 2002a)	No records	Yes
Pleocoma crinita Linsley, 1938 [Coleoptera: Scarabaeidae]	Rain beetle	Pl (Reidl and Beers 2007)	No (Cassis *et al.* 1992)	Yes
Pleocoma minor Linsley, 1938 [Coleoptera: Scarabaeidae]	Rain beetle	Pl (Reidl and Beers 2007)	No (Cassis *et al.* 1992)	Yes
Pleocoma oregonensis Leech,1933 [Coleoptera: Scarabaeidae]	Rain beetle	Pl (Reidl and Beers 2007)	No (Cassis *et al.* 1992)	Yes

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Polydrusus impressifrons (Gyllenhal, 1834) [Coleoptera: Curculionidae]	Leaf weevil; Pale green weevil	Pe, Pl (Beers *et al.* 2003)	No record	Yes
Popillia japonica Newman, 1841 [Coleoptera: Scarabaeidae]	Japanese beetle	N, Pe, Pl (APHIS 2002a)	No (Cassis *et al.* 1992) No (Poole 2008)	Yes
Pyrrhalta cavicollis (LeConte, 1856) [Coleoptera: Chrysomelidae]	Cherry leaf beetle	N, Pe, Pl (APHIS 2002a)	No records	Yes
Sciopithes obscurus Horn, 1876 [Coleoptera: Curculionidae]	Obscure root weevil	N, Pe, Pl (Beers *et al.* 2003)	No records	Yes
Scolytus rugulosus (Müller, 1818) [Coleoptera: Curculionidae]	Shot-hole borer	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	No records	Yes
Sitona californicus (Fahraeus, 1840) [Coleoptera: Curculionidae]	Weevil	Pe (Beers *et al.* 2003)	No records	Yes
Stamoderes lanei (VanDyke, 1936) [Coleoptera: Curculionidae]	Weevil	Pe (Beers *et al.* 2003)	No records	Yes
Syneta albida LeConte, 1857 [Coleoptera: Chrysomelidae]	Fruit tree leaf beetle; Western fruit beetle; Syneta leaf beetle	Pl (Berry 1998)	No records	Yes
Thricolepis inornata Horn, 1876 [Coleoptera: Curculionidae]	Small gray leaf weevil; Prune leaf weevil	Pe, Pl (Beers *et al.* 2003)	No records	Yes
Xyleborus dispar (Fabricius, 1792) Synonym: *Anisandrus dispar* (Ferrari, 1867) [Coleoptera: Curculionidae]	Pear blight beetle; European shot hole borer	N, Pe, Pl (APHIS 2002a)	No records	Yes
Xyleborus saxeseni (Ratzeburg, 1837) [Coleoptera: Scolytidae]	Ambrosia beetle	N, Pe, Pl (APHIS 2002a)	Yes. NSW, Tas., Vic., WA (APPD 2009) WA (Poole 2008)	No
Xylosandrus crassiusculus (Motschulsky, 1866) Synonym: *Xyleborus crassiusculus* (Motschulsky, 1866) [Coleoptera: Scolytidae]	Ambrosia beetle; Asian ambrosia beetle; Granulate ambrosia beetle	N, Pe, Pl (APHIS 2002a)	No records	Yes

Scientific Name	**Common Name(s)**	**Association with stone fruit production in California, Idaho, Oregon or Washington (Apricot, Nectarine, Peach, Plum)**	**Presence in Australia**	**Consider Further ?**
DERMAPTERA				
Forficula auricularia Linnaeus, 1758 [Dermaptera: Forficulidae]	European Earwig	A (APHIS 2006a) N (Curtis *et al.* 1992)	Yes. NSW (Bower 1993), widespread in the eastern states and also present in WA (Rees *et al.* 2001)	No
DIPTERA (Flies)				
Anastrepha ludens (Loew, 1873) [Diptera: Tephritidae]	Mexican fruit fly	Peach is an occasional host (EPPO/CABI 1997f) Occasional outbreaks in California (Weems Jr. *et al.* 2004a)	No (White and Elson-Harris 1992)	No[5]
Anastrepha striata Schiner, 1868 [Diptera: Tephritidae]	Guava fruit fly	Not present in the US. A few specimens have been collected from southern Texas and California (Norrbom 2003), but these are considered adventitious captures.	No (White and Elson-Harris 1992)	No[5]
Anastrepha suspensa (Loew, 1862) [Diptera: Tephritidae]	Caribbean fruit fly	Occasional transient in California and Texas (APHIS 2002a)	No records	No[5]
Bactrocera correcta (Bezzi, 1916) Synonym: *Dacus correctus* (Bezzi, 1916) [Diptera: Tephritidae]	Guava fruit fly	Single fly detected in California in 2006 (Frances 2006), but outbreak not declared. Peach is a host (CDFA 2005).	No (White and Elson-Harris 1992)	No[5]
Bactrocera cucurbitae (Coquillett, 1899) [Diptera: Tephritidae]	Melon fruit fly	Peach is considered an occasional host (Weems Jr *et al.* 2004b) Recorded from California, but eradicated (EPPO/CABI 1997g)	No (White and Elson-Harris 1992)	No[5]
Bactrocera dorsalis (Hendel, 1912) [Diptera: Tephritidae]	Oriental fruit fly	Pe, Pl (EPPO/CABI 1997h). Outbreaks in California are eradicated.	No (White and Elson-Harris 1992)	No[5]
Bactrocera zonata (Saunders, 1842) Synonym: *Dacus zonatus* (Saunders, 1842) [Diptera: Tephritidae]	Peach fruit fly	A Pe (APHIS 2006b). Outbreak in California in 2006. Since declared as eradicated.	No (White and Elson-Harris 1992)	No[5]

[5] The occasional presence of these pests is not considered justification that the pest is likely to be found on stone fruit sourced from California or the Pacific Northwest. The maintanence of area freedom for these fruit flies will be required unless other quarantine measures are imposed.

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Ceratitis capitata (Wiedemann, 1824) [Diptera: Tephritidae]	Mediterranean fruit fly	N, Pe, Pl (APHIS 2002a) Established in Hawaii, and is considered a transient species in California and Florida. Infestations are subject to eradication efforts.	Yes. WA (Poole 2008) Occasional outbreaks in other states are eradicated.	No[5]
Drosophila suzukii (Matsumura) Kamizawa, 1931 [Diptera: Drosophilidae]	Spotted wing drosophila, cherry vinegar fly	A, N, Pe, Pl (APHIS 2010). Recently confirmed in the United States and affecting stone fruit, primarily in non-commercial settings. Has been recorded affecting commercial peaches in Oregon.	No records.	No[6]
Phytomyza persicae Frick,1954 [Diptera: Agromyzidae]	Peach leafminer	N, Pe, Pl (APHIS 2002a)	No (Spencer 1977)	Yes
Rhagoletis completa Cresson, 1929 Synonym: *Rhagoletis suavis* (Loew) [Diptera: Tephritidae]	Walnut husk fly; Walnut husk maggot	N, Pe, Pl (APHIS 2002a; Yokoyama and Miller 1997)	No (White and Elson-Harris 1992)	Yes
Rhagoletis fausta (Osten-Sacken, 1877) [Diptera: Tephritidae]	Black cherry fruit fly	Present (EPPO/CABI 1997i). Principally a pest of wild cherries, but may occasionally attack cultivated cherries. Not known to attack other stone fruits.	No (White and Elson-Harris 1992)	No
Rhagoletis indifferens Curran, 1932 [Diptera: Tephritidae]	Western cherry fruit fly	Present in the Pacific Northwest, but lives only on cherries (Smith 2005)	No (White and Elson-Harris 1992)	No
Rhagoletis pomonella (Walsh, 1867) [Diptera: Tephritidae]	Apple maggot	Apple and hawthorn are preferred hosts, but other fruits are attacked (Varela *et al.* 2008). Hosts include peach and plum (Yee and Goughnour 2006)	No (White and Elson-Harris 1992)	Yes

[6] Biosecurity Australia is currently conducting a pest-initiated pest risk analysis for *D. suzukii*. It is not assessed here in detail, but the outcome of the pest risk analysis will determine any quarantine measures that will be required.

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
HEMIPTERA (Aphids, leafhoppers, mealybugs, psyllids, scales, true bugs, whiteflies)				
Acanthocephala femorata (Fabricius, 1775) [Hemiptera: Coreidae]	Leaf footed bug	N, Pe, Pl (APHIS 2002a)	No (Cassis and Gross 2002)	Yes
Acrosternum hilare (Say, 1831) [Hemiptera: Pentatomidae]	Green stink bug	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	No (Cassis and Gross 2002)	Yes
Aleurodicus dispersus Russell, 1965 [Hemiptera: Aleyrodidae]	Spiralling whitefly	Recorded from the US, but only known from Florida and Hawaii (CABI 2007).	Yes. NT, Qld. (APPD 2009), but under quarantine control. Not in WA (Poole 2008) and no records for other states.	No
Aonidiella aurantii (Maskell, 1879) [Hemiptera: Diaspididae]	California red scale	Pl (Ben-Dov *et al*. 2006)	Yes. NSW, NT, Qld., Vic., SA, WA (APPD 2009)	No
Aonidiella citrina (Coquillett, 1891) [Hemiptera: Diaspididae]	Yellow scale	N, Pe, Pl (CABI 2007)	Yes. NSW, Vic. (APPD 2009) NSW, Vic., SA, WA (Poole 2008)	No
Aphis spiraecola Patch, 1914 [Hemiptera: Aphididae]	Spiraea aphid; Green citrus aphid	A, Pe, Pl (CABI 2007)	Yes. NSW, Qld., Tas., Vic., SA (Hollis and Eastop 2005); NSW, Qld., Tas, Vic., SA, WA (APPD 2009) NSW, Qld., Tas., Vic., SA, WA (Poole 2008)	No
Aphis gossypii Glover, 1877 [Hemiptera: Aphididae]	Cotton aphid Melon aphid	A, Pe, Pl (CABI 2007) Highly polyphagous species	Yes. NSW, Qld., NT, Tas., SA, Vic., WA (APPD 2009)	No
Aspidiotus destructor Signoret, 1869 [Hemiptera: Diaspididae]	Transparent scale	Pe (Ben-Dov *et al.* 2006)	NSW, Qld., NT, WA (APPD 2009)	No
Aspidiotus nerii Bouché, 1833 [Hemiptera: Diaspididae]	Oleander Scale; Aucuba scale	Pe (CABI 2007)	Yes. WA (Poole 2008) NSW, NT, SA, Tas., Vic., Qld., WA (APPD 2009)	No
Aulacaspis rosae (Bouché, 1833) [Hemiptera: Diaspididae]	Rose scale	N, Pe, Pl (APHIS 2002a)	Yes. NSW, Tas. (APPD 2009) WA (Poole 2008)	No

Scientific Name	**Common Name(s)**	**Association with stone fruit production in California, Idaho, Oregon or Washington (Apricot, Nectarine, Peach, Plum)**	**Presence in Australia**	**Consider Further ?**
Boisea rubrolineata (Barber, 1956) Synonym: *Leptocoris rubrolineatus* Barber, 1956 [Hemiptera: Rhopalidae]	Western boxelder bug	Pe, Pl (Anthon 1993)	No Records.	Yes
Brachycaudus cardui (Linnaeus, 1758) Synonym: *Aphis cardui* Linnaeus [Hemiptera: Aphididae]	Thistle aphid	A, Pl (Beers and Brunner 2009)	No records	Yes
Brachycaudus helichrysi (Kaltenbach, 1843) Synonym: *Anuraphis helichrysi* Kaltenbach, 1843 [Hemiptera: Aphididae]	Leaf curl plum aphid	N, Pe, Pl (APHIS 2002a)	Yes. SA (Hollis and Eastop 2005); NSW, Qld., Tas., Vic. WA (APPD 2009) WA (Poole 2008)	No
Brachycaudus persicae (Passerini, 1860) Synonym: *Anuraphis persicae* (Passerini, 1860) [Hemiptera: Aphididae]	Black peach aphid	N, Pe, Pl (APHIS 2002a)	Yes. NSW, Tas., Vic. WA (APPD 2009) WA (Poole 2008)	No
Brachycaudus schwartzi (Börner, 1931) Synonym: *Anuraphis schwartzi* (Börner, 1931) [Hemiptera: Aphididae]	Aphid, almond aphid	N, Pe, Pl (APHIS 2002a)	No records	Yes
Carneocephala fulgida Nottingham, 1932 [Hemiptera: Cicadellidae]	Red-headed sharpshooter	Plum cultivars and more generally, *Prunus* spp. are among the herbaceous and woody host plants (Mizell 2008)	No records	Yes
Ceresa alta Walker, 1851 Synonym: *Ceresa bubalus* (Fabricius, 1794) [Hemiptera: Membracidae]	Buffalo treehopper	Stone fruit, including peach (CABI 2007)	No (Fletcher 2009)	Yes

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Ceroplastes ceriferus (Fabricus, 1778) [Hemiptera: Coccidae]	Indian white wax scale	Stone fruit including plum (CABI 2007)	Yes. NSW, Qld. WA (APPD 2009) NSW, Qld., WA (Poole 2008)	No
Ceroplastes floridensis Comstock, 1881 [Hemiptera: Coccidae]	Florida wax scale	N, Pe, Pl (APHIS 2002a)	Yes. NSW, Qld., (APPD 2009) Not in WA (Poole 2008)	Yes (WA)[7]
Ceroplastes sinensis Del Guercio, 1900 [Hemiptera: Coccidae]	Chinese wax scale	Pe (Ben-Dov *et al*. 2006)	Yes. ACT, NSW, NT, Qld. (APPD 2009) NSW, Qld., Vic., SA, WA (CSIRO 2004)	No
Chionaspis furfura (Fitch, 1857) [Hemiptera: Diaspididae]	Scurfy scale	Pe, Pl (Ben-Dov *et al.* 2006)	No records	Yes
Chlorochroa sayi (Stål, 1872) [Hemiptera: Pentatomidae	Peach stink bug	Pe (Pickel *et al.* 2006f)	No (Cassis and Gross 2002)	Yes
Chlorochroa uhleri (Stål, 1872) [Hemiptera: Pentatomidae]	Peach stink bug	Pe (Pickel *et al.* 2006f)	No (Cassis and Gross 2002)	Yes
Clavaspis disclusa Ferris, 1938 [Hemiptera: Diaspididae]	Armoured scale	N, Pe, Pl (APHIS 2002a)	No (Ben-Dov *et al.* 2006)	Yes
Closterotomus norvegicus (Gmelin, 1788) Synonym: *Calocoris norvegicus* (Gmelin, 1788) [Hemiptera: Miridae]	Potato bug	Pe (Pickel *et al.* 2006b)	Yes. Tas. (APPD 2009).	Yes (WA)
Coccus hesperidum Linnaeus, 1758 [Hemiptera: Coccidae]	Soft brown scale	N, Pe, Pl (CABI 2007)	Yes. ACT, NSW, NT, Qld., SA, Tas, Vic, WA (APPD 2009) NSW, NT, Qld., SA, Tas, Vic., WA (Poole 2008)	No
Colladonus clitellarius (Say, 1831) [Hemiptera: Cicadellidae]	Saddled leafhopper	N, Pe, Pl (APHIS 2002a)	No (Fletcher 2009)	Yes

[7] (WA) indicates that this pest is considered a quarantine pest for the state of Western Australia. The pest is not known from that state and quarantine measures exist that would prevent its introduction into that state.

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Colladonus geminatus (Van Duzee, 1890) [Hemiptera: Cicadellidae]	Leafhopper	Pe (Welch and Kondratieff 1993)	No (Fletcher 2009)	Yes
Colladonus montanus (Van Duzee, 1892) [Hemiptera: Cicadellidae]	Mountain leafhopper	Pe, Pl (CABI 2007)	No (Fletcher 2009)	Yes
Cuerna costalis (Fabricius, 1803) [Hemiptera: Cicadellidae]	Leafhopper	N, Pe, Pl (APHIS 2002a)	No (Fletcher 2009)	Yes
Dialeurodes citri (Ashmead, 1885) [Hemiptera: Aleyrodidae]	Citrus whitefly	*Prunus* spp. (CABI 2007)	No records	Yes
Diaspidiotus ancylus (Putnam, 1878) Synonym: *Abgrallaspis howardi* (Cockerell, 1895) [Hemiptera: Diaspididae]	Putnam scale; Howard scale; Maple bark louse	Pe, Pl (CABI 2007)	Yes. Qld., NSW (APPD 2009) No records for WA.	Yes (WA)
Diaspidiotus forbesi (Johnson, 1896) Synonym: *Quadraspidiotus forbesi* (Johnson, 1896) [Hemiptera: Diaspididae]	Forbes scale	N, Pe, Pl (APHIS 2002a)	No (Ben-Dov *et al.* 2006)	Yes
Diaspidiotus juglansregiae (Comstock, 1881) Synonym: *Quadraspidiotus juglansregiae* (Comstock, 1881) [Hemiptera: Diaspididae]	Walnut scale	N, Pe, Pl (APHIS 2002a)	No (Ben-Dov *et al.* 2006)	Yes
Diaspidiotus ostreaeformis (Curtis, 1843) [Hemiptera: Diaspididae]	Oystershell scale; Pear oyster scale; European fruit scale	Pl, *Prunus* spp. (CABI 2007) Listed in Idaho, Oregon and Washington (Nakahara 1982)	Yes. NSW, SA, Tas., Vic. (APPD 2009) No records for WA.	Yes (WA)
Diaspidiotus perniciosus (Comstock, 1881) Synonym: *Quadraspidiotus perniciosus* (Comstock, 1881) [Hemiptera: Diaspididae]	San Jose scale; Californian scale; Chinese scale	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	Yes. NSW, Vic., WA (APPD 2009) NSW, Vic., SA, Tas., WA (Poole 2008) Previously a quarantine pest for Tasmania, but Import Requirement 16 has since been revoked.	No

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (Apricot, Nectarine, Peach, Plum)	Presence in Australia	Consider Further ?
Draeculacephala minerva Ball, 1927 [Hemiptera: Cicadellidae]	Green sharpshooter	Plum cultivars and more generally, *Prunus* spp. are among the herbaceous and woody host plants (Mizell *et al*. 2003)	No records	Yes
Epidiaspis leperii (Signoret, 1869) [Hemiptera: Diaspididae]	Italian pear scale	N, Pe, Pl (APHIS 2002a)	No (Ben-Dov *et al.* 2006)	Yes
Eriosoma lanigerum (Hausmann, 1802) [Hemiptera: Aphididae]	Woolly aphid	Pl (CABI 2007)	Yes. NSW, Qld., Tas., Vic., WA (APPD 2009) WA (Poole 2008)	No
Eulecanium caryae (Fitch, 1857) [Hemiptera: Coccidae]	Large hickory lecanium	Pe (Ben-Dov *et al* 2009)	No records	Yes
Eulecanium cerasorum (Cockerell, 1900f) [Hemiptera: Coccidae]	Calico scale	Stone fruit (Dreistadt *et al.* 2007a)	No (Ben-Dov *et al.* 2006)	Yes
Eulecanium kunoense (Kuwana, 1907) [Hemiptera: Coccidae]	Kuno scale	Pl, stone fruit (Dreistadt *et al.* 2007a)	No (Ben-Dov *et al.* 2006)	Yes
Euschistus conspersus Uhler, 1897 [Hemiptera: Pentatomidae]	Stink bug	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	No (Poole 2008)	Yes
Euschistus servus (Say, 1832) [Hemiptera: Pentatomidae]	Brown stink bug	N, Pe, Pl (APHIS 2002a)	No (Cassis and Gross 2002)	Yes
Euschistus tristigmus (Say, 1831) [Hemiptera: Pentatomidae]	Dusky stink bug	N, Pe, Pl (APHIS 2002a)	No (Cassis and Gross 2002)	Yes
Euschistus variolarius (Palisot de Beauvois, 1817) [Hemiptera: Pentatomidae]	One spotted stink bug	N, Pe, Pl (APHIS 2002a)	No (Cassis and Gross 2002)	Yes
Fieberiella florii (Stål, 1864) [Hemiptera: Cicadellidae]	Leafhopper	N, Pe, Pl (APHIS 2002a)	No (Fletcher 2009)	Yes
Graphocephala atropunctata (Signoret, 1854) [Hemiptera: Cicadellidae]	Blue-green sharpshooter	Peach and plum cultivars and more generally, *Prunus* spp. are among the herbaceous and woody host plants (Mizell *et al*. 2003)	No records	Yes

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Graphocephala versuta (Say, 1830) [Hemiptera: Cicadellidae]	Leafhopper	N, Pe, Pl (APHIS 2002a)	No (Fletcher 2009)	Yes
Heliococcus osborni (Sanders, 1902) [Hemiptera: Pseudococcidae]	Osborn mealybug	Prunus sp. (Ben-Dov *et al* 2009)	No records	Yes
Hemiberlesia lataniae (Signoret, 1869) [Hemiptera: Diaspididae]	Latania scale	Pe, Pl (Ben-Dov *et al* 2009)	NSW, NT, Qld., Vic., and WA (APPD 2009)	No
Hemiberlesia rapax (Comstock, 1881) [Hemiptera: Diaspididae]	Greedy scale	Pl (Ben-Dov *et al* 2009)	NSW, Qld., Vic., Tas., WA (APPD 2009)	No
Homalodisca vitripennis (Germar, 1821) Synonym: *Homalodisca coagulata* (Say, 1832) [Hemiptera: Cicadellidae]	Glassy-winged sharpshooter	N, Pe, Pl (APHIS 2002a)	No (Fletcher 2009) No (Poole 2008)	Yes
Homalodisca insolita (Walker, 1858) [Hemiptera: Cicadellidae]	Leafhopper	N, Pe, Pl (APHIS 2002a)	No (Fletcher 2009)	Yes
Howardia biclavis (Comstock, 1883) [Hemiptera: Diaspididae]	Mining scale	This scale was previously present in California, but has since been eradicated (Gill 1997). *Prunus* is a host.	Qld. (APPD 2009)	No
Hyalopterus pruni (Geoffroy, 1762) [Hemiptera: Aphididae]	Mealy plum aphid	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	Yes. Qld., Tas., Vic. (APPD 2009) No records for WA,	Yes (WA)
Icerya purchasi Maskell, 1878 [Hemiptera: Margarodidae]	Cottony cushion scale	N, Pe, Pl (APHIS 2002a)	Yes. NSW, NT, Qld., Tas., WA (APPD 2009) Qld., NSW, Tas., SA, WA (Poole 2008)	No
Ischnaspis longirostris (Signoret, 1882) [Hemiptera: Diaspididae]	Black thread scale	This pest was previously present in California. Eradicated (Gill 1997). *Prunus* is considered a host by some authors.	NT, Qld. (APPD 2009)	No
Lepidosaphes ulmi (Linnaeus, 1758) [Hemiptera: Diaspididae]	Oystershell scale; Mussel scale	N, Pe, Pl (APHIS 2002a)	Yes. NSW, Qld., Tas., WA (APPD 2009) WA (Poole 2008)	No
Lepidosaphes pinnaeformis (Bouché, 1851) [Hemiptera: Diaspididae]	Cymbidium scale	Pe (Ben-Dov 20090	NSW, Qld., Vic. (APPD 2009)	Yes (WA)

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Lygus elisus van Duzee, 1914 [Hemiptera: Miridae]	Pale legume bug; Lucerne plant bug	N, Pe, Pl (APHIS 2002a)	No (Cassis and Gross 2002)	Yes
Lygus hesperus Knight, 1917 [Hemiptera: Miridae]	Western tarnished plant bug	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	No (Cassis and Gross 2002)	Yes
Lygus lineolaris (Palisot de Beauvois, 1818) [Hemiptera: Miridae]	Tarnished plant bug	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	No (Cassis and Gross 2002)	Yes
Maconellicoccus hirsutus (Green, 1908) [Hemiptera: Pseudococcidae]	Pink hibiscus mealybug	Pl (CABI 2007)– localised in California (recent introduction)	Yes. NT, Qld., Vic., WA (APPD 2009) NT, Qld., WA (Poole 2008)	No
Magicicada septendecim (Linnaeus, 1758) [Hemiptera: Cicadidae]	Periodic cicada	N, Pe, Pl (APHIS 2002a)	No records	Yes
Melanaspis obscura (Comstock, 1881a) [Hemiptera: Diaspididae]	Obscure scale	N, Pe, Pl (APHIS 2002a)	Yes. NSW (APPD 2009) No records for WA,	Yes (WA)
Melanaspis tenebricosa (Comstock, 1881) [Hemiptera: Diaspididae]	Gloomy scale	Pe (Ben-Dov 2009)	No records	Yes
Mercetaspis halli (Green, 1923) [Hemiptera: Diaspididae] Synonym: *Nilotaspis halli* (Green, 1923)	Hall scale	N, Pe, Pl (APHIS 2002a) This scale has been eradicated and is not found in California (Gill 1997). No records from the Pacific Northwest are known.	No (Ben-Dov *et al.* 2006)	No
Mesolecanium nigrofasciatum (Pergande, 1898) [Hemiptera: Coccidae]	Terrapin scale	N, Pe, Pl (APHIS 2002a)	No (Ben-Dov *et al.* 2006)	Yes
Metcalfa pruinosa (Say, 1830) [Hemiptera: Flatidae]	Plant hopper	N, Pe, Pl (APHIS 2002a)	No (Fletcher 2009)	Yes
Myzus persicae (Sulzer, 1776) [Hemiptera: Aphididae]	Green peach aphid	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	Yes. NSW, NT, Qld., Vic., Tas. WA (APPD 2009) NSW, Qld., Vic., Tas., SA, WA (Poole 2008)	No
Neopinnaspis harperi McKenzie, 1949 [Hemiptera: Diaspididae]	Armoured scale	N, Pe, Pl (APHIS 2002a)	No (Ben-Dov *et al.* 2006)	Yes

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (Apricot, Nectarine, Peach, Plum)	Presence in Australia	Consider Further ?
Neopulvinaria innumerabilis innumerabilis (Rathvon, 1854) [Hemiptera: Coccidae] Synonym: *Pulvinaria innumerabilis* (Rathvon, 1854)	Cottony maple scale	N, Pe, Pl (APHIS 2002a)	No (Ben-Dov *et al.* 2006)	Yes
Nezara viridula (Linnaeus, 1758) [Hemiptera: Pentatomidae]	Southern green stink bug	N, Pe, Pl (APHIS 2002a)	Yes. ACT, NSW, NT, Qld., Tas., Vic., WA (APPD 2009) WA (Poole 2008)	No
Norvellina seminudus (Say, 1830) [Hemiptera: Cicadellidae]	Leafhopper	N, Pe, Pl (APHIS 2002a)	No (Fletcher 2009)	Yes
Oncometopia orbona (Fabricius, 1798) [Hemiptera: Cicadellidae]	Leafhopper	N, Pe, Pl (APHIS 2002a)	No (Fletcher 2009)	Yes
Parabemisia myricae (Kuwana, 1927) [Hemiptera: Aleyrodidae]	Bayberry whitefly	Pe, Pl (CABI 2007)	Qld. (CSIRO 2004)	Yes
Paraphlepsius irroratus (Say, 1830) [Hemiptera: Cicadellidae]	Brown speckled leafhopper; Irrorate spittlebug	N, Pe, Pl (APHIS 2002a)	No (Fletcher 2009)	Yes
Parlatoreopsis chinensis (Marlatt, 1908) [Hemiptera: Diaspididae]	Chinese obscure scale	*Prunus sp.* (Ben-Dov 2009)	No records	Yes
Parlatoria oleae (Colvée, 1880) [Hemiptera: Diaspididae]	Olive parlatoria scale	N, Pe, Pl (APHIS 2002a)	Yes. NSW, Qld (Ben-Dov *et al.* 2006) No records for WA,	Yes (WA)
Parlatoria theae Cockerell, 1896 [Hemiptera: Diaspididae]	Tea parlatoria scale	N, Pe, Pl (APHIS 2002a). Although reported from leaves and stems of stone fruit in California, this species is noted as having been eradicated in California prior to 1950 (Gill 1997).	No (Ben-Dov *et al.* 2006)	No
Parthenolecanium corni (Bouché, 1844) [Hemiptera: Coccidae]	Plum scale; European fruit lecanium	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	Yes. Tas (APPD 2009) No records for WA,	Yes (WA)
Parthenolecanium persicae (Fabricius, 1776) [Hemiptera: Coccidae]	European peach scale	N, Pe, Pl (APHIS 2002a)	Yes. ACT, NSW, Qld., SA, Tas., WA (APPD 2009) WA (Poole 2008)	No

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Parthenolecanium pruinosum (Coquillett, 1891) [Hemiptera: Coccidae]	Frosted scale	Feeds on many deciduous tree species including most of the pome and stone fruits (Gill 1988). Distributed throughout California and several other western states (Gill 1988).	Yes. NSW, Tas. (APPD 2009) WA (Poole 2008)	No
Phenacoccus aceris (Signoret, 1875) [Hemiptera: Pseudococcidae]	Apple mealybug	All deciduous fruit including plum and apricot (Beers 2007)	No records	Yes
Phenacoccus graminicola Leonardi, 1908 [Hemiptera: Pseudococcidae]	Ryegrass mealybug	Pe (Ben-Dov 2009)	Qld., SA (APPD 2009) WA (Poole 2008)	No
Phenacoccus madeirensis Green, 1923 [Hemiptera: Pseudococcidae]	Mexican mealybug	*Phenacoccus gossypii* was listed in the original pests list as being a pest of nectarine, peach and plum in California (APHIS 2002a) based on literature from 1980 and earlier. However, it is generally accepted that most records are misidentifications of *P. madeirensis* (Ben-Dov *et al.* 2006) and *P. gossypii* is considered extremely rare.	No (Ben-Dov *et al*. 2006)	Yes
Philaenus spumarius (Linnaeus,1758) [Hemiptera: Aphrophoridae]	Meadow froghopper; Meadow spittle bug	Pe, *Prunus* spp. (CABI 2007)	No (Fletcher 2009)	Yes
Phorodon humuli (Schrank, 1801) [Hemiptera: Aphididae]	Hop aphid	Pl (Hollingsworth 2007)	No records	Yes
Pinnaspis strachani (Cooley, 1899) [Hemiptera: Diaspididae]	Cotton white scale	Pe (Ben-Dov 2009)	NSW, Qld., NT, WA (APPD 2009)	No
Pseudaonidia duplex (Cockerell, 1896) [Hemiptera: Diaspididae]	Camphor scale	N, Pe, Pl (APHIS 2002a)	No (Ben-Dov *et al*. 2006)	Yes

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Pseudaulacaspis pentagona (Targioni Tozzetti, 1886) [Hemiptera: Diaspididae]	Peach white scale	N, Pe, Pl (APHIS 2002a) Recorded from California but eradicated (Gill 1997; Nakahara 1982). Listed as present in Oregon (Nakahara 1982). Until recently, *Pseudaulacaspis prunicola* was considered a synonym of *P. pentagona* (Davidson and Miller 1990). There is therefore confusion surrounding host records and distribution of this insect (Davidson and Miller 1990). This species is commonly collected from *Prunus*, particularly flowering cherries (Davidson and Miller 1990; Semel 2006). Many of the host and distribution records for *P. pentagona* prior to 1980 would likely be *P. prunicola*.	Yes. NSW, Qld. (APPD 2009) Not in WA (Poole 2008) No specific records for *P. prunicola.* However, until recently *P. prunicola* was considered a synonym of *P. pentagona* (Davidson and Miller 1990). There is therefore confusion surrounding host records and distribution of this insect (Davidson and Miller 1990). Commonly collected from *Prunus*, particularly flowering cherries (Davidson and Miller 1990; Semel 2006). Many of the host and distribution records for *P. pentagona* prior to 1980 would likely be *P. prunicola*. Due to this uncertainty, both species are considered further.	Yes (WA)
Pseudaulacaspis prunicola (Maskell, 1895) [Hemiptera: Diaspididae]	White prunicola scale			
Pseudococcus calceolariae (Maskell, 1879) [Hemiptera: Pseudococcidae]	Citrophilus mealybug	N, Pe, Pl (APHIS 2002a)	Yes. NSW, SA, Tas., Qld. (APPD 2009) Not in WA (Poole 2008)	Yes (WA)
Pseudococcus comstocki (Kuwana, 1902) [Hemiptera: Pseudococcidae]	Comstock mealybug	N, Pe, Pl (APHIS 2002a)	No (Poole 2008)	Yes
Pseudococcus longispinus (Targioni Tozzetti, 1867) [Hemiptera: Pseudococcidae]	Long-tailed mealybug	Pl (Ben-Dov 2009)	ACT, NSW, Qld., SA, Tas., Vic., WA (APPD 2009)	No
Pseudococcus maritimus (Ehrhorn, 1900) [Hemiptera: Pseudococcidae]	Grape mealybug	Pe, Pl (CABI 2007) *Prunus* sp. (Ben-Dov *et al*. 2006)	No records	Yes
Pseudococcus viburni (Signoret, 1875) Synonym*: Pseudococcus obscurus* (Essig, 1909) [Hemiptera: Pseudococcidae]	Obscure mealybug; Californian mealybug	N, Pe, Pl (APHIS 2002a)	Yes. NSW, Qld., SA, Tas., WA (APPD 2009) WA (Poole 2008)	No
Pulvinaria rhois Ehrhorn, 1898 [Hemiptera: Coccidae]	Fruit tree pulvinaria	Prunus sp. (Ben-Dov 2009)	No records	Yes

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (Apricot, Nectarine, Peach, Plum)	Presence in Australia	Consider Further ?
Pulvinaria vitis (Linnaeus, 1758) [Hemiptera: Coccidae]	Cottony grape scale	A, Pe, Pl (Ben-Dov 2009)	No records	Yes
Rhizoecus falcifer Künckel d' Herculais, 1878 [Hemiptera: Pseudococcidae]	Ground mealybug	N, Pe, Pl (APHIS 2002a)	Yes. NSW, Qld. (APPD 2009) Not in WA (Poole 2008)	Yes (WA)
Rhopalosiphum padi (Linnaeus, 1758) [Hemiptera: Aphididae]	Oat aphid	*Prunus* sp. (CABI 2007)	NSW, Qld., SA, Tas., Vic., WA (APPD 2009)	No
Rhopalosiphum rufiabdominalis (Sasaki, 1899) [Hemiptera: Aphididae]	Rice root aphis	*Prunus* sp. (CABI 2007)	NSW, Qld., SA, Tas., Vic., WA (APPD 2009)	No
Saissetia coffeae (Walker, 1852) [Hemiptera: Coccidae]	Hemispherical scale	Known from California (Gill 1988) and is known to be a pest of plum and peach (Ben-Dov *et al.* 2009).	ACT, NSW, Qld., Tas., WA (APPD 2009)	No
Saissetia oleae (Olivier, 1791) [Hemiptera: Coccidae]	Black scale	N, Pe, Pl (APHIS 2002a) *Prunus* sp. (CABI 2007)	Yes. NSW, Qld., Tas., Vic., WA (APPD 2009) WA (Poole 2008)	No
Scaphytopius acutus (Say, 1830) [Hemiptera: Cicadellidae]	Leafhopper	N, Pe, Pl (APHIS 2002a)	No (Fletcher 2009)	Yes
Sphaerolecanium prunastri (Boyer de Fonscolombe, 1834) [Hemiptera: Coccidae]	Globose scale	N, Pe, Pl (APHIS 2002a)	No (Ben-Dov *et al.* 2006)	Yes
Thyanta custator (Fabricius, 1803) [Hemiptera: Pentatomidae]	Stink bug	N, Pe, Pl (APHIS 2002a)	No (Cassis and Gross 2002)	Yes
Thyanta pallidovirens (Stål, 1859) [Hemiptera: Pentatomidae]	Redshouldered stink bug	N Pe, (Bentley *et al.* 2006e; Pickel *et al.* 2006f)	No (Cassis and Gross 2002)	Yes
Trialeurodes packardi (Morrill, 1903) [Hemiptera: Aleyrodidae]	Strawberry white fly	N, Pe, Pl (APHIS 2002a)	No records	Yes
Trialeurodes vaporariorum (Westwood, 1856) [Hemiptera: Aleyrodidae]	Greenhouse white fly	N, Pe, Pl (APHIS 2002a)	Yes. ACT, NSW, NT, Qld., SA, Tas., Vic., WA (APPD 2009) WA (Poole 2008)	No

Scientific Name	**Common Name(s)**	**Association with stone fruit production in California, Idaho, Oregon or Washington (Apricot, Nectarine, Peach, Plum)**	**Presence in Australia**	**Consider Further ?**
HYMENOPTERA (Ants, Bees, Sawflies, Wasps)				
Hoplocampa cookei (Clarke, 1906) [Hymenoptera: Tenthredinidae]	Cherry fruit sawfly	Pl, Pe, A (Duruz 1922)	No records	Yes
LEPIDOPTERA (Butterflies, Moths)				
Acleris minuta (Robinson, 1869) [Lepidoptera: Tortricidae]	Yellowheaded fireworm	Pl (Chapman and Lienk 1971)	No (Nielsen *et al.* 1996)	Yes
Acrobasis tricolorella Grote, 1878 [Lepidoptera: Pyralidae]	Mineola moth; Destructive prune worm	Pl (Epstein *et al.* 2007)	No (Nielsen *et al.* 1996)	Yes
Agrotis ipsilon (Hufnagel, 1766) [Lepidoptera: Notodontidae]	Black cutworm moth	Pe, Pl (CABI 2007)	Yes. ACT, NSW, NT, Qld., Tas., WA (APPD 2009) WA (Poole 2008)	No
Alsophila pometaria (Harris, 1841) [Lepidoptera: Geometridae]	Fall cankerworm	Pl (Pickel *et al.* 2009)	No (Poole 2008)	Yes
Amphipyra pyramidoides Guenée, 1852 [Lepidoptera: Noctuidae]	Noctuid	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	No (Poole 2008)	Yes
Amyelois transitella (Walker, 1863) [Lepidoptera: Pyralidae]	Navel orange worm	N, Pe, Pl (APHIS 2002a)	No (Poole 2008)	Yes
Anarsia lineatella Zeller, 1839 [Lepidoptera: Gelechiidae]	Peach twig borer moth	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	No (Nielsen *et al.* 1996)	Yes
Antheraea polyphemus (Cramer, 1775) [Lepidoptera: Saturniidae]	Polyphemus moth; Silk moth	Pe, Pl (Oehlke 2006; Opler *et al.* 2009)	No (Nielsen *et al.* 1996)	Yes
Archips argyrospila (Walker, 1863) [Lepidoptera: Tortricidae]	Fruit-tree leafroller	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	No (Nielsen *et al.* 1996)	Yes
Archips podana (Scopoli, 1763) [Lepidoptera: Tortricidae]	Great brown twist moth	Pl (Cooperative Agriculture Pest Survey Program 2003)	No (Nielsen *et al.* 1996)	Yes
Archips rosana (Linnaeus, 1758) [Lepidoptera: Tortricidae]	European leafroller; Rose tortrix moth	Pl (CABI 2007) A (APHIS 2006a)	No (Nielsen *et al.* 1996) No (Poole 2008)	Yes

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Argyrotaenia citrana (Fernald, 1889) [Lepidoptera: Tortricidae]	Orange tortrix	Pl (Bentley *et al.* 2009d) A (APHIS 2006a)	No (Nielsen *et al.* 1996) No (Poole 2008)	Yes
Bondia comonana (Kearfott, 1907) [Lepidoptera: Carposinidae]	Prune limb borer	N (Bentley *et al.* 2006f) Pe (Pickel *et al.* 2006g)	No (Nielsen *et al.* 1996)	Yes
Choreutis pariana (Clerck, 1759) [Lepidoptera: Choreutidae]	Apple leaf skeletoniser	A, Pe, (CABI 2007)	No (Nielsen *et al.* 1996)	Yes
Choristoneura rosaceana (Harris, 1841) [Lepidoptera: Tortricidae]	Oblique banded leafroller	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	No (Nielsen *et al.* 1996) No (Poole 2008)	Yes
Coleophora sacramenta Heinrich, 1914 [Lepidoptera Coleophoridae]	California pistol case bearer	N, Pe, Pl (APHIS 2002a)	No (Nielsen *et al.* 1996)	Yes
Cydia latiferreana (Walsingham, 1879) [Lepidoptera: Tortricidae]	Filbertworm	N (Curtis *et al.* 1992)	No records	Yes
Cydia pomonella (Linnaeus, 1758) [Lepidoptera: Tortricidae]	Codling moth	N, Pe, Pl (APHIS 2002a)	Yes. ACT, NSW, NT, Qld., SA, Tas., Vic. (APPD 2009) Eradicated from WA (Poole 2008)	Yes (WA)
Datana ministra (Drury, 1773) [Lepidoptera: Notodontidae]	Yellow necked caterpillar	N, Pe, Pl (APHIS 2002a)	No (Nielsen *et al.* 1996)	Yes
Egira curialis (Grote, 1873) Synonym: *Xylomyges curialis* (Grote, 1873) [Lepidoptera: Noctuidae]	Citrus cutworm	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	No (Nielsen *et al.* 1996)	Yes
Enarmonia formosana (Scopoli, 1763) [Lepidoptera: Tortricidae]	Cherry bark tortrix	A, Pl (CABI 2007)	No (Nielsen *et al.* 1996)	Yes
Euproctis chrysorrhoea (Linnaeus, 1758) [Lepidoptera: Lymantriidae]	Brown tail moth	A, Pl (CABI 2007)	No (Nielsen *et al.* 1996) No (Poole 2008)	Yes
Euzophera semifuneralis (Walker, 1863) [Lepidoptera: Pyralidae]	American plum borer	N, Pe, Pl (APHIS 2002a)	No (Nielsen *et al.* 1996)	Yes

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Grapholita molesta (Busck, 1916) [Lepidoptera: Tortricidae]	Oriental fruit moth	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	Yes. ACT, NSW, Qld., Tas., Vic. (APPD 2009_ Not in WA (Poole 2008)	Yes (WA)
Grapholita packardi Zeller, 1875 Synonym: *Cydia prunivora* (Zeller, 1875) [Lepidoptera: Tortricidae]	Cherry fruitworm	Pe, Pl (CABI 2007)	No (Nielsen *et al.* 1996) No (Poole 2008)	Yes
Grapholita prunivora (Walsh, 1868) Synonym: *Cydia prunivora* (Walsh, 1868) [Lepidoptera: Tortricidae]	Lesser apple fruitworm; Plum moth	N, Pe, Pl (APHIS 2002a)	No (Nielsen *et al.* 1996) No (Poole 2008)	Yes
Hyphantria cunea (Drury, 1773) [Lepidoptera: Arctiidae]	Fall webworm; American white moth	N, Pe, Pl (APHIS 2002a)	No (Nielsen *et al.* 1996) No (Poole 2008)	Yes
Lithophane antennata (Walker, 1858) [Lepidoptera: Noctuidae]	Green fruit worm	N, Pe, Pl (APHIS 2002a)	No (Nielsen *et al.* 1996)	Yes
Malacosoma americanum (Fabricius, 1793) [Lepidoptera: Lasiocampidae]	Eastern tent caterpillar	N, Pe, Pl (APHIS 2002a)	No (Nielsen *et al.* 1996)	Yes
Malacosoma californica (Packard, 1864) [Lepidoptera: Lasiocampidae] ssp. *pluviale* Dyar	Western tent caterpillar	Pe, Pl (EPPO/CABI 1997j)	No (Nielsen *et al.* 1996)	Yes
Malacosoma disstria Hübner, 1820 [Lepidoptera: Lasiocampidae]	Forest tent caterpillar	N, Pe, Pl (APHIS 2002a)	No (Nielsen *et al.* 1996)	Yes
Operophtera brumata (Linnaeus, 1758) [Lepidoptera: Geometridae]	Winter moth	A, Pe, Pl (CABI 2007)	No (Nielsen *et al.* 1996) No (Poole 2008)	Yes
Orgyia antiqua (Linnaeus, 1758) [Lepidoptera: Lymantriidae]	Rusty tussock moth; European tussock moth	Pl (Alford 2007) Present in Oregon (Hughes 1976)	No (Nielsen *et al.* 1996)	Yes
Orgyia vetusta Boisduval, 1852 [Lepidoptera: Lymantriidae]	Western tussock moth	Pl (Bentley and Day 2009) A (APHIS 2006a)	No (Nielsen *et al.* 1996)	Yes

Scientific Name	**Common Name(s)**	**Association with stone fruit production in California, Idaho, Oregon or Washington** **(Apricot, Nectarine, Peach, Plum)**	**Presence in Australia**	**Consider Further ?**
Orthosia hibisci (Guenée, 1852) [Lepidoptera: Noctuidae]	Speckled green fruit worm	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	No (Nielsen *et al.* 1996)	Yes
Ostrinia nubilalis (Hübner, 1796) [Lepidoptera: Pyralidae]	European corn borer	N, Pe, Pl (APHIS 2002a)	No (Nielsen *et al.* 1996) No (Poole 2008)	Yes
Paleacrita vernata (Peck, 1795) [Lepidoptera: Geometridae]	Spring cankerworm	Pl (Pickel *et al.* 2009)	No (Nielsen *et al.* 1996)	Yes
Pandemis pyrusana Kearfott, 1907 [Lepidoptera: Tortricidae]	Apple pandemis; pandemis leafroller	N, Pe, Pl (Hollingsworth 2007) A (APHIS 2006a)	No (Nielsen *et al.* 1996)	Yes
Papilio eurymedon Lucas, 1852 [Lepidoptera: Papilionidae]	Pale swallowtail	*Prunus* spp. (CABI 2007)	No (Nielsen *et al.* 1996)	Yes
Papilio rutulus Lucas, 1852 [Lepidoptera: Papilionidae]	Western tiger swallowtail	Stone fruits (Shapiro 2009) Pe, Pl (Butterflycorner.net 2009)	No (Nielsen *et al.* 1996)	Yes
Peridroma saucia (Hübner, 1808) [Lepidoptera: Notodontidae]	Variegated cutworm moth; Finnish dart	A, Pe, Pl (CABI 2007)	No (Nielsen *et al.* 1996)	Yes
Phyllonorycter crataegella (Clemens, 1859) [Lepidoptera: Gracillariidae]	Apple blotch leafminer	Pl (CABI 2007)	No (Nielsen *et al.* 1996)	Yes
Phyllonorycter elmaella Doganlar & Mutuura, 1980 [Lepidoptera: Gracillariidae]	Western spotted tentiform leafminer	Pl (CABI 2007)	No (Nielsen *et al.* 1996)	Yes
Platynota stultana Walsingham, 1884 [Lepidoptera: Tortricidae]	Orange tortrix Omnivorous leafroller	Pe (CABI 2007)	No (Nielsen *et al.* 1996) No (Poole 2008)	Yes
Plodia interpunctella (Hübner, 1813) [Lepidoptera: Pyralidae]	Indian meal moth	*Prunus* spp. (CABI 2007)	Yes. ACT, NSW, NT, Qld., Tas., Vic., WA (APPD 2009) WA (Poole 2008)	No
Schizura concinna (Smith, 1797) [Lepidoptera: Notodontidae]	Red humped caterpillar moth	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	No (Nielsen *et al.* 1996)	Yes

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Sphinx drupiferarum (Smith, 1797) [Lepidoptera: Sphingidae]	Wild cherry sphinx	N, Pe, Pl (APHIS 2002a)	No (Nielsen *et al.* 1996)	Yes
Spilonota ocellana (Denis & Schiffermueller, 1775) [Lepidoptera: Tortricidae]	Eye-spotted bud moth	Pe, Pl (CABI 2007)	No (Nielsen *et al.* 1996) No (Poole 2008)	Yes
Spodoptera frugiperda (Smith, 1797) [Lepidoptera: Noctuiidae]	Fall armyworm	Pe (CABI 2007)	No (Nielsen *et al.* 1996) No (Poole 2008)	Yes
Synanthedon exitiosa (Say, 1823) [Lepidoptera: Aegeriidae]	Peach tree borer moth	N, Pe, Pl (APHIS 2002a) A (APHIS 2006a)	No (Nielsen *et al.* 1996)	Yes
Synanthedon pictipes (Grote & Robinson, 1868) [Lepidoptera: Aegeriidae]	Lesser peach tree borer moth	N, Pe, Pl (APHIS 2002a)	No (Nielsen *et al.* 1996)	Yes
Xestia c-nigrum (Linnaeus, 1758) [Lepidoptera: Notodontidae]	Spotted cutworm	Pe (CABI 2007) A (APHIS 2006a)	No (Nielsen *et al.* 1996) No (Poole 2008)	Yes
Zeuzera pyrina (Linnaeus, 1761) [Lepidoptera: Cossidae]	Leopard moth	N, Pe, Pl (APHIS 2002a)	No (Nielsen *et al.* 1996)	Yes
ORTHOPTERA (crickets, grasshoppers, katydids)				
Melanoplus femurrubrum (DeGeer, 1773) [Orthoptera: Acrididae]	Red-legged grasshopper	N, Pe, Pl (APHIS 2002a)	No (Rentz 2006; CABI 2007)	Yes
Microcentrum retinerve (Burmeister, 1838) [Orthoptera: Tettigoniidae]	Angular winged katydid	N (Bentley and Day 2006b) Pe (Pickel *et al.* 2006h) Pl (Bentley *et al.* 2009f)	No (Rentz 2006)	Yes
Scudderia furcata Brunner von Wattenwyl, 1878 [Orthoptera: Tettigoniidae]	Forktailed bush katydid	N (Bentley and Day 2006b) Pe (Pickel *et al.* 2006h) Pl (Bentley *et al.* 2009f)	No (Rentz 2006)	Yes
THYSANOPTERA (thrips)				
Frankliniella bispinosa (Morgan, 1913) [Thysanoptera: Thripidae]	Thrips	N, Pe, Pl (APHIS 2002a)	No (Poole 2008)	Yes

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Frankliniella fusca (Hinds, 1902) [Thysanoptera: Thripidae]	Tobacco thrips	N, Pe, Pl (APHIS 2002a)	No (Poole 2008)	Yes
Frankliniella minuta (Moulton, 1907) [Thysanoptera: Thripidae]	Minute flower thrips	Pe (Texas A&M University 2006)	No (Poole 2008)	Yes
Frankliniella occidentalis (Pergande, 1895) [Thysanoptera: Thripidae]	Western flower thrips	N, Pe, Pl (APHIS 2002a)	Yes. ACT, NSW, Qld., Tas., Vic., WA (APPD 2009) WA (Poole 2008) Absent from NT. Under official control in Tas.	Yes
Frankliniella tritici (Fitch, 1855) [Thysanoptera: Thripidae]	Flower thrips	N, Pe, Pl (APHIS 2002a)	No (Poole 2008)	Yes
Frankliniella intonsa (Trybom, 1895) [Thysanoptera: Thripidae]	Taiwan flower thrips	Pe (CABI 2007)	No (Poole 2008)	Yes
Heliothrips haemorrhoidalis (Bouché, 1833) [Thysanoptera: Thripidae]	Greenhouse thrips	*Prunus* spp. (CABI 2007)	Yes. NSW, NT, Qld., SA., Tas., Vic., WA (APPD 2009) WA (Poole 2008)	No
Taeniothrips inconsequens (Uzel, 1895) [Thysanoptera: Thripidae]	Pear thrips	*Prunus* spp. (CABI 2007)	No (CABI 2007; EPPO/CABI 1989; Poole 2008)	Yes
Thrips hawaiiensis (Morgan, 1913) [Thysanoptera: Thripidae]	Hawaiian flower thrips	N, Pe, Pl (APHIS 2002a)	Yes (Mound and Gillespie 1997) Qld., NSW, NT, WA (Poole 2008)	No
GASTROPODA				
Helix aspersa Muller,1774 [Helicidae]	Brown garden snail	N, Pe, Pl (APHIS 2002a)	Yes. Qld, NSW, Vic, Tas, SA, WA (CSIRO 2004) NSW, NT, Tas. (APPD 2009)	No
BACTERIA				
Erwinia amylovora (Burrill 1882) Winslow, Broadhurst, Buchanan, Krumwiede, Rogers and Smith, 1920 [Enterobacteriales: Enterobacteriaceae]	Fire blight of apple	There are two reports of natural infection of *Prunus* species. (Mohan 2007; Mohan and Thomson 1996)	No. *Erwinia amylovora* was reported from the Melbourne Royal Botanic Garden in 1996 and its eradication was confirmed by a survey in 1997 (Jock *et al.* 2000).	Yes

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Pseudomonas syringae pv. *syringae* van Hall, 1902 [Pseudomonadales: Pseudomonadaceae]	Bacterial canker; Gummosis; Blossom blast; Dieback; Spur blight; Twig blight	N, Pe, Pl (APHIS 2002b) A (APHIS 2006a)	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2009) to species level as *Pseudomonas syringae* WA (APPD 2009) as *Pseudomonas syringae* pv. *syringae* NT (Bradbury 1986)	No
Pseudomonas viridiflava (Burkholder 1930) Dowson 1939 [Pseuromonadales: Pseudomonadaceae]		A (CABI 2007)	Qld., Vic., WA (APPD 2009)	No
Rhizobium radiobacter (Smith & Townsend, 1907) Conn, 1942 [Rhizobiales: Rhizobiaceae]	Crown gall	N, Pe, Pl (APHIS 2002b) A (APHIS 2006a)	Yes. NSW, Qld. SA, Tas., Vic. WA (APPD 2009) WA (Shivas 1989)	No
Xanthomonas arboricola pv. *pruni* (Smith) Vauterin *et al.* [Xanthomonadales: Xanthomonadaceae]	Bacterial spot	Pe, Pl, A (EPPO/CABI 1997k)	Yes. NSW, Tas. (APPD 2009) Qld., Vic., WA (EPPO/CABI 1997k) NSW, NT, Qld., SA, Tas., Vic., and WA (APPD 2008) as *X. campestris* pv. *pruni*.	No
Xylella fastidiosa Wells, Raju, Hung, Weisburg, Mandelco-Paul and Brenner, 1987 [Xanthomonadales: Xanthomonadaceae]	Phoney peach disease;	Pe, Pl. Present in California (CABI 2007)	No records	Yes
FUNGI				
Alternaria alternata (Fr.:Fr.) Keissl. [Anamorphic Pleosporaceae]	Alternaria spot; Alternaria fruit rot; Cork spot; Leaf spot; Storage rot	Pe, Pl (Farr and Rossman 2009) Pl (APHIS 2002b)	Yes. All states and territories (APPD 2009)	No

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Apiosporina morbosa (Schwein.:Fr.) Arx [Dothideales: Venturaceae]	Black knot	A, Pe, Pl Present in all states (CABI 2007)	Possibly. *Fusicladium* sp. NSW, Tas., Vic. (APPD 2009; Farr and Rossman 2009) *Fusicladium* sp. SA (Cook and Dubé 1989). *Fusicladium* sp. WA (Shivas 1989)	Yes
Armillaria mellea (Vahl:Fr.) P. Kumm. [Agaricales: Armillariaceae]	Crown & root rot; Shoe-string rot; Armillaria root rot; Honey agaric; Oak root fungus	Pe, Pl (APHIS 2002b) A, N, Pe, Pl (Farr and Rossman 2009) N, Pe, Pl (APHIS 2002b) A (APHIS 2006a)	No evidence that *A. mellea* is established in Australia (May and Wood 1997).	Yes
Armillaria gallica Marxmüller & Romagni [Agaricales: Armillariaceae]	Armillaria root rot	A, Pe, Pl (CABI 2007) Present in California (Baumgartner and Rizzo 2001)	No records	Yes
Armillaria ostoyae (Romagn.) Herink [Agaricales: Armillariaceae]	Armillaria root rot	Pe (CABI 2007) Present in California (Baumgartner and Rizzo 2001)	No records	Yes
Armillaria NABSX (North American Biological Strain X – unnamed) [Agaricales: Armillariaceae]	Armillaria root rot	(Anderson and Ullrich 1979)	No records	Yes
Aspergillus niger Tiegh. [Anamorphic Trichocomaceae]	Black mould	A, N, Pe, Pl (APHIS 2002b; Farr and Rossman 2009)	Yes. ACT, NSW, NT, Qld, SA, Vic., WA (APPD 2009)	No
Aureobasidium pullulans (de Bary) G. Arnaud [Anamorphic Dothioraceae]		N, Pe, Pl (Hong and Michailides 2000)	Yes. All states and territories (APPD 2009)	No
Blumeriella jaapii (Rehm) Arx Anamorph: *Phloeosporella padi* (Lib.) Arx [Helotiales: Dermateaceae]	Cherry leaf spot	A (Farr and Rossman 2009) Other hosts are susceptible, but area freedom has been previously assessed for cherry imports.	No. Previously present. Eradicated (Cook and Dubé 1989)	Yes

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Botrytis cinerea Pers.:Fr. Teleomorph: *Botryotinia fuckeliana* (de Bary) Whetzel [Heliotiales: Sclerotiniaceae]	Grey mould	A, N, Pe, Pl (APHIS 2002b; Farr and Rossman 2009) N, Pe, Pl (APHIS 2002b) A (APHIS 2006a)	Yes. ACT, NSW, Qld, SA, Tas., Vic., WA (APPD 2009)	No
Candida albicans (C.P. Robin) Berkhout [Anamorphic Saccharomycetales]	Sour rot	Pe (APHIS 2002b; Farr and Rossman 2009)	Yes. Widespread yeast, commonly isolated from humans.	No
Ceratocystiopsis alba (DeVay, R.W. Davidson & W.J. Moller) H.P. Upadhyay 1981 [Ophiostomatales: Ophiostomataceae]	Canker	A (DeVay *et al.* 1968)	Vic. single records (APPD 2009)	Yes
Ceratocystis fimbriata Ellis & Halst. Anamorph: *Chalara* sp. [Ophiostomatales: Ceratocystidaceae]	Canker; Mallet wound fungus	A, Pe, Pl (APHIS 2002b; Farr and Rossman 2009) N, Pe, Pl (APHIS 2002b) A (APHIS 2006a)	Yes. NSW, Qld, SA, Vic., WA (APPD 2009)	No
Ceriporia spissa (Schwein.) Rajchenberg [Polyporales: Hapalopilaceae]		Pe (Farr and Rossman 2009)	Yes. Tas. (APPD 2009). No records for WA,	Yes (WA)
Chondrostereum purpureum (Pers.:Fr.) Pouzar [Meruliales: Meruliaceae]	Silver leaf; Leaf rot; Heart rot	Pe, Pl (APHIS 2002b) A, Pe, Pl (Farr and Rossman 2009)	Yes. NSW, SA, Tas., Vic. WA (APPD 2009)	No
Cladosporium herbarum (Pers.:Fr.) Link [Anamorphic Mycosphaerellaceae]	Cladosporium rot	Pl (Farr and Rossman 2009)	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2009)	No
Colletotrichum acutatum J.H. Simmonds [Anamorphic Glomerellaceae]	Anthracnose	Pe, Pl CA (Bernstein and Miller 1995)	Yes. NSW, Qld, SA, Vic., WA (APPD 2009)	No
Colletotrichum gloeosporioides (Penz.) Penz. & Sacc. In Penz. Teleomorph: *Glomerella cingulata* (Stoneman) Spauld. & H. Schrenk [Phyllachorales: Glomerellaceae]	Anthracnose	Pe, Pl (Bernstein and Miller 1995)	Yes. All states and territories (APPD 2009) *Glomerella cingulata* NSW, NT, Qld, Vic., WA (APPD 2009)	No

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Dendrophoma sp. [Anamorphic Xylariales]		Pe (Farr and Rossman 2009)	Yes. SA, Vic. (APPD 2009) No *Dendrophoma* species is listed as a declared pest in List A or List B of Tasmania's Plant Quarantine Act 1997.	Yes (WA)
Diplocarpon mespili (Sorauer) Sutton Anamorph: *Entomosporium maculatum* Lév. [Heliotales: Dermateaceae]	Leaf blight	Pe (APHIS 2002b; Farr and Rossman 2009)	Yes. Qld (APPD 2009) *Entomosporium mespili* ACT, NSW, Qld., Tas., Vic., WA (APPD 2009) SA (Cook and Dubé 1989) WA (Shivas 1989)	No
Eutypa lata (Pers.:Fr.) Tul. & C. Tul. [Xylariales: Diatrypaceae]	Eutypa dieback	A, Pl (Farr and Rossman 2009)	Yes. NSW, Qld, SA, Vic. (APPD 2009) NSW, Qld., SA, Tas., Vic., WA under its synonym *E. armeniacae* (APPD 2009)	No
Fuscoporia gilva (Schwein.:Fr.) T. Wagner & M. Fisch. [Hymenochaetales: Hymenochaetaceae]	White rot	As *Phellinus gilvus*: Pe (Farr and Rossman 2009)	Yes. NSW, NT, Qld, Vic., WA (APPD 2009) SA (Cook and Dubé 1989)	No
Fomes fomentarius (L.:Fr.) J. Kickx [Polyporales: Polyporaceae]	Trunk rot	Pl (Farr and Rossman 2009)	Yes. Vic. (APPD 2009) No records for WA.	Yes (WA)
Fomitiporia robusta (P. Karst.) Fiasson & Niemelä [Hymenochaetales: Hymenochaetaceae]		Pl (Farr and Rossman 2009)	Yes. NSW, NT, Qld, Vic., WA (APPD 2009) SA (Cook and Dubé 1989)	No
Fomitopsis cajanderi (P. Karst.) Kotlaba & Pouzar [Polyporales: Fomitopsidaceae]	Brown cubical rot	A, Pl (Farr and Rossman 2009)	No records	Yes
Fomitopsis pinicola (Sw.:Fr.) P. Karst. [Polyporales: Fomitopsidaceae]	Brown cubical rot	Pl (Farr and Rossman 2009)	Yes. Vic. (APPD 2009) No records for WA,	Yes (WA)
Fomitopsis rosea (Albertini & Schwein.:Fr.) P. Karst. [Polyporales: Fomitopsidaceae]	Brown pocket rot	Pe (Farr and Rossman 2009) as *Fomes roseus*	No records	Yes

Scientific Name	**Common Name(s)**	**Association with stone fruit production in California, Idaho, Oregon or Washington** **(A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	**Presence in Australia**	**Consider Further ?**
Fusarium avenaceum (Fr.:Fr.) Sacc. Teleomorph: *Gibberella avenacea* R.J. Cooke [Hypocreales: Nectriaceae]	Fruit rot	Pe (APHIS 2002b; Farr and Rossman 2009)	Yes. NSW, NT, Qld., SA, Tas., Vic., WA (APPD 2009)	No
Fusarium graminearum Schwabe Teleomorph: *Gibberella zeae* (Schwein.) Petch [Hypocreales: Nectriaceae]	Root rot	Pe (APHIS 2002b; Farr and Rossman 2009) as *Fusarium roseum*	Yes. NSW, Qld, SA, Vic., WA, Tas. (APPD 2009)	No
Fusarium lateritium Nees:Fr. Teleomorph:*Gibberella baccata* (Wallr.) Sacc. [Hypocreales: Nectriaceae]	Bud rot; Twig rot	Pe (APHIS 2002b) A, Pe (Farr and Rossman 2009)	Yes. NSW, SA, Tas., Vic., WA (APPD 2009)	No
Fusarium oxysporum Schlechtend.:Fr. [Anamorphic Nectriaceae]	Fruit rot; Basal stem rot	Pe (APHIS 2002b; Farr and Rossman 2009)	Yes. All states and territories (APPD 2009)	No
Fusarium solani (Mart.) Sacc. Teleomorph: *Nectria haematococca* Berk. & Broome [Hypocreales: Nectriaceae]	Fruit rot	Pe (APHIS 2002b; Farr and Rossman 2009)	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2009)	No
Fusicladium carpophilum (Thuem.) Oudem. Teleomorph: *Venturia carpophila* E.E. Fisher [Dothideales: Venturiaceae]	Scab; Scab & freckle; Black spot	N, Pe (APHIS 2002b) A, N, Pe, Pl (Farr and Rossman 2009)	Yes. NSW, Qld (APPD 2009) WA (Shivas 1989) as *Cladosporium carpophilum* *Venturia carpophila* Qld, Vic. (APPD 2009)	No
Ganoderma australe (Fr. : Fr.) Pat. 1890 [Polyporales: Ganodermataceae]		Pe (Farr *et al.* 2007)	Yes. NSW, Qld., Tas., Vic., WA (APPD 2009)	No
Ganoderma applanatum (Pers.) Pat. [Polyporales: Ganodermataceae]	White rot	Pe, Pl (Farr and Rossman 2009)	Records of *G. applanatum* in Australia are misidentifications (Smith and Sivasithamparam 2003)	Yes
Ganoderma brownii (Murrill) R.L. Gilbertson [Polyporales: Ganodermataceae]		Pe (Farr and Rossman 2009)	No records	Yes

Scientific Name	**Common Name(s)**	**Association with stone fruit production in California, Idaho, Oregon or Washington** **(A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	**Presence in Australia**	**Consider Further ?**
Ganoderma lucidum (Curtis : Fr.) P. Karst. 1881 [Polyporales: Ganodermataceae]		Pe (Farr and Rossman 2009)	Records of *G. lucidum* in Australia are misidentifications (Smith and Sivasithamparam 2003)	Yes
Geotrichum candidum Link var. *citri-aurantii* (Ferraris) Cif. & F.Cif. Teleomorph: *Galactomyces citri-aurantii* E.E. Butler [Saccharomycetales: Dipodascaceae]	Sour rot	N, Pe (Michailides *et al.* 2004)	Yes. NSW, NT, Qld, Tas., Vic., WA (APPD 2009) SA (Cook and Dubé 1989)	No
Gilbertella persicaria (E.D. Eddy) Hesseltine [Mucorales: Choanephoraceae]	Fruit rot	Pe (APHIS 2002b) A, Pe (Farr and Rossman 2009)	No records	Yes
Gloeophyllum sepiarium (Wulfen:Fr.) P. Karst. [Polyporales: Gloeophyllaceae]	Brown rot	Prunus (Farr *et al.* 1989)	No records	Yes
Gloeoporus dichrous (Fr. :Fr.) Bres [Polyporales: Meruliaceae]	Wood rot	A (Adaskaveg and Ogawa 1990)	Qld., (APPD 2009) Status uncertain.	Yes
Heterobasidion annosum (Fr. :Fr.) Bref [Russulales: Bondarzewiaceae]	Root rot	A (Farr and Rossman 2009)	Absent from Australia (Liberato *et al.* 2007)	Yes
Issatchenkia scutulata (Phaff, M.W. Mill. & M. Miranda) Kurtzman, M.J. Smiley & C.J. Johnson [Saccharomycetales: Saccharomycetaceae]	Sour rot	N, Pe (Michailides *et al.* 2004)	No records	Yes
Kloeckera apiculata (Reess) Janke [Saccharomycetales: Saccharomycetaceae]	Post-harvest disease; Sour rot	N, Pe (Michailides *et al.* 2004)	WA (APPD 2009)	Yes
Laetiporus sulphureus (Bull. :Fr.) Murrill [Polyporales: Fomitopsidaceae]	Heart rot	A, Pe (Farr and Rossman 2009)	NSW, Qld. (APPD 2009) May be a regional quarantine pest	Yes
Lambertella pruni Whetzel, Zeller, & Dumont in Dumont [Helotiales: Rutstroemiaceae]	Fruit rot	Pl (APHIS 2002b) A, Pl (Farr and Rossman 2009)	No records	Yes

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Leucostoma persoonii Höhn Anamorph: *Cytospora leucostoma* Sacc. [Diaporthales: Valsaceae]	Peach canker; Cytospora canker	N, Pe, Pl (APHIS 2002b) A (APHIS 2006a)	Yes. NSW, SA (APPD 2009) *Leucostoma persoonii* Vic. (APPD 2009) No records for WA. *Leucostoma persoonii* is not listed as declared pests in List A or List B of Tasmania's Plant Quarantine Act 1997.	Yes (WA)
Macrophomina phaseolina (Tassi) Goid. [Botryosphaeriales: Botryosphaeriaceae]	Charcoal rot	Pe (Farr *et al.* 2009)	ACT, NSW, NT, Qld., SA, Vic., and WA (APPD 2009)	No
Maireina marginata (McAlpine) W.B. Cooke [Agaricales: Tricholomataceae]	Twig blight	Pe (Farr and Rossman 2009)	No records	Yes
Monilinia fructicola (G. Wint.) Honey Anamorph: *Monilia* sp. [Helotiales: Sclerotiniaceae]	Blossom and twig blight; Gummosis; Fruit and hull rot; Brown rot	N, Pe, Pl (APHIS 2002b) A, N, Pe, Pl (Farr and Rossman 2009)	Yes. ACT, NSW, Qld, SA, Tas., Vic., WA (APPD 2009) SA (Cook and Dubé 1989)	No
Monilinia fructigena Honey in Whetzel Anamorph: *Monilia fructigena* Pers.:Fr. [Heliotales: Sclerotiniaceae]	Brown rot;	Old reports of this pathogen exist (Farr and Rossman 2009), but are considered to be misidentifications of *M. fructicola*. Not known from California or the Pacific Northwest.	No records	No
Monilinia laxa (Aderhold & Ruhland) Honey Synonyms: *Monilia cinerea* Bonord. [Helotiales: Sclerotiniaceae]	Blossom and twig blight; Gummosis; Brown rot; Fruit rot	N, Pe, Pl (APHIS 2002b) A, N, Pe, Pl (Farr and Rossman 2009)	Yes. ACT, NSW, Qld, SA, Tas., Vic., WA (APPD 2009) Present in WA	No
Mucor plumbeus Bonord. [Mucorales: Mucoraceae]		A, Pe (Michailides 1991)	WA and Qld. (APPD 2009)	No

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (Apricot, Nectarine, Peach, Plum)	Presence in Australia	Consider Further ?
Mucor circinelloides Tiegh. [Mucorales: Mucoraceae]		Pe (Farr and Rossman 2009)	Yes. Qld, Vic. (APPD 2009) No *Mucor* species are listed as declared pests in List A or List B of Tasmania's Plant Quarantine Act 1997.	Yes (WA)
Mucor piriformis A. Fisch. [Mucorales: Mucoraceae]	Fruit rot	Pe (APHIS 2002b) A, Pe, Pl (Farr and Rossman 2009)	Yes. Qld, Vic. (APPD 2009) No *Mucor* species are listed as declared pests in List A or List B of Tasmania's Plant Quarantine Act 1997.	Yes (WA)
Mucor racemosus Fresen. [Mucorales: Mucoraceae]	Storage rot	A, N, Pl (Farr and Rossman 2009)	Yes. ACT, NSW, Vic. (APPD 2009) No *Mucor* species are listed as declared pests in List A or List B of Tasmania's Plant Quarantine Act 1997.	Yes (WA)
Nectria cinnabarina (Tode:Fr.) Fr. Anamorph: *Tubercularia vulgaris* Tode:Fr. [Hypocreales: Nectriaceae]	Twig blight; Dieback; Coral spot fungus	A, Pe (Farr and Rossman 2009)	Yes. Qld, Tas., Vic. (APPD 2009) No records for WA,	Yes (WA)
Neoscytalidium dimidiatum (Penz.) Crous & Slippers [Botryosphaeriales: Botryosphaeriaceae]	Gummosis	A, Pe (Farr and Rossman 2009) as *Hendersonula toruloidea*	WA (APPD 2009) as *Scytalidium, dimidiatum* Qld. (APPD 2009) as *Torula dimidiata*	No.
Ophiostoma californicum (DeVay, R.W. Davidson & W.J. Moller) Georg Hausner, J. Reid & Klassen [Ophiostomatales: Ophiostounaceae]		Pl (Farr and Rossman 2009) as *Ceratocystis californica*	No records	Yes
Oxyporus corticola (Fr. :Fr.) Ryvarden [Basidiomycetes: Hymenochaetales]	White rot	Pe (Adaskaveg and Ogawa 1990) A (Ogawa *et al.* 2003)	References to occurrences in Australia exist (May *et al.* 2009)	Yes
Oxyporus similis (Bres.) Ryvarden [Basidiomycetes: Hymenochaetales]	White rot	Pe (Adaskaveg and Ogawa 1990)	No records.	Yes

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Passalora circumcissa (Sacc.) U. Braun Teleomorph: *Mycosphaerella cerasella* Aderhold [Mycosphaerellales: Mycosphaerellaceae]	Cercospora leaf spot; Shot hole; Leaf spot	Pl (APHIS 2002b)	Yes. NSW, Qld, SA, Vic. (APPD 2009) *Mycosphaerella cerasella* NT, Qld (APPD 2009) No records for WA. *Passalora circumcissa* is not listed as a declared pest in List A or List B of Tasmania's Plant Quarantine Act 1997.	Yes (WA)
Penicillium expansum Link [Anamorphic Trichocomaceae]	Penicillium fruit rot; Blue mould; Soft rot; Storage rot	A, Pl (Farr and Rossman 2009)	Yes. NSW, Qld, Vic., WA (APPD 2009) SA (Cook and Dubé 1989) Tas.(Sampson and Walker 1982) WA (Shivas 1989)	No
Pestalotia laurocerasi Westend. [Ascomycetes: Xylariales]		A (Farr and Rossman 2009)	No records	Yes
Phanerochaete arizonica Burdsall & R.L. Gilbertson [Meruliales: Phanerachaetaceae]	White rot	Pe (Farr and Rossman 2009)	No records	Yes
Phanerochaete velutina (DC. :Fr.) P. Karst. [Basidiomycetes: Polyporales]		P(Adaskaveg and Ogawa 1990)	No records.	Yes
Phoma pomorum Thuem. var. *pomorum* [Anamorphic Leptosphaeriaceae]	Scurfy bark; Leaf spot; Phoma fruit spot; Shot-hole spot	A, Pe, Pl, N. Present in Washington (Farr and Rossman 2009)	Yes. NSW, Qld, SA, Vic., WA (APPD 2009) Tas. (Sampson and Walker 1982) as *Phoma* sp.	No
Phomopsis prunorum (Cooke) Grove [Diaporthales: Diaporthaceae]		Pl (Farr and Rossman 2009)	NSW, Qld., SA, Tas., and WA (APPD 2009) as *P. mali*	No
Phyllactinia guttata (Wallr. :Fr.) Lév. [Erysiphales: Erysiphaceae]	Powdery mildew	A (Farr and Rossman 2009)	No records	Yes
Phyllosticta circumscissa Cooke [Botryosphaeriales: Botryosphaeriaceae]		A, Pe, Pl (Farr and Rossman 2009)	No records	Yes

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Phymatotrichopsis omnivora (Duggar) Hennebert [Pezizales: Rhizinaceae]	Root rot	Prunus (Farr *et al.* 1989)	No records	Yes
Plicaturopsis crispa (Pers.:Fr.) D. Reid [Polyporales: Atheliaceae]		Pl (Farr and Rossman 2009) as *Trogia crispa*	Yes. Qld., Vic. (May and Wood 1997). *Plicaturopsis crispa* is not listed as a declared pest in List A or List B of Tasmania's Plant Quarantine Act 1997.	Yes (WA)
Podosphaera clandestina (Wallr.:Fr.) Lév. Anamorph: *Oidium crataegi* Grognot. [Erysiphales: Erysiphaceae]	Hawthorne powdery mildew	Pe, Pl (APHIS 2002b) A (APHIS 2006a)	Yes. Recorded in NSW, Tas., and Vic., on *Cretaegus* spp. (APPD 2009) and from WA under the synonym *P. oxyacanthae* on *Malus sylvestris* and *Pyrus communis* (Shivas 1989). North American strain not present in Australia.	Yes
Podosphaera leucotricha (Ellis & Everh.) E.S. Anamorph: *Oidium mespili* Cooke [Erysiphales: Erysiphaceae]	Apple powdery mildew	Pe (APHIS 2002b; Farr and Rossman 2009)	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2009)	No
Podosphaera pannosa (Wallr.) de Bary Anamorph: *Oidium leucoconium* Desmaz. [Erysiphales: Erysiphaceae]	Rose powdery mildew	N, Pe (APHIS 2002b) Prunus (Farr *et al.* 1989) A (APHIS 2006a)	Yes. All states and territories (APPD 2009)	No
Podosphaera tridactyla (Wallr.) de Bary Anamorph: *Oidium passerinii* G. Bertol. [Erysiphales: Erysiphaceae]	Cherry powdery mildew	A (Farr and Rossman 2009)	Yes. ACT, NSW, SA, Tas., Vic. (APPD 2009) Qld (Simmonds 1966) No records for WA,	Yes (WA)
Rhizoctonia solani Kühn Teleomorph: *Thanatephorus cucumeris* (A.B. Frank) Donk [Ceratobasidiales: Ceratobasidiaceae]	Thread blight; Damping-off; Root rot	Pe, Pl (APHIS 2002b)	Yes. ACT, NSW, Qld, SA, Tas., Vic., WA (APPD 2009) *Thanatephorus cucumeris* NSW, NT, Qld, SA, Tas., Vic. (APPD 2009)	No

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Rhizopus stolonifer (Ehrenb.:Fr.) Vuill. [Mucorales: Mucoraceae]	Rhizopus rot; Post-harvest decay of fruit; Soft rot; Coryneum blight	Pl (APHIS 200b) A, Pe, Pl (Farr and Rossman 2009)	Yes. NSW, NT, Qld, Vic., WA (APPD 2009) SA (Cook and Dubé 1989) Tas. (Sampson and Walker 1982) WA (DAWA 2006)	No
Rhodosticta quercina J.C. Carter [Anamorphic Phyllachoraceae]	President plum canker	Pl (APHIS 2002b; Farr and Rossman 2009)	No records	Yes
Schizophyllum commune Fr.:Fr. [Agaricales: Schizophyllaceae]	Wood rot; Wound rot	Pe (APHIS 2002b) A (APHIS 2006a)	Yes. NSW, NT, Qld, SA, Vic., WA (APPD 2009) Tas. (Sampson and Walker 1982)	No
Schizothyrium pomi (Mont. & Fr.) Arx Anamorph: *Zygophiala jamaicensis* E. Mason [Dothideales: Schizothyriaceae]	Fly speck on fruits & twigs	Pe (Farr and Rossman 2009) as *Leptothyrium pomi.*	Yes. NSW (APPD 2009) Qld (Simmonds 1966) NSW, WA under the synonym *Leptothyrium pomi* (APPD2009; Shivas 1989). *Schizothyrium pomi* is not listed as a declared pest in List A or List B of Tasmania's Plant Quarantine Act 1997.	No
Sclerotinia sclerotiorum (Lib.) de Bary [Helotiales: Sclerotiniaceae]	Blossom blight; Green fruit rot	Pe (APHIS 2002b) A, Pe (Farr and Rossman 2009)	Yes. ACT, NSW, Qld, SA, Tas., Vic., WA (APPD 2009) Vic. (Washington and Nancarrow 1983) WA (DAWA 2006)	No
Sistotrema brinkmannii (Bres.) J. Erikss. [Polyporales: Sistotremataceae]	No common name but usually associated with wood	Pe (Farr and Rossman 2009)	Reported from SA (Warcup & Talbot 1962), but considered to be a complex species with different forms that are difficult to separate. Considered further due to uncertainties associated with the record.	Yes

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Stereum hirsutum (Willd.:Fr.) S.F.Gray [Stereales: Stereaceae]	White rot	Pe, Pl (Farr and Rossman 2009)	Yes. NSW, Qld, SA, Vic., WA (APPD 2009)	No
Stereum ochraceoflavum (Schwein.) Ellis [Russulales: Stereaceae]		A (SBML 2009)	Yes. NSW, Vic. (APPD 2009) as *Stereum vellereum*.	Yes (WA)
Stigmina carpophila (Lév.) M.B. Ellis [Anamorphic Pothidiaceae]	Shot hole disease; Stone fruit gumspot; Shot-hole disease	N, Pe, Pl (APHIS 2002b) A, N, Pe, Pl (Farr and Rossman 2009)	Yes. ACT, NSW, Tas., Vic., WA (APPD 2009) WA (Shivas 1989)	No
Taphrina deformans (Berk.) Tul. [Taphrinales: Taphrinaceae]	Peach leaf curl	N, Pe (APHIS 2002b) A, N, Pe, Pl (Farr and Rossman 2009)	Yes. ACT, NSW, Qld, SA, Tas., Vic., WA (APPD 2009) WA (Shivas 1989)	No
Taphrina pruni Tul. [Taphrinales: Taphrinaceae]	Leaf blister; Plum pockets; Bladder plum	Pl (APHIS 2002b) A, Pl (Farr and Rossman 2009)	Yes. NSW (APPD 2009) Vic. (Washington and Nancarrow) No records for WA. *Taphrina pruni* is not listed as a declared pest in List A or List B of Tasmania's Plant Quarantine Act 1997.	Yes (WA)
Taphrina pruni-subcordatae (Zeller) Mix [Taphrinales: Taphrinaceae]	Witches' broom	Pl (Farr and Rossman 2009)	No records	Yes
Trametes hirsuta (Wulfen:Fr.) Lloyd [Polyporales: Polyporaceae]	White rot	A, Pe (Farr and Rossman 2009)	Yes. NSW, Qld. (APPD 2009) WA under its synonym *Coriolis velutinus* (Poole 2006)	No
Trametes versicolor (L.:Fr.) Lloyd [Polyporales: Polyporaceae]	White rot; Heart rot	A, Pe, Pl (Farr and Rossman 2009)	Yes. ACT, NSW, Qld, Tas., Vic., WA (APPD 2009)	No

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Tranzschelia discolor f.sp. *domesticae* Bolkan, J.M. Ogawa, Michailides & Kable [Uropyxidiaceae: Uropyxidiaceae]	Prune leaf rust	Pl (Farr and Rossman 2009)	Yes. The Australian plant pest database only record this pathogen to species level, but it has been recorded from apricot, peach and plum. The separate *formae speciales* are recognised by the host they are isolated from, with *T. discolour* f.sp. *domesticae*, affecting plums (Bolkan *et al.* 1985; Adaskaveg *et al.* 2000) Therefore this *formae speciales* is considered to be present in Australia and is considered non-quarantinable.	No
Tranzschelia discolor (Fuckel) Tranzschel & Litv. f. sp. *persica* Bolkan, Ogawa, Michaelides & Kable [Uredinales: Uropyxidiaceae]	Rust	N, Pe, Pl (APHIS 2002b) Pe (Farr and Rossman 2009) A (APHIS 2006a)	Yes. ACT, NSW, NT, Qld, SA, Tas., Vic., WA (APPD 2009)	No
Tranzschelia pruni-spinosae (Pers.:Pers.) Dietel [Uredinales: Uropyxidiaceae]	Rust	A, Pe, Pl (Farr and Rossman 2009) Host of telial stage (Heteroecious)	Yes. SA, Vic. (APPD 2009) as *Puccinia pruni-spinosae* Tas. (Sampson and Walker 1982) as *Tranzschelia discolor* WA (Shivas 1989)	No
Trichothecium roseum (Pers.:Fr.) Link [Anamorphic Bionectriaceae]	Pink fruit rot; Pink mould fruit rot	Pe (APHIS 2002b; Farr and Rossman 2009)	Yes. ACT, NSW, Qld, SA, Vic., WA (APPD 2009) SA (Cook and Dubé 1989) WA (Shivas 1989) Not listed as a regional quarantine pest for Tasmania under the Plant Quarantine Act Section 10.	No
Tyromyces galactinus (Berk.) J. Lowe [Polyporales: Polyporaceae]		Pl (Farr and Rossman 2009) as *Polyporus galactinus*	No records	Yes

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Valsa ceratosperma (Tode :Fr.) Maire [Diaporthales: Valsaceae]	Canker	Prunus (Farr *et al.* 1989)	Yes. ACT, NSW, Tas. (APPD 2009)	Yes (WA)
Valsaria insitiva (Tode) Ces. & De Not. Anamorph: *Cytospora cincta* Sacc. [Diaporthales: Valsaceae]	Perennial canker of peach; Canker; Dieback	Pe, Pl (Farr and Rossman 2009) A (APHIS 2006a)	Yes. NT (APPD 2009) *Leucostoma cincta* NSW, Vic. (APPD 2009) No records for WA. *Valsaria insitiva* is not listed as a declared pest in List A or List B of Tasmania's Plant Quarantine Act 1997.	Yes (WA)
Verticillium albo-atrum Reinke & Berthier [Anamorphic Phyllachorales]	Verticillium wilt	A, Pe, Pl (Farr and Rossman 2009)	Yes. Qld., SA, Tas., Vic. (APPD 2009)	Yes (WA)
Verticillium dahliae Kleb. [Anamorphic Phyllachorales]	Verticillium wilt	N, Pe, Pl (APHIS 2002b) A, N, Pe, Pl (Farr and Rossman 2009)	Yes. ACT, NSW, Qld, SA, Tas., Vic., WA (APPD 2009)	No
PHYTOPLASMAS				
Candidatus Phytoplasma pruni	X-disease	N, Pe, Pl (APHIS 2002b) A (APHIS 2006a)	No records	Yes
Candidatus Phytoplasma ulmi	Peach yellows	Pe (CDFA 2006)	No records	Yes
STRAMINOPILA				
Phytophthora cactorum (Lebert & Cohn) Schröt. [Peronosporales: Pythiaceae]	Crown & root rot	N, Pe, Pl (APHIS 2002b) A, N, Pe, Pl (Farr and Rossman 2009)	Yes. ACT, NSW, Qld., SA, Tas., Vic., WA (APPD 2009)	No
Phytophthora cambivora (Petri) Buisman [Peronosporales: Pythiaceae]	Crown & root rot	N, Pe, Pl (APHIS 2002b) A, N, Pe, Pl (Farr and Rossman 2009)	Yes. NSW, Qld., SA, Vic., WA (APPD 2009)	No
Phytophthora cinnamomi Rands [Peronosporales: Pythiaceae]	Crown & root rot	A, Pe (Farr and Rossman 2009)	Yes. ACT, NSW, NT, Qld., SA, Tas., Vic., WA (APPD 2009)	No

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Phytophthora citricola Sawada [Peronosporales: Pythiaceae]	Crown & root rot	A, Pe (Farr and Rossman 2009)	Yes. NSW, SA, Vic., and WA (APPD 2009; DAWA 2006)	No
Phytophthora citrophthora (R.E. Sm. & E.H. Sm.) Leonian [Peronosporales: Pythiaceae]	Crown & trunk canker	Pe (APHIS 2002b) A, Pe (Farr and Rossman 2009)	Yes. ACT, NSW, Qld., SA, Vic., WA (APPD 2009) Qld (Simmonds 1966) Tas. (Sampson and Walker 1982)	No
Phytophthora cryptogea Pethybr. & Lafferty [Peronosporales: Pythiaceae]	Crown & root rot	Pe (APHIS 2002b) A, Pe (Farr and Rossman 2009)	Yes. ACT, NSW, Qld., SA, Tas., Vic., WA (APPD 2009)	No
Phytophthora megasperma Drechs. [Peronosporales: Pythiaceae]	Crown & root rot	Pe, Pl (APHIS 2002b) A, Pe, Pl (Farr and Rossman 2009)	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2009) WA (Shivas 1989)	No
Phytophthora syringae (Kleb.) Kleb. [Peronosporales: Pythiaceae]	Canker; Brown rot; Crown & root rot	Pe (APHIS 2002b) A, Pe (Farr and Rossman 2009)	Yes. NSW, Vic. (APPD 2009) SA (Cook and Dubé 1989) No records for WA,	Yes (WA)
Pythium sylvaticum W.A. Campb. & J.W. Hendrix [Pythiales: Pythiaceae]		Pe (Farr and Rossman 2009)	No records	Yes
Pythium ultimum Trow [Peronosporales: Pythiaceae]	Damping-off	Pe (Farr and Rossman 2009)	Yes. ACT, NSW, NT, Qld., SA, Tas., Vic., WA (APPD 2009) Qld (Simmonds 1966) WA (Shivas 1989)	No
VIROIDS				
Apple scar skin viroid		Present in Washington State (CABI 2009). Apricot (Zhao and Niu 2008a) and peach (Zhao and Niu 2008b) are known hosts.	No records	Yes
Peach latent mosaic viroid	Peach blotch Peach calico	N, Pe, (APHIS 2002b)	Yes. SA First report of this viroid in an Australian orchard (Di Serio *et al.* 1999) No records for WA,	Yes (WA)

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
VIRUSES				
American plum line pattern virus ICTV 00.010.0.02.002	APLPV	Pl, Pe (CABI 2007; Nemeth 1986)	No records	Yes
Apple chlorotic leaf spot trichovirus ICTV 76.0.1.0.001 Synonyms: Pear ring pattern mosaic virus (Cropley, 1969) Apple latent virus type 1 Plum pseudopox virus	ACLS Apple chlorotic leaf spot	Peach is susceptible (Brunt *et al.* 1996) and this virus has been detected in California (CDFA 2006) although not on *Prunus* spp.	Yes. Qld, Tas., Vic. (APPD 2009) Widespread (Constable *et al.* 2007)	No
Apple mosaic ilarvirus ICTV 10.0.2.03.01 Synonyms: European plum line pattern virus Dutch plum line pattern virus Hop A virus	ApM Apple mosaic	Pl (CDFA 2006)	Yes. Qld, SA, Vic., WA (APPD 2009). Widespread (Constable *et al.* 2007)	No
Apple stem pitting virus ICTV 79.0.P.DE.02	ASP Apple stem pitting;	A, Pe (CDFA 2006)	Yes. Qld, SA, Tas., Vic., WA (APPD 2009). Widespread (Constable *et al* 2007)	No
Apricot ring pox Synonyms: Apricot pit pox	Cherry twisted leaf; Apricot ring spot	Pe (APHIS 2002b) A (APHIS 2006a) There is some literature suggesting that this may be a synonym of apple stem pitting, but the available information was considered insufficient to confirm the synonymy. Therefore, this disease has been considered separately.	Yes. NSW (APPD 2009) Vic. (Washington and Nancarrow 1983). Apricot ring pox is not listed as a declared pest in List A or List B of Tasmania's Plant Quarantine Act 1997.	Yes (WA)
Asteroid spot virus Synonym: Peach asteroid spot agent		N, Pe, (APHIS 2002b)	No records	Yes

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Cherry green ring mottle virus		A, N, Pe (CABI 2009)	Yes, but no distribution data (CABI 2009)	Yes
Cherry mottle leaf virus ICTV 76.0.1.T.DE.1 Synonym: Prunus virus 1		Pe (APHIS 2002b) N, Pe (CDFA 2006) Apricot and peach are considered susceptible (Brunt *et al.* 1996).	Yes. NSW (APPD 2009) No records for WA,	Yes (WA)
Cherry rasp leaf virus ICTV 18.0.3.T.003 Synonym: Flat apple virus	Cherry rasp leaf	Pe (APHIS 2002b; CDFA 2006)	There only two records in the Australian Plant Pest Database, NSW and Tasmania (APPD 2009). Listed as present in Australia (Büchen-Osmond *et al.* 1988). However, these specimens are believed to be based on symptoms that may have been caused by other viruses (Büchen-Osmond *et al.* 1988, Priest pers. comm. 28 Sept 2009). There is therefore doubt that this virus is correctly reported from Australia.	Yes
Cherry rusty mottle virus		A, Pe, Pl (Nemeth 1986; Mink 1995a)	No records	Yes
Cherry virus A		A, Pe, Pl (Barone and Alioto 2006; Svanella-Dumas *et al* 2005)	No records	Yes
Peach mosaic virus	Peach mosaic	N (APHIS 2002b) A (APHIS 2006a)	No records	Yes
Peach mule's ear Synonym: Almond bud failure		N, Pe (APHIS 2002b)	No records	Yes
Peach stubby twig virus		N, Pe (APHIS 2002b)	No records	Yes

Scientific Name	Common Name(s)	Association with stone fruit production in California, Idaho, Oregon or Washington (**A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	Presence in Australia	Consider Further ?
Peach wart virus Synonym: Peach blister virus		Pe (APHIS 2002b; CDFA 2006)	No records	Yes
Plum pox virus ICTV 57.0.1.0.054 *Prunus* virus 7 Sharka virus	Sharka; Plum pox	Recorded from Pennsylvania, New York State and Michigan. California and the Pacific Northwest are believed to be free of this virus.	No records	Yes
Prune dwarf virus ICTV 10.0.2.04.01 Synonyms: Peach stunt virus Cherry chlorotic ringspot virus Sour cherry yellows virus	Prune dwarf	N, Pe, Pl (APHIS 2002b) A, N, Pe, Pl (CDFA 2006)	Yes. NSW (APPD 2009) NSW, SA, Vic., WA (Büchen-Osmond *et al.* 1988) SA (Cook and Dubé 1989) Not listed as a regional quarantine pest for Tasmania under the Plant Quarantine Act Section 10.	No
Prunus diamond canker virus		Pe (APHIS 2002b)	No records	Yes
Prunus necrotic ringspot virus ICTV 10.0.2.03.02 European plum line pattern virus Hop B virus Hop C virus Peach ringspot virus Plum line pattern virus Prunus ringspot virus	Prunus necrotic ringspot	N, Pe, Pl (APHIS 2002b) A, N, Pe, Pl (CDFA 2006)	Yes. NSW, Qld., SA, Vic., WA (Büchen-Osmond *et al.* 1988) NSW, Tas (APPD 2009) SA (Cook and Dubé 1989)	No

Scientific Name	**Common Name(s)**	**Association with stone fruit production in California, Idaho, Oregon or Washington** **(A**pricot, **N**ectarine, **Pe**ach, **Pl**um)	**Presence in Australia**	**Consider Further ?**
Tobacco necrosis viruses: *Chenopodium necrosis virus* *Olive mild mosaic virus* *Tobacco necrosis virus A* *Tobacco necrosis virus D* *Tobacco* necrosis virus Nebraska isolate		Presence in the US: Probably in every state but species and strain distributions are largely unknown. Records in CA, IL, NE, NY, OR, UT, WI (Babos and Kassanis 1963; Grogan and Uyemoto 1967; Uyemoto and Gilmer 1972; APHIS 2007b; CABI 2009). Widely prevalent in OR (APHIS 2007b). Occurs in fruit trees in the US (Nemeth 1986). Isolated from apricot. Trees infected with Tobacco necrosis viruses show no symptoms (Uyemoto and Gilmer 1972)	Yes. Viruses likely to be strains of tobacco necrosis viruses A and D have been recorded in Vic. and Qld (Findlay and Teakle 1969; Teakle 1988). Tobacco necrosis virus Nebraska isolate has not been recorded in Australia, nor have other tobacco necrosis viruses that have since been renamed or have not yet been formally recognised (Tomlinson *et al*. 1983; Zhang *et al*. 1993; Cardoso *et al*. 2005; NCBI 2009).	Yes
Tomato ringspot nepovirus 18.0.3.0.029 Synonyms: Peach yellow bud mosaic virus Prune brown line Prunus stem pitting	Tomato ringspot	N, Pe, Pl (APHIS 2002b) A (APHIS 2006a)	Yes. SA (Cook and Dubé 1989). *Tomato ringspot nepovirus* is not listed as a declared pest in List A or List B of Tasmania's Plant Quarantine Act 1997.	Yes (WA)

Table A2: Association of stone fruit pests that are absent from Australia with the import pathway

Scientific Name	**Common Name(s)**	**Is the pest likely to be associated with mature, fresh harvested fruit?**	**Consider Further ?**
ACARI (Mites)			
Diptacus gigantorhynchus (Nalepa, 1892) [Acari: Eriophyidae]	Big-beaked plum mite	No. *Diptacus gigantorhynchus* is an eriophyid mite that feeds on new leaves causing withering and silvering. High densities may affect photosynthesis (Bentley *et al.* 2009g). There are no reports that this mite causes damage to the fruit or is found on the fruit.	No
Eotetranychus carpini (Oudemans, 1905) [Acari: Tetranychidae]	Yellow spider mite	No. Eggs are laid among the webbing, primarily on the lower leaf surfaces (Jeppson *et al.* 1975). Feeding occurs on the undersurface of leaves, primarily along the veins, and not fruit (Jeppson *et al.* 1975).	No
Eotetranychus pruni (Oudemans, 1931) [Acari: Tetranychidae]		No. Eggs are laid among the webbing, primarily on the lower leaf surfaces (Jeppson *et al.* 1975). Feeding occurs on the undersurface of leaves, primarily along the veins, and not fruit (Jeppson *et al.* 1975).	No
Eriophyes insidiosus (Keifer & Wilson, 1955) [Acari: Eriophyidae]	Peach bud mite	No. *Eriophyes insidiosus* survives only within vegetative buds where it feeds and reproduces between closely adhering bud scales (Gispert *et al.* 1998). *Eriophyes insidiosus* reproduces only in the buds of its hosts (Gispert *et al.* 1997). Normally limited to adventitious buds on the trunk or lower branches (EPPO/CABI 1997l). In California, it is recorded from flowering peaches in a few areas of the San Joaquin Valley (Oldfield 1970).	No
Tarsonemus smithi Ewing, 1939 [Acari: Tarsonemidae]	Tarsonemid mite	Yes. *Tarsonemus* spp. are fungi feeders, often associated with sooty moulds on fruit and are often present around the stem or calyx of fruit. *Tarsonemus smithi* has been intercepted on stone fruit from New Zealand (DAFF 2003).	Yes
Tetranychus canadensis (McGregor, 1950) [Acari: Tetranychidae]	Four-spotted spider mite	Yes. Tetranychid mites are principally leaf feeders, with most species in this genus preferring the underside of leaves. Evidence of feeding includes mottling of leaves and in some cases silken webbing, though some *T. canadensis* is considered to produce very little webbing (Jeppson *et al.* 1975). However, some species are recorded occasionally fruit, including the detection of *T. pacificus* during packing house sampling (Curtis *et al.* 1992). While fruit infestation appears to be uncommon, if population densities are high then mites may be associated with fruit. Tetranychid mites have also been intercepted on imported stone fruit from New Zealand (DAFF 2003), suggesting that these mites may be imported on US stone fruit.	Yes
Tetranychus mcdanieli McGregor, 1931 [Acari: Tetranychidae]	McDaniel spider mite		Yes
Tetranychus pacificus (McGregor, 1919) [Acari: Tetranychidae]	Pacific spider mite		Yes
Tetranychus turkestani Ugarov & Nikolski, 1937 [Acari: Tetranychidae]	Strawberry spider mite		Yes
COLEOPTERA (Beetles, Weevils)			
Adaleres ovipennis Casey, 1895 [Coleoptera: Curculionidae]	Weevil	No. Primary hosts are oak and California lilac (*Ceanothus*), but can be destructive to buds and leaves. Fruit are not mentioned (Beers *et al.* 2003).	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Agriotes lineatus (Linnaeus, 1767) [Coleoptera: Elateridae]	Lined click beetle	No. Larvae inhabit the soil and feed on seeds, plant roots and general organic material (LaGasa *et al.* 2001). Not associated with tree fruit. *Agriotes lineatus* larvae eat underground parts of carrot, hop, tomato, onion, leek, chicory, lettuce, broad bean, ornamental plants or young trees (INRA 2006).	No
Ambrosiodmus rubricollis (Eichhoff, 1875) [Coleoptera: Scolytidae]	Bark beetle	No. Ambrosia beetles are cryptic species that spend their entire life, excepting a short flight period, inside woody stems (Coyle *et al.* 2005). *Ambrosiodmus rubricollis* is found in boles and stumps of trees in US (Wood 1982)	No
Ambrosiodmus tachygraphus (Zimmermann, 1868) [Coleoptera: Scolytidae]	Bark beetle	No. Ambrosia beetles are cryptic species that spend their entire life, excepting a short flight period, inside woody stems (Coyle *et al.* 2005). *Ambrosiodmus tachygraphus* is found in stems and tree branches 3–5 cm in diameter (Wood 1982).	No
Amotus setulosus (Schönherr, 1847) [Coleoptera: Curculionidae]	Weevil	No. Considered as one of the most injurious bud weevils, hollowing out buds and feeding on pruning cuts (Beers *et al.* 2003).	No
Anametis granulata (Say, 1831) [Coleoptera: Curculionidae]	Gray snout beetle	No. Damages buds and bark of peach trees (Beers *et al.* 2003).	No
Anthonomus quadrigibbus Say, 1831 [Coleoptera: Curculionidae	Apple curculio (weevil)	No. While records exist of this pest being associated with stone fruit in Washington (Beers *et al.* 2003), this is primarily an apple pest that is also reported to attack pears and wild Prunus hosts such as sour cherries (EPPO/CABI 1997m). The records cited by Beers (Beers *et al.* 2003) are historical and there are no modern reports for this species being associated with the stone fruit species in California, the Pacific Northwest, or the wider US.	No
Carpophilus freemani Dobson, 1856 [Coleoptera: Nitidulidae]	Dried fruit beetle	No. There is limited literature available on this species. *Carpophilus* species are attracted to and penetrate ripening fruit, causing rapid breakdown (Hely *et al.* 1982). Dried fruit beetles primarily infest decaying and dried fruit but some species in this genus are known to attack ripe fruit also. *Carpophilus freemani* may be associated with the development of brown rot of stone fruits in California from June to August, but were not recorded to be attracted to uninjured healthy fruit (Tate and Ogawa 1975).	No
Cercopedius artemisiae (Pierce, 1910) [Coleoptera: Curculionidae]	Lesser sagebrush weevil	No. Associated with bud injury and also found feeding on sap at newly cut shoots. Drops to the ground when disturbed (Beers *et al.* 2003).	No
Chrysobothris femorata (Oliver, 1790) [Coleoptera: Buprestidae]	Flat headed apple tree borer	No. Flatheaded borers are attracted to diseased or injured limbs, where the larvae excavate caverns beneath the bark and bore tunnels into the cambium tissue. Adults lay eggs directly onto injured or weakened areas of the tree (Pickel *et al.* 2006i).	No
Chrysobothris mali Horn, 1886 [Coleoptera: Buprestidae]	Pacific flatheaded borer	No. Flatheaded borers are attracted to diseased or injured limbs, where the larvae excavate caverns beneath the bark and bore tunnels into the cambium tissue. Adults lay eggs directly onto injured or weakened areas of the tree (Pickel *et al.* 2006i).	No
Cleonidius canescens (LeConte, 1875) [Coleoptera: Curculionidae]	Weevil	No. Considerable numbers recorded on buds in early 1900's (Beers *et al.* 2003). Peach is not a major host and damage has only been recorded in new tree plantings.	No
Coccotorus scutellaris (LeConte, 1858) [Coleoptera: Curculionidae]	Plum gouger	No. This species is reported to attack fruit and plum is included as a potential host (Beers *et al.* 2003). However, the references provided by Beers *et al.* (2003) list historical records that note this species as a potential pest of apples and cherries. Based on this and the absence of recent records of this pest, it is unlikely that this pest will be associated with exported stone fruit.	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Conotrachelus anaglypticus (Say, 1831) [Coleoptera: Curculionidae]	Cambium curculio	No. Larvae feed under the bark of fruit trees. However adults may oviposit in fruit if the fruit has been previously damaged (Beers *et al.* 2003). However, the reference for this pest (Brooks 1924) does not provide specific reports for the relevant states and damaged fruit will be removed during grading operations. It is unlikely that this pest, if present, would follow the pathway.	No
Conotrachelus nenuphar (Herbst, 1797) [Coleoptera: Curculionidae]	Apple curculio; plum curculio	No. Reported by Beers *et al.* (2003) to be a pest of stone fruit and while recorded from Washington, it is not considered a pest in that state. Both the Californian and the Washington state departments report that this pest is not known from their respective states (APHIS 2007a) and this is supported by the European Plant Protection (EPPO/CABI 1997n) data sheet that refer to this pest as being only east of the Rocky Mountains. Damaged fruit has distinctive and serious damage and usually drops prematurely (Campbell *et al.* 1989).	No
Cotinis mutabilis (Gory & Percheron, 1833) [Coleoptera: Scarabaeidae]	Peach beetle	No. Reported to be a pest of fruit in California (Stone 1982). Adults may occasionally be found feeding on already damaged fruit, while eggs are laid in rotting vegetation and compost (Faulkner 2006). Only adult beetles are considered to have any association with fruit and, due to their large size, would be dislodged during harvesting operations. Fruit susceptible to attack, particularly over-ripe or damaged fruit, would not be included in exported fruit.	No
Cotinis nitida (Linnaeus, 1764) [Coleoptera: Scarabaeidae]	Green June beetle	No. Principally a turf pest, where larvae feed on roots. However, adults may also attack fruit such as peaches (Flanders and Cobb 2000), showing a preference for overripe fruits. Not associated with mature, harvested fruit as the large adults would be disturbed and dislodged during harvest.	No
Dyslobus nigrescens (Pierce, 1913) [Coleoptera: Curculionidae]	Weevil	No. Reported to destroy buds of young peach and apple trees (Beers *et al.* 2003).	No
Elaphidionoides villosus (Fabricius, 1792) Synonym: *Anelaphus villosus* Fabricius [Coleoptera: Cerambycidae]	Twig pruner	No. Flowering fruit trees are considered a common host. Adult females chew and girdle small twigs. Oviposition occurs in the girdled area and the developing larvae feeds inside the dead section of twig (Barrett 2001). Not known to damage, or be present on, fruit.	No
Epicaerus imbricatus (Say, 1824) [Coleoptera: Curculionidae]	Imbricated snout beetle	No. It is reported that adults gnaw at twigs and fruit, injuring buds and newly forming fruit (Beers *et al.* 2003), but the references cited by Beers do not make any mention of mature fruit being attacked. Other sources cited by Beers and describing this species mention only damage to grasslands, ground crops, some berries and occasionally apple buds. Adults feed on foliage, buds or stems and larvae live in the roots or stems of its hosts.	No
Magdalis aenescens LeConte, 1876 [Coleoptera: Curculionidae]	Bronze appletree weevil	No. Associated with the canker of stems and trunks of apple trees. Also associated with injured trees (Beers *et al.* 2003).	No
Magdalis gracilis (LeConte, 1857) [Coleoptera: Curculionidae]	Black fruit tree weevil	No. Recorded as damaging plum foliage only (Beers *et al.* 2003).	No
Melalgus confertus (LeConte, 1856) [Coleoptera: Bostrichidae]	Prune branch borer	No. Eggs are laid on dead wood where larvae feed. Adults bore into small twigs and branches. Not associated with healthy plants and not commonly found on prunes (Pickel *et al.* 2006e).	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Monarthrum fasciatum (Say, 1826) [Coleoptera: Scolytidae]	Peach bark beetle	No. Scolytids are bark beetles that build galleries in woody material, specifically trunks. *Monarthrum fasciatum* attacks unthrifty, injured, or recently cut limbs larger than about 10 cm in diameter (Wood 1982)	No
Omias saccatus (LeConte, 1857) [Coleoptera: Curculionidae]	Sagebrush weevil	No. Recorded as damaging the leaves and buds of young (<2 years) apple trees (Beers *et al.* 2003).	No
Omileus epicaeroides Horn, 1876 [Coleoptera: Curculionidae]	Weevil	No. Recorded as damaging the foliage of peach trees, while the normal host is oak (Beers *et al.* 2003).	No
Ophryastes cinerascens (Pierce, 1913) [Coleoptera: Curculionidae]	Weevil	No. Found feeding on newly planted cherry trees in Washington. Adults feed on buds of young (<2 years) trees (Beers *et al.* 2003).	No
Ophryastes geminatus (Horn, 1876) [Coleoptera: Curculionidae]	White bud Weevil	No. Sagebrush is considered the main host, but has been found attacking fruit trees in early spring (Beers *et al.* 2003). White bud weevil is not likely to be associated with mature, fresh harvested fruit	No
Otiorhynchus ligneus (Olivier, 1807) [Coleoptera: Curculionidae]	Weevil	No. *Otiorhynchus ligneus* are recorded as polyphagous and ground living (Morris 1997).	No
Otiorhynchus ovatus (Linnaeus, 1758) [Coleoptera: Curculionidae]	Strawberry root weevil	No. Principally a strawberry pest, this species is considered to be ground living and nocturnal. Eggs are laid in the soil, or on leaves near the surface of the ground. Larvae gnaw at roots, while adults feed on the foliage buds and shoots of a wider range of hosts (University of Alberta 2009).	No
Otiorhynchus singularis (Linnaeus, 1767) [Coleoptera: Curculionidae]	Clay-colored weevil	No. Eggs are deposited in soil, where larvae gnaw at roots, while adults feed on grafts, stems, buds and leaves (CABI 2007).	No
Panscopus aequalis (Horn, 1876) [Coleoptera: Curculionidae]	Weevil	No. Adults recorded as feeding on buds of 1 year old apple trees and the sap from freshly cut shoots (Beers *et al.* 2003).	No
Paraptochus sellatus (Boheman, 1859) [Coleoptera: Curculionidae]	Apricot leaf weevil	No. Feeds on buds and leaves (Beers *et al.* 2003).	No
Phloeotribus liminaris (Harris, 1852) [Coleoptera: Scolytidae]	Ambrosia beetle; Peach tree bark beetle	No. Ambrosia beetles bore into the bark and trunks of trees. There are no records of damage to, or presence on, fruit. Adults and larvae attack unhealthy, injured, or cut limbs of *Prunus* trees; adults overwinter in tunnels in healthy or injured bark of host trees (Wood 1982).	No
Pleocoma crinita Linsley, 1938 [Coleoptera: Scarabaeidae]	Rain beetle	No. *Pleocoma* larvae feed on the roots of forest and orchard trees (Reidl and Beers 2007). Adults can be longed lived, but do not feed (Reidl and Beers 2007). Females are flightless and lay eggs in their pupation burrow under the soil surface (Reidl and Beers 2007).	No
Pleocoma minor Linsley, 1938 [Coleoptera: Scarabaeidae]	Rain beetle	No. *Pleocoma* larvae feed on the roots of forest and orchard trees (Reidl and Beers 2007). Adults can be longed lived, but do not feed (Reidl and Beers 2007). Females are flightless and lay eggs in their pupation burrow under the soil surface (Reidl and Beers 2007).	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Pleocoma oregonensis Leech,1933 [Coleoptera: Scarabaeidae]	Rain beetle	No. *Pleocoma* larvae feed on the roots of forest and orchard trees (Reidl and Beers 2007). Adults can be longed lived, but do not feed (Reidl and Beers 2007). Females are flightless and lay eggs in their pupation burrow under the soil surface (Reidl and Beers 2007).	No
Polydrusus impressifrons (Gyllenhal, 1834) [Coleoptera: Curculionidae]	Leaf weevil; Pale green weevil	No. Feeds on leaves, especially margins and buds of some non-tree hosts (Beers *et al.* 2003).	No
Popillia japonica Newman, 1841 [Coleoptera: Scarabaeidae	Japanese beetle	No. Larvae feed on roots of a variety of plants. Adults feed on foliage and flowers (EPPO/CABI 1997o; Gyeltshen and Hodges 2005).	No
Pyrrhalta cavicollis (LeConte, 1856) [Coleoptera: Chrysomelidae]	Cherry leaf beetle	No. Chrysomelid beetles are leaf feeders. This species is reported to feed on young leaves (APHIS 2002a).	No
Sciopithes obscurus Horn, 1876 [Coleoptera: Curculionidae]	Obscure root weevil	No. Larvae feed on roots while adults feed on leaves causing notching (Berry 1998). Eggs are laid on the tips of leaves and the leaf is folded over and cemented in place (Berry 1998). Mostly a problem in home ornamental production.	No
Scolytus rugulosus (Müller, 1818) [Coleoptera: Curculionidae]	Shot-hole borer	No. Feeding, reproduction and development occurs in the bark and wood of twigs, branches and tree trunks of infested trees (Pennsylvania State University 2008). Not associated with the fruit.	No
Sitona californicus (Fahraeus, 1840) [Coleoptera: Curculionidae]	Weevil	No. Larval stage feeds below ground (Rudgers and Hoeksema 2003). Adults feed on leaves and young stems.	No
Stamoderes lanei (VanDyke, 1936) [Coleoptera: Curculionidae]	Weevil	No. Recorded as damaging to buds and feeding on cut shoots of cherry in a newly planted Washington block (Beers *et al.* 2003).	No
Syneta albida LeConte, 1857 [Coleoptera: Chrysomelidae]	Fruit tree leaf beetle; Western fruit beetle; Syneta leaf beetle	No. Larvae burrow into the soil where they feed on fibrous roots (Berry 1998). Adults feed on buds, blossoms and leaves and also chew on the stems of fruit resulting in fruit drop (Berry 1998). Adults may feed on developing fruit, causing scarring or deformation (Berry 1998), but are not reported on mature fruit.	No
Thricolepis inornata Horn, 1876 [Coleoptera: Curculionidae]	Small gray leaf weevil; Prune leaf weevil	No. Reported as stripping the foliage of young prune trees (Beers *et al.* 2003).	No
Xyleborus dispar (Fabricius, 1792) Synonym: *Anisandrus dispar* (Ferrari, 1867) [Coleoptera: Curculionidae]	Pear blight beetle; European shot hole borer	No. Ambrosia beetles bore into wood, especially in damaged or unhealthy trees. Principally fungal feeders, these beetles culture fungi in the bored tunnels (CABI 2007). Woody plant material is infested, not fruit. *Xyleborus dispar* attacks unthrifty or injured limbs and boles 5–20 cm in diameter or larger (Wood 1982)	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Xylosandrus crassiusculus (Motschulsky, 1866) Synonym: *Xyleborus crassiusculus* (Motschulsky, 1866) [Coleoptera: Scolytidae]	Ambrosia beetle	No. Ambrosia beetles bore into wood, especially in damaged or unhealthy trees. Principally fungal feeders, these beetles culture fungi in the bored tunnels (CABI 2007). Woody plant material is infested, not fruit. *Xylosandrus crassiusculus* attacks cut plant material ranging from twigs 1.5 cm in diameter to large logs (Wood 1982). It also attacks the root collar of newly transplanted seedlings (Wood 1982).	No
DIPTERA (Flies)			
Phytomyza persicae Frick,1954 [Diptera: Agromyzidae]	Peach leafminer	No. There is little information in the literature regarding *P. persicae.* However, feeding, reproduction and development of all life stages of other Agromyzid flies occurs in the leaves, and not reported from fruit (CABI 2007).	No
Rhagoletis completa Cresson, 1929 Synonym: *Rhagoletis suavis* (Loew) [Diptera: Tephritidae]	Walnut husk fly; Walnut husk maggot	Yes. *Rhagoletis completa* larvae usually develop in the husks of species of walnut (*Juglans* spp.) although peaches (*Prunus persica*) are attacked under certain conditions; eggs are laid below the skin of the host fruit, larvae feed inside the fruit and pupation occurs in the soil under the host plant; the pupa is the usual overwintering stage (EPPO/CABI 1997a).	Yes
Rhagoletis pomonella (Walsh, 1867) [Diptera: Tephritidae]	Apple maggot	Yes. *Rhagoletis pomonella* is a serious pest of apple but has also been recorded from Chickasaw plum (*Prunus angustifolia*), peach (*P. persica*), plum and cherry (*Prunus* spp.) (Weems Jr and Fasulo 2002) and in Utah has adapted to attacking sour cherry (*P. cerasus*) (White and Elson-Harris 1992); eggs are laid singly beneath the skin in the pulp; larvae (maggots) develop slowly in the green fruit but complete their growth after infested fruits have dropped from the tree and pupae can diapause for several seasons (Weems Jr and Fasulo 2002).	Yes
HEMIPTERA (Aphids, leafhoppers, mealybugs, psyllids, scales, true bugs, whiteflies)			
Acanthocephala femorata (Fabricius, 1775) [Hemiptera: Coreidae]	Leaf footed bug	No. A pest of the leaves and stems of plants such as potatoes and sunflowers. Leaf-footed bugs are occasionally noted as pests of crops such as peaches and some species are known to feed on peaches and nectarines (Mizell 2008), which results in 'catfacing' (depressions centred around a feed wound). These bugs are considered to be present on the fruit for short feeding periods only and would be disturbed, and thus likely removed from the pathway, during harvesting operations.	No
Acrosternum hilare (Say, 1831) [Hemiptera: Pentatomidae]	Green stink bug	No. Stink bugs are reported as pests of peaches and may cause 'catfacing' injury to fruit (Mizell 2008). These bugs are considered to be present on the fruit for short feeding periods only and would be disturbed, and thus likely removed from the pathway, during harvesting operations.	No
Boisea rubrolineata (Barber, 1956) Synonym: *Leptocoris rubrolineatus* Barber, 1956 [Hemiptera: Rhopalidae]	Western boxelder bug	Anthon (1993) notes this species as a "sporadic and usually minor orchard pest found throughout western North America". The primary host for this pest is *Acer negundo* (boxelder), but, boxelder bug will attack tree fruit on apples, pears, cherries, peaches and plums causing dimples and deformations on fruit (Anthon 1993). However, These bugs are considered to be present on the fruit for short feeding periods only and would be disturbed, and thus removed from the pathway, during standard harvesting and packing house operations.	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Brachycaudus cardui (Linnaeus, 1758) Synonym: *Aphis cardui* Linnaeus [Hemiptera: Aphididae]	Thistle aphid	No. Only reported as an occasional pest of apricots and plums in the Pacific Northwest (Beers and Brunner 2009). Egg deposition and feeding occurs on twigs and leaves with no life stages reported to be associated with the fruit (Beers and Brunner 2009). During summer periods, this species migrates from fruit hosts to weeds, ornamental plants and vegetables, and does not return until autumn (Beers and Brunner 2009). Given the limited information and the historic nature of reports of this species on Prunus, coupled with its unlikely presence during harvest periods, suggests this pest is unlikely to be associated with the importation pathway.	No
Brachycaudus schwartzi (Börner, 1931) Synonym: *Anuraphis schwartzi* (Börner, 1931) [Hemiptera: Aphididae]	Aphid, almond aphid	No. Linked to transmission of *plum pox virus* biotype M (Manachini *et al.* 2004). Peach is considered the primary host and spring colonies are considered to cause curling and disfiguration of leaves (Stoetzel and Miller 1998). No evidence that this pest is associated with the fruit.	No
Carneocephala fulgida Nottingham, 1932 [Hemiptera: Cicadellidae]	Red-headed sharpshooter	No. Economically important as a potential vector. Irrigated pastures, hay fields, or grasses on ditch backs are the principal breeding and feeding habitats (Gubler *et al.* 2008). Sharpshooter feeding tendency favours succulent new growth of shoots, not fruit (Redak et al 2004). Furthermore, given the large size and mobility of sharpshooter species, they are easily detected and disturbed during harvest and packing house operations.	No
Ceresa alta Walker, 1851 Synonym: *Ceresa bubalus* (Fabricius, 1794) [Hemiptera: Membracidae]	Buffalo treehopper	No. Eggs are laid in slits cut in twigs of woody plants (CABI 2007). The impact to fruit trees is only reported as a result of damage to twigs.	No
Ceroplastes floridensis Comstock, 1881 [Hemiptera: Coccidae]	Florida wax scale	No. Wax scales feed on sap from the vascular system of plants. Heavy infestations may cause limb dieback or leaf drop (CABI 2007; Stimmel 1998) .	No
Chionaspis furfura (Fitch, 1875) [Hemiptera: Diaspididae]	Scurfy scale	No. This pest is reported as a sap-sucking insect that primarily causes twig and branch dieback (Cranshaw et al 1994; Wawrzynski and Ascerno 2009). While reported from peach and plum (Ben-Dov *et al.* 2006), there appears to be no such records from the exporting states. This species prefers lower branches of its hosts, although at high population densities, spread to new growth and fruit is possible (Ben-Dov *et al.* 2006). However, crawlers primarily feed on leaves, branches and trunks (Wawrzynski and Ascerno 2009). It is therefore unlikely that this pest is associated with mature, fresh harvested fruit.	No
Chlorochroa sayi (Stål, 1872) [Hemiptera: Pentatomidae	Peach stink bug	No. Adults insert their stylus into fruit to feed on the juices (Pickel *et al.* 2006f). These bugs are considered to be present on the fruit for short feeding periods only and would be disturbed, and thus likely removed from the pathway, during harvesting operations.	No
Chlorochroa uhleri (Stål, 1872) [Hemiptera: Pentatomidae]	Peach stink bug	No. Adults insert their stylus into fruit to feed on the juices (Pickel *et al.* 2006f). These bugs are considered to be present on the fruit for short feeding periods only and would be disturbed, and thus likely removed from the pathway, during harvesting operations.	No
Clavaspis disclusa Ferris, 1938 [Hemiptera: Diaspididae]	Armoured scale	No. Limited information on this species and genus. Occurs on twigs and larger branches (Gill 1997).	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Closterotomus norvegicus (Gmelin, 1788) Synonym: *Calocoris norvegicus* (Gmelin, 1788) [Hemiptera: Miridae]	Potato bug	Yes. Adults lay eggs and feed on the soft tissues of shoot tips. Eggs may also be laid into fruits from mid-May (Pickel *et al.* 2006b).	Yes (WA)
Colladonus clitellarius (Say, 1831) [Hemiptera: Cicadellidae]	Saddled leafhopper	No. Vector of Western X disease. Eggs overwinter in fallen leaves. Adults feed and oviposit on leaves of hardwood trees (George and Davidson 1959).	No
Colladonus geminatus (Van Duzee, 1890) [Hemiptera: Cicadellidae]	Leafhopper	No. Vector of Western X disease. Primarily collected from lucerne, this pest may also be present in stone fruit orchards from June onwards. This pest is of economic importance as a virus vector, but there is no information to suggest that it is associated with fruit.	No
Colladonus montanus (Van Duzee, 1892) [Hemiptera: Cicadellidae]	Mountain leafhopper	No. Vector of Western X disease. Vector of buckskin of cherry. May be present in cherry orchards, but cherries are not a preferred host (Van Steenwyk *et al.* 2006a). This pest is of economic importance as a virus vector, but there is no information to suggest that it is associated with fruit.	No
Cuerna costalis (Fabricius, 1803) [Hemiptera: Cicadellidae]	Leafhopper	No. Potential virus vector of phony peach disease and Pierce's disease. Feeds on xylem fluids, particularly grasses, but may also be in orchards. Eggs are laid on the lower leaves of grasses (Barnes 2004).	No
Dialeurodes citri (Ashmead, 1885) [Hemiptera: Aleyrodidae]	Citrus whitefly	No. Eggs are laid on the undersides of leaves, where nymphs settle to feed (CABI 2007).	No
Diaspidiotus ancylus (Putnam, 1878) Synonym: *Abgrallaspis howardi* (Cockerell, 1895) [Hemiptera: Diaspididae]	Putnam scale; Howard scale	No. Very similar to *D. ostreaeformis* and also is found on twigs and bark. Sometimes found on leaves of hosts such as elm. High population densities may cause branch dieback (Watson 2006).	No
Diaspidiotus forbesi (Johnson, 1896) Synonym: *Quadraspidiotus forbesi* (Johnson, 1896) [Hemiptera: Diaspididae]	Forbes scale	Yes. Inhabit twigs, branches and fruit (Grantham 2006).	Yes
Diaspidiotus juglansregiae (Comstock, 1881) Synonym: *Quadraspidiotus juglansregiae* (Comstock, 1881) [Hemiptera: Diaspididae]	Walnut scale	Yes. Found on the fruit (Curtis *et al.* 1992).	Yes

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Diaspidiotus ostreaeformis (Curtis, 1843) [Hemiptera: Diaspididae]	Oystershell scale; Pear oyster scale	Yes. Highly polyphagous and primarily found on bark and twigs but may also be present on leaves or fruit (Watson 2006). Can also cause red spotting on fruit (CABI 2007).	Yes (WA)
Draeculacephala minerva Ball, 1927 [Hemiptera: Cicadellidae]	Green sharpshooter	No. Economically important as a potential vector and most abundant in riparian habitats in association with weeds, shrubs and trees (Redak et al 2004). Sharpshooter feeding tendency favours succulent new growth of shoots, not fruit (Redak et al 2004). Furthermore, given the large size and mobility of sharpshooter species, they are easily detected and disturbed during harvest and packing house operations.	No
Epidiaspis leperii (Signoret, 1869) [Hemiptera: Diaspididae]	Italian pear scale	No. Causes pitting of young stems of apples, pears and plums and may cause distortion of branches (CABI 2007). No evidence to suggest that this pest is associated with the fruit.	No
Eulecanium caryae (Fitch, 1857) [Hemiptera: Coccidae]	Large hickory lecanium	No. This pest has previously been reported from peach in Niagara, Ontario in 1898 in low numbers, but never in abundance (King 1901). It has been historically reported from California, but not since 1936 (Gill 1988). No records exist for the other exporting states in the USA. It is considered unlikely that this pest will be associated with the crop in the exporting area or the export pathway.	
Eulecanium cerasorum (Cockerell, 1900f) [Hemiptera: Coccidae]	Calico scale	No. This scale is a phloem feeder present on the twigs and branches of host trees (Hubbard and Potter 2002).	No
Eulecanium kunoense (Kuwana, 1907) [Hemiptera: Coccidae]	Kuno scale	No. Soft scales feed on phloem and are associated with leaves, twigs and branches (Dreistadt *et al.* 2007a). Crawlers migrate to leaves, nymphs develop on leaves during summer, returning to twigs before leaf drop in autumn (Gill 1988).	No
Euschistus conspersus Uhler, 1897 [Hemiptera: Pentatomidae]	Stink bug	No. Adult stink bugs feed on fruit and cause 'cat-facing' injuries (Pickel *et al.* 2006f). These bugs are considered to be present on the fruit for short feeding periods only and would be disturbed, and thus likely removed from the pathway, during harvesting operations.	No
Euschistus servus (Say, 1832) [Hemiptera: Pentatomidae]	Brown stink bug	No. Adult stink bugs feed on fruit and cause 'cat-facing' injuries (Pickel *et al.* 2006f). These bugs are considered to be present on the fruit for short feeding periods only and would be disturbed, and thus likely removed from the pathway, during harvesting operations.	No
Euschistus tristigmus (Say, 1831) [Hemiptera: Pentatomidae]	Dusky stink bug	No. Adult stink bugs feed on fruit and cause 'cat-facing' injuries (Pickel *et al.* 2006f). These bugs are considered to be present on the fruit for short feeding periods only and would be disturbed, and thus likely removed from the pathway, during harvesting operations.	No
Euschistus variolarius (Palisot de Beauvois, 1817) [Hemiptera: Pentatomidae]	One spotted stink bug	No. Adult stink bugs feed on fruit and cause 'cat-facing' injuries (Pickel *et al.* 2006f). These bugs are considered to be present on the fruit for short feeding periods only and would be disturbed, and thus likely removed from the pathway, during harvesting operations.	No
Fieberiella florii (Stål, 1864) [Hemiptera: Cicadellidae]	Leafhopper	No. Vector of a number of diseases including Western X disease (Swenson 1974). Pears (Swenson 1974) and cherries (Van Steenwyk *et al.* 2006b) are reported to be major hosts, but these leafhoppers are found in other stone fruit orchards. Economically significant in its ability to transmit viruses, but feed on leaves and branches, not fruit.	No

Scientific Name	**Common Name(s)**	**Is the pest likely to be associated with mature, fresh harvested fruit?**	**Consider Further ?**
Graphocephala atropunctata (Signoret, 1854) [Hemiptera: Cicadellidae]	Blue-green sharpshooter	No. Economically important as a potential vector and most abundant in riparian habitats in association with weeds, shrubs and trees (Redak et al 2004). Sharpshooter feeding tendency favours succulent new growth of shoots, not fruit (Redak et al 2004). Furthermore, given the large size and mobility of sharpshooter species, they are easily detected and disturbed during harvest and packing house operations.	No
Graphocephala versuta (Say, 1830) [Hemiptera: Cicadellidae]	Leafhopper	No. Economically important as a potential vector. Feeds mainly on leaves (Hopkins and Purcell 2002). Furthermore, given the large size and mobility of sharpshooter species, they are easily detected and disturbed during harvest and packing house operations.	No
Heliococcus osborni (Sanders, 1902) [Hemiptera: Pseudococcidae]	Osborn mealybug	No. Occurs under the loose bark and not found on the fruit (Kosztarab 2008 Pers. Comm).	No
Homalodisca vitripennis (Germar, 1821) Synonym: *Homalodisca coagulata* (Say, 1832) [Hemiptera: Cicadellidae]	Glassy-winged sharpshooter	No. Economically important as a potential vector. Tendency to feed on stems rather than petioles, leaf veins, or fruit (Redak *et al.* 2004). Furthermore, given the large size and mobility of sharpshooter species, they are easily detected and disturbed during harvest and packing house operations.	No
Homalodisca insolita (Walker, 1858) [Hemiptera: Cicadellidae]	Leafhopper	No. Economically important as a potential vector. Feeds primarily on herbaceous hosts (Redak *et al.* 2004; Tipping *et al.* 2005). As a grass feeding specialist, it is considered to be less important in the transmission of Phony peach disease (Horton and Mizell III 2005). Feeds on stems of peach (Horton and Mizell III 2005), not fruit. Furthermore, given the large size and mobility of sharpshooter species, they are easily detected and disturbed during harvest and packing house operations.	No
Hyalopterus pruni (Geoffroy, 1762) [Hemiptera: Aphididae]	Mealy plum aphid	No. Mealy plum aphid can build up in large numbers on the underside of leaves (Bentley and Day 2006c). Honeydew from aphids may drop onto fruit, but there is no evidence that the aphids are directly associated with the fruit.	No
Lepidosaphes pinnaeformis (Bouché, 1851) [Hemiptera: Diaspididae]	Cymbidium scale	No. While *Prunus* spp. are reported as hosts, Watson (2006) notes this pest as being associated with the leaves and sometimes stems of its hosts, and as being primarily a pest of orchids in greenhouses. Furthermore, this pest is noted as being only an occasional pest in California and again mainly on orchids (Watson 2006).	No
Lygus elisus van Duzee, 1914 [Hemiptera: Miridae]	Pale legume bug; Lucerne plant bug	Yes. Adults lay eggs and feed on the soft tissues of shoot tips. Eggs may also be laid into fruits from mid-May (Pickel *et al.* 2006b).	Yes
Lygus hesperus Knight, 1917 [Hemiptera: Miridae]	Western tarnished plant bug	Yes. Adults lay eggs and feed on the soft tissues of shoot tips. Eggs may also be laid into fruits from mid-May (Pickel *et al.* 2006b).	Yes
Lygus lineolaris (Palisot de Beauvois, 1818) [Hemiptera: Miridae]	Tarnished plant bug	Yes. Adults are reported to cause 'cat-facing' injury to peaches (Bobb 1970), but may also lay eggs in the fruit.	Yes
Magicicada septendecim (Linnaeus, 1758) [Hemiptera: Cicadidae]	Periodic cicada	No. Adults feed on leaves and eggs are laid on branches. Larvae feed on the roots of grasses and trees (Hoover 2003).	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Melanaspis obscura (Comstock, 1881a) [Hemiptera: Diaspididae]	Obscure scale	No. Damaging to shade trees, but *Prunus* spp. may be a minor host. Feeds on the bark, causing a knurled appearance and possible branch dieback (Miller and Davidson 2005).	No
Melanaspis tenebricosa (Comstock, 1881) [Hemiptera: Diaspididae]	Gloomy scale	While listed by Ben-Dov *et al.* (2009) as being associated with peach and known from California, Nakahara (1982) does not list this species as present in any of the exporting states. This scale was reported from the San Jose area in 1891 where it was causing damage to apples, however the accuracy of this determination is considered questionable and if accurate, the scale has never been recollected (Gill 1997). The preferred hosts are red and silver maples, however boxelder, catalpa, elm, hackberry, mulberry, and sycamore are also susceptible. Additionally, this scale is reported on bark, branches, or twigs of its hosts (Ben-Dov *et al.* 2006; Krischik and Davidson, 2007). It is considered unlikely that this pest would be associated with fresh, harvested fruit.	No
Mesolecanium nigrofasciatum (Pergande, 1898) [Hemiptera: Coccidae]	Terrapin scale	No. Nymphs found on underside of leaves and females on twigs (Ben-Dov and Hodgson 1997). Crawlers settle on the underside of leaves and return to twigs and branches as adults for egg laying (Ben-Dov and Hodgson 1997).	No
Metcalfa pruinosa (Say, 1830) [Hemiptera: Flatidae]	Plant hopper	No. Normally does very little damage to plants. Reported to feed on buds (Mead 2004).	No
Neopinnaspis harperi McKenzie, 1949 [Hemiptera: Diaspididae]	Armoured scale	No. Reported from the bark of twigs and branches and only rarely from leaves (Miller and Davidson 2005).	No
Neopulvinaria innumerabilis innumerabilis (Rathvon, 1854) [Hemiptera: Coccidae] Synonym*: Pulvinaria innumerabilis* (Rathvon, 1854)	Cottony maple scale	No. Ovisacs formed on twigs. Polyphagous and normally found on grapes (Gill 1988).	No
Norvellina seminudus (Say, 1830) [Hemiptera: Cicadellidae]	Leafhopper	No. Reported to feed on leaves (APHIS 2002a). No other information found.	No
Oncometopia orbona (Fabricius, 1798) [Hemiptera: Cicadellidae]	Leafhopper	No. Economically important as a potential virus vector. Feeds on stems of peach (Horton and Mizell III 2005), not fruit. Furthermore, given the large size and mobility of sharpshooter species, they are easily detected and disturbed during harvest and packing house operations.	No
Parabemisia myricae (Kuwana, 1927) [Hemiptera: Aleyrodidae]	Bayberry whitefly	No. Eggs are laid on the edges or upper surfaces of young leaves. After hatching, nymphs move to the underside of leaves where they become sessile (CABI 2007).	No
Paraphlepsius irroratus (Say, 1830) [Hemiptera: Cicadellidae]	Brown speckled leafhopper	No. Found on leaves (APHIS 2002a), not fruit.	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Parlatoreopsis chinensis (Marlatt, 1908) [Hemiptera: Diaspididae]	Chinese obscure scale	No. Occurs on the bark of twigs and branches and not noted as a serious economic pest in the parts of the US where it is known to occur (Gill, 1997).	No
Parlatoria oleae (Colvée, 1880) [Hemiptera: Diaspididae]	Olive parlatoria scale	Yes. Reported to cause serious injury to fruit (Verma and Dinabandhoo 2005).	Yes (WA)
Parthenolecanium corni (Bouché, 1844) [Hemiptera: Coccidae]	Plum scale; European fruit lecanium	No. Crawlers feed on leaves and return to twigs and branches before autumn (Gill 1988). *Parthenolecanium corni* sucks plant juices from leaves and twigs. After hatching, crawlers move to the leaves, and on deciduous hosts, the nymphs move back to the twigs and branches before autumn (Gill 1988). Immature female scales overwinter on the bark of twigs (Henderson 2001).	No
Phenacoccus aceris (Signoret, 1875) [Hemiptera: *Pseudococcidae*]	Apple mealybug	Yes. Primarily occurs on leaves and stems (Ben-Dov 1994), however crawlers may disperse to leaves, twigs, leaf axils and fruit to feed; and can also directly infest and feed on fruit (Beers 2007).	Yes
Philaenus spumarius (Linnaeus,1758) [Hemiptera: Aphrophoridae]	Meadow froghopper; Meadow spittle bug	No. Important as a vector for a number of viruses. Feeds on stems (CABI 2007).	No
Phorodon humuli (Schrank, 1801) [Hemiptera: Aphididae]	Hop aphids	No. Linked to transmission of *plum pox virus* biotype M (Manachini *et al.* 2004). Damages leaves and reduces tree vitality (Olsen 2008), but not associated with the fruit.	No
Pseudaonidia duplex (Cockerell, 1896) [Hemiptera: Diaspididae]	Camphor scale	No. Crawlers settle on bark of stems and branches (Watson 2006).	No
Pseudaulacaspis pentagona (Targioni Tozzetti, 1886) [Hemiptera: Diaspididae]	Peach white scale	Yes. Leaves and fruit are not generally infested, but fruit infestations can occur and result in discolouration of the fruit (Watson 2006).	Yes (WA)
Pseudaulacaspis prunicola (Maskell, 1895) [Hemiptera: Diaspididae]	White prunicola scale	Yes. Generally occurs on the bark and fruit of its host (Davidson and Miller 1990).	Yes (WA)
Pseudococcus calceolariae (Maskell, 1879) [Hemiptera: Pseudococcidae]	Citrophilus mealybug	Yes. Citrophilus mealybugs may be present on fruit and have been intercepted previously on consignments of stone fruit (DAFF 2003).	Yes (WA)
Pseudococcus comstocki (Kuwana, 1902) [Hemiptera: Pseudococcidae]	Comstock mealybug	Yes. Injures the plant by extracting plant sap (CABI 2007). Eggs may be deposited in the calyx of fruit such as pears. A range of fruits may also be infested and this pest has been intercepted on fruit from New Zealand, demonstrating the capacity to be associated with imported fruit (DAFF 2003).	Yes
Pseudococcus maritimus (Ehrhorn, 1900) [Hemiptera: Pseudococcidae]	Grape mealybug	Yes. Feeding occurs primarily on the leaves, but adult females migrate to the trunk for oviposition (Ben-Dov *et al.* 2006). Recognised as a sporadic pest of minor importance. The second generation of this pest in each season may be associated with fruit (Washington State University 2007).	Yes

Scientific Name	**Common Name(s)**	**Is the pest likely to be associated with mature, fresh harvested fruit?**	**Consider Further ?**
Pulvinaria rhois Ehrhorn, 1898 [Hemiptera: Coccidae]	Fruit tree pulvinaria	No. Though occurrences on *Prunus* have been reported by Ben-Dov et al (2008), the primary citations for this reference are not in association with *Prunus*, but rather poison oak (Ferris 1920). Additionally, it is noted as being a sporadic pest (Ferris, 1920). It is unlikely this pest is associated with fresh, mature harvested stone fruit.	No
Pulvinaria vitis (Linnaeus, 1758) [Hemiptera: Coccidae]	Cottony grape scale	No. Though occurrences on *Prunus* in the US have been reported by Ben-Dov et al (2008), the primary citations in support of these reports do not note its occurrence in the export region, or in the instance of Ferris (1920), refer to its occurrence on other hosts. It is unlikely this pest would be associated with fresh, mature stone fruit in the US.	No
Rhizoecus falcifer Künckel d' Herculais, 1878 [Hemiptera: Pseudococcidae]	Ground mealybug	No. Feeds on the roots of a number of plant species and may also be present on the soil.	No
Scaphytopius acutus (Say, 1830) [Hemiptera: Cicadellidae]	Leafhopper	No. Potential as a virus vector. Feeds on leaves (APHIS 2002a).	No
Sphaerolecanium prunastri (Boyer de Fonscolombe, 1834) [Hemiptera: Coccidae]	Globose scale	No. Crawlers settle on twigs, mainly on the lower surfaces but not on the leaves, green twigs, large branches or on the main trunk (Ben-Dov and Hodgson 1997). Nymphs and females are found on the underside of twigs and branches (Ben-Dov and Hodgson 1997).	No
Thyanta custator (Fabricius, 1803) [Hemiptera: Pentatomidae]	Stink bug	No. Feeds on fruit, leaves and stems (APHIS 2002a). These bugs are considered to be present on the fruit for short feeding periods only and would be disturbed, and thus likely removed from the pathway, during harvesting operations.	No
Thyanta pallidovirens (Stål, 1859) [Hemiptera: Pentatomidae]	Redshouldered stink bug	No. Eggs are laid on the foliage and first instar stink bugs feed on developing fruit causing severe damage to unharvested fruit. Adult stink bugs feed on fruit and cause 'cat-facing' injuries (Pickel *et al.* 2006f). These bugs are considered to be present on the fruit for short feeding periods only and would be disturbed, and thus likely removed from the pathway, during harvesting operations.	No
Trialeurodes packardi (Morrill, 1903) [Hemiptera: Aleyrodidae]	Strawberry white fly	No. Feeds on leaf tissue (Zalom *et al.* 2009) and is principally a pest on strawberries.	No
HYMENOPTERA (Ants, Bees, Sawflies, Wasps)			
Hoplocampa cookei (Clarke, 1906) [Hymenoptera: Tenthredinidae]	Cherry fruit sawfly	No. While this species is reported to attack cherries, plums and occasionally peaches and apricots (Duruz 1922), the lack of contemporary literature published since 1924 on its economic importance indicates the species is of little concern for its reported hosts. Larvae are reported to bore through the fruit and into the kernel and discoloured fruit falls to the ground (Essig 1914). Infested fruit would be discounted at harvest due to the presence of symptoms.	No
LEPIDOPTERA (Butterflies, Moths)			
Acleris minuta (Robinson, 1869) [Lepidoptera: Tortricidae]	Yellowheaded fireworm	No. Considered to be uncommon on tree fruits (Oregon State University 2005; Weires and Riedl 1991) .	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Acrobasis tricolorella Grote, 1878 [Lepidoptera: Pyralidae]	Mineola moth; Destructive prune worm	No. Reports in Idaho and Oregon are historic (Shull and Wakeland 1941), but this species has been trapped in California during the past decade (University of California 2009b). Tart cherries and plums are preferred hosts in the eastern US (Epstein *et al.* 2007), where second generation larvae may feed inside the fruit for 11-14 days before dropping to the ground to pupate. This moth is considered to rarely be a pest in the eastern states where it is known (Agnello *et al.* 2006), while there are few records from California and the Pacific Northwest. The absence of evidence for the association of this moth with stone fruit production in the exporting states, coupled with the obvious symptoms of damage suggest that it is unlikely that this pest would be associated with exported stone fruit.	No
Alsophila pometaria (Harris, 1841) [Lepidoptera: Geometridae]	Fall cankerworm	No. Larvae are primarily leaf feeders, but occasionally feed on young fruit, which causes deep holes and serious scarring (Pickel *et al.* 2009). This is not likely to be associated fruit at harvest and the serious damage caused would result in culling at harvest.	No
Amphipyra pyramidoides Guenée, 1852 [Lepidoptera: Noctuidae]	Noctuid	No. Reported to feed on fruit (APHIS 2002a). Eggs hatch around the time of bud burst and larvae feed on leaves and buds. Late instar larvae that are 20-35 mm long may feed on developing fruit, resulting in serious scarring and corky lesions as the fruit develops to maturity. The larvae drop to the soil to pupate before the fruit approaches maturity and is therefore not present during harvest (Rings 1968).	No
Amyelois transitella (Walker, 1863) [Lepidoptera: Pyralidae]	Navel orange worm	No. A significant pest of almonds, but not reported as a pest of stone fruit. Feeds on mummified fruit (APHIS 2002a).	No
Anarsia lineatella Zeller, 1839 [Lepidoptera: Gelechiidae]	Peach twig borer moth	Yes. May feed directly on fruit (Pickel *et al.* 2006c).	Yes
Antheraea polyphemus (Cramer, 1775) [Lepidoptera: Saturniidae]	Polyphemus moth; Silk moth	No. May be occasional pest in peach or plum orchards. Larvae feed on leaves (Opler *et al.* 2009), not fruit.	No
Archips argyrospila (Walker, 1863) [Lepidoptera: Tortricidae]	Fruit-tree leafroller	Yes. Native American species found on a wide range of hosts. Feeding on leaves may cause defoliation and also feeds on young fruit, causing fruit drop or scarring (Weires and Riedl 1991).	Yes
Archips podana (Scopoli, 1763) [Lepidoptera: Tortricidae]	Great brown twist moth	Yes. An introduced European species. Early in the season this leafroller attacks leaves and buds while in the late season, early instar larvae can cause skin damage to mature fruits (Dickler 1991).	Yes
Archips rosana (Linnaeus, 1758) [Lepidoptera: Tortricidae]	European leafroller	Yes. Similar biology to *Archips argyrospila*. A frequent pest of tree and small fruits (Weires and Riedl 1991).	Yes
Argyrotaenia citrana (Fernald, 1889) [Lepidoptera: Tortricidae]	Orange tortrix	Yes. Highly polyphagous species that feeds on young and mature fruit causing extensive damage (Weires and Riedl 1991).	Yes
Bondia comonana (Kearfott, 1907) [Lepidoptera: Carposinidae]	Prune Limb Borer	No. Sporadic pest in stone fruit orchards. Eggs are laid near callus tissue around pruning cuts. Larvae bore into the tree (Pickel *et al.* 2006g). Not associated with the fruit	No
Choreutis pariana (Clerck, 1759) [Lepidoptera: Choreutidae]	Apple leaf skelentoniser	No. Apple is the preferred host, where larvae feed on and skeletonise leaves. Larvae drop to the ground on silken threads when disturbed (Suomi 1999)	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Choristoneura rosaceana (Harris, 1841) [Lepidoptera: Tortricidae]	Oblique banded leafroller	Yes. North American native species that feeds on the foliage and occasionally on fruit (Weires and Riedl 1991). Not previously considered an important pest as cover sprays provided effective control, but insecticide resistance has dictated a need for specific control measures.	Yes
Coleophora sacramenta Heinrich, 1914 [Lepidoptera Coleophoridae]	California pistol case bearer	No. Eggs are laid on both sides of the leaves and larvae construct a case while skeletonising leaves. Later the larvae move to twigs and branches where they hibernate (Davidson 1918).	No
Cydia latiferreana (Walsingham, 1879) [Lepidoptera: Tortricidae]	Filbertworm	Yes. Larvae bore into fruit (Curtis *et al.* 1992).	Yes
Cydia pomonella (Linnaeus, 1758) [Lepidoptera: Tortricidae]	Codling moth	Yes. European pest that attacks fruit, especially apples (Dickler 1991)	Yes (WA)
Datana ministra (Drury, 1773) [Lepidoptera: Notodontidae]	Yellow necked caterpillar	No. Larvae aggregate near the ends of branches and twigs and feed on leaves, causing skeletonisation (Hoover 2002b). Principally a pest of shade trees.	No
Egira curialis (Grote, 1873) Synonym: *Xylomyges curialis* (Grote, 1873) [Lepidoptera: Noctuidae]	Citrus cutworm	No. Reported to feed on fruit (APHIS 2002a), but damage is incidental as leaves and blossoms are the main food for the older larvae. Mature fruit are rarely attacked, and if disturbed, the larvae drop to the ground (Bentley *et al.* 2009h).	No
Enarmonia formosana (Scopoli, 1763) [Lepidoptera: Tortricidae]	Cherry bark tortrix	No. A widely distributed tortricid. Eggs are deposited in bark crevices and the larvae bore into the bark to feed (Dickler 1991). May cause death of twigs or branches (Dickler 1991).	No
Euproctis chrysorrhoea (Linnaeus, 1758) [Lepidoptera: Lymantriidae]	Brown tail moth	No. Eggs are laid on the branches and leaves of suitable hosts. Young larvae are gregarious leaf feeders and may cause defoliation (CABI 2007).	No
Euzophera semifuneralis (Walker, 1863) [Lepidoptera: Pyralidae]	American plum borer	No. Sporadic pest in stone fruit orchards. Eggs are laid near callus tissue around pruning cuts. Larvae bore into the tree (Pickel *et al.* 2006g).	No
Grapholita molesta (Busck, 1916) [Lepidoptera: Tortricidae]	Oriental fruit moth	Yes. Serious internal pest of stone fruit (Dickler 1991). Peach is a major host and other stone fruit are also infested.	Yes (WA)
Grapholita packardi Zeller, 1875 Synonym: *Cydia packardi* (Zeller, 1875) [Lepidoptera: Tortricidae]	Cherry fruitworm	Yes. Recorded from the fruits of peach and plum (Weires and Riedl 1991).	Yes
Grapholita prunivora (Walsh, 1868) Synonym: *Cydia prunivora* (Walsh, 1868) [Lepidoptera: Tortricidae]	Lesser apple fruitworm; Plum moth	Yes. North American native internal fruit feeder known to infest plums (Weires and Riedl 1991).	Yes

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Hyphantria cunea (Drury, 1773) [Lepidoptera: Arctiidae]	Fall webworm; American white moth	No. Native to the US (CABI 2007). Eggs deposited on leaves and larvae may cause defoliation of trees (CABI 2007).	No
Lithophane antennata (Walker, 1858) [Lepidoptera: Noctuidae]	Green fruit worm	No. Reported to feed on the fruit (APHIS 2002a). This species overwinters as adults and lays eggs in the spring, with fruit feeding restricted to the later instars (Rings 1973). Larvae drop to the soil in the first weeks of summer to pupate and emerge from late September to early November (Rings 1973), and are therefore not likely to be associated with fruit during harvest (Rings 1973). Usually only of importance in unsprayed orchards or home fruit plantings (Rings 1973) and unlikely to be associated with commercially harvested stone fruits for export.	No
Malacosoma americanum (Fabricius, 1793) [Lepidoptera: Lasiocampidae]	Eastern tent caterpillar	No. May only be present in the eastern US. Primarily a nuisance pest, but also noted for defoliating trees. Larvae are gregarious leaf feeders that created silken tents for shelter (EPPO/CABI 1997j).	No
Malacosoma californica (Packard, 1864) [Lepidoptera: Lasiocampidae] ssp. *pluviale* Dyar	Western tent caterpillar	No. Found in the western states. Primarily a nuisance pest, but also noted for defoliating trees. Larvae are gregarious leaf feeders that created silken tents for shelter (EPPO/CABI 1997j). Subspecies *pluviale* (also recorded as *M. pluviale*) is known as the northern tent caterpillar (CABI 2007).	No
Malacosoma disstria Hübner, 1820 [Lepidoptera: Lasiocampidae]	Forest tent caterpillar	No. As for other *Malacosoma* species this is a leaf feeder pest that may cause defoliation. Not reported from the fruit of host trees (CABI 2007).	No
Operophtera brumata (Linnaeus, 1758) [Lepidoptera: Geometridae]	Winter moth	No. Eggs are laid in crevices in the bark and other concealed places in the tree canopy. Feeds primarily on leaves, but also on fruitlets of apple (CABI 2007). Not associated with mature fruit.	No
Orgyia antiqua (Linnaeus, 1758) [Lepidoptera: Lymantriidae]	Rusty tussock moth; European tussock moth	No. Larvae feed externally on leaves, sometimes causing complete defoliation of shrubs and trees. The cocoon is spun up in chinks of bark, amongst leaves, in crevices in walls, or in any protected spot. The female lays her eggs on the cocoon (CABI 2007).	No
Orgyia vetusta Boisduval, 1852 [Lepidoptera: Lymantriidae]	Western tussock moth	No. Cocoons are spun in twigs and the flightless females lay eggs nearby, usually on the cocoon. Larvae are leaf feeders that may cause defoliation if in large numbers (Furniss and Knopf 1971)	No
Orthosia hibisci (Guenée, 1852) [Lepidoptera: Noctuidae]	Speckled green fruit worm	No. Reported to feed on fruit (APHIS 2002a). Eggs hatch around the time of bud burst and larvae commence their feeding on buds and young leaves. Larvae from the third instar may feed on fruit as well as leaves, but the most serious damage is caused by the late instar larvae, which are 21-41mm long. These late instars eat large sections of the fruit causing serious damage, but drop to the ground to pupate before harvest (Rings 1970).	No
Ostrinia nubilalis (Hübner, 1796) [Lepidoptera: Pyralidae]	European corn borer	No. Principally a pest for crops such as maize, sorghum, cotton, capsicum and potato. Recorded feeding on peach trees (APHIS 2002a). Not associated with fruit.	No
Paleacrita vernata (Peck, 1795) [Lepidoptera: Geometridae]	Spring cankerworm	No. Larvae are primarily leaf feeders, but occasionally feed on young fruit (Pickel *et al.* 2009). Not associated with mature fruit.	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Pandemis pyrusana Kearfott, 1907 [Lepidoptera: Tortricidae]	Apple pandemis; Pandemis leafroller	Yes. A historical pest of apple and also reported from various stone fruit. Principally a leaf feeder, but also causes damage to fruits (Brunner 1993; Brunner and Beers 1990)	Yes
Papilio eurymedon Lucas, 1852 [Lepidoptera: Papilionidae]	Pale swallowtail	No. Larvae are leaf feeders. Females lay eggs singly on host plant (trees and shrubs in the Rosaceae, Rhamnaceae and Betulaceae families including cherry (*Prunus emarginata*), coffee-berry (*Rhamnus californica*), and ash (*Fraxinus* spp.) leaves. Caterpillars feed on leaves and rest on silken mats in shelters of curled leaves (Opler *et al.* 2009).	No
Papilio rutulus Lucas, 1852 [Lepidoptera: Papilionidae]	Western tiger swallowtail	No. Larvae are leaf feeders. Females lay eggs singly on surface of host plant (cottonwood and aspen (*Populus*), willows (*Salix*), wild cherry (*Prunus*), and ash (*Fraxinus*)) leaves. Caterpillars feed on leaves and rest on silken mats in shelters of curled leaves; pupae hibernate (Opler *et al.* 2009).	No
Peridroma saucia (Hübner, 1808) [Lepidoptera: Notodontidae]	Variegated cutworm moth; Finnish dart	No. While this pest is suggested as a pest of apricot, peach and plum (CABI 2007), there are no records of this pest on stone fruit in the US and the records appear to be based on reports from Italy (Castellari 1976). Early instar larvae feed only on leaves, while late instar larvae may incidentally feed on fruit and cause scarring. However, larvae return to the soil during the day (Castellari 1976). It is unlikely that this pest would be associated with mature harvested fruit.	No
Phyllonorycter crataegella (Clemens, 1859) [Lepidoptera: Gracillariidae]	Apple blotch leafminer	No. Principally a pest of apples. Larvae feed on the underside of leaves, damaging the leaf surface and feeding on the juices (CABI 2007). Considered a sporadic pest only in the eastern US.	No
Phyllonorycter elmaella Doganlar & Mutuura, 1980 [Lepidoptera: Gracillariidae]	Western spotted tentiform leafminer	No. Larvae feed on leaves and join leaves with silken threads to form a tent like structure where pupation occurs (Alston and Reding 2003).	No
Platynota stultana Walsingham, 1884 [Lepidoptera: Tortricidae]	Orange tortrix; Omnivorous leafroller	Yes. Feeds on leaves and occasionally on fruit (APHIS 2002a).	Yes
Schizura concinna (Smith, 1797) [Lepidoptera: Notodontidae]	Red humped caterpillar moth	No. Feeds on leaves and may cause skeletonisation (Coates and Steenwyk 2007).	No
Sphinx drupiferarum (Smith, 1797) [Lepidoptera: Sphingidae]	Wild cherry sphinx	No. Recorded as a rare/endangered species in the US. Feed nocturnally on the leaves of cherry and plum (Oejlke 2006).	No
Spilonota ocellana (Denis & Schiffermueller, 1775) [Lepidoptera: Tortricidae]	Eye-spotted bud moth	No. Although Prunus is reported as a potential host for this species, it is principally a pest of pear and apple where buds are attacked causing economic losses (Dickler 1991). Fruit feeding is recognised, however, this pest feeds mainly on leaves. Additionally, this pest is commonly found in abandoned orchards or native vegetation and is rarely found in commercial orchards (Weires and Reidl 1991; Brunner 1993). No direct evidence for damage to stone fruit.	No
Spodoptera frugiperda (Smith, 1797) [Lepidoptera: Noctuiidae]	Fall armyworm	No. Eggs are laid on leaves and the larvae feed there. Pupation occurs in the soil (CABI 2007).	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Synanthedon exitiosa (Say, 1823) [Lepidoptera: Aegeriidae]	Peach tree borer moth	No. Native to the US. All *Prunus* spp. are considered to be hosts. The peach tree borer prefers healthy plants (Strickland 2002). Eggs are laid on the trunk around the soil line and larvae bore into the trunk, large roots and stems (Strickland 2002). Oozing sap mixed with frass exuding from entrance holes is a typical sign of infestation (Strickland 2002).	No
Synanthedon pictipes (Grote & Robinson, 1868) [Lepidoptera: Aegeriidae]	Lesser peach tree borer moth	No. Native to the US. All *Prunus* spp. are considered to be hosts. The lesser peach tree borer prefers unhealthy plants. Eggs are laid on the trunk around the soil line and larvae bore into the trunk, large roots and stems (Strickland 2002). Oozing sap mixed with frass exuding from entrance holes is a typical sign of infestation (Strickland 2002).	No
Xestia c-nigrum (Linnaeus, 1758) [Lepidoptera: Notodontidae]	Spotted cutworm	No. Feeds on buds and shoots, especially in the lower canopy. Feeds at night, then descend to the ground and hides during the day (CABI 2007)	No
Zeuzera pyrina (Linnaeus, 1761) [Lepidoptera: Cossidae]	Leopard moth	No. Larvae feed internally in stems (CABI 2007).	No
ORTHOPTERA (crickets, grasshoppers, katydids)			
Melanoplus femurrubrum (DeGeer, 1773) [Orthoptera: Acrididae]	Redlegged grasshopper	No. Feeds on fruit and leaves (APHIS 2002a). This grasshopper is considered to be a sporadic pest that feeds for short periods before moving away from the fruit. It is considered that this pest would be disturbed during harvesting operations and would not be on graded fruit.	No
Microcentrum retinerve (Burmeister, 1838) [Orthoptera: Tettigoniidae]	Angular winged katydid	No. Katydids are considered occasional pests in orchards where nymphs may feed on developing or mature fruit. Damage tends to consist of single bites on a number of fruit (Bentley *et al.* 2009f). This katydid is considered to be a sporadic pest that feeds for short periods before moving away from the fruit. It is considered that this pest would be disturbed during harvesting operations and would not be on graded fruit.	No
Scudderia furcata Brunner von Wattenwyl, 1878 [Orthoptera: Tettigoniidae]	Forktailed bush katydid	No. Katydids are considered occasional pests in orchards where nymphs may feed on developing or mature fruit. Damage tends to consist of single bites on a number of fruit (Bentley *et al.* 2009f). This katydid is considered to be a sporadic pest that feeds for short periods before moving away from the fruit It is considered that this pest would be disturbed during harvesting operations and would not be on graded fruit.	No
THYSANOPTERA (thrips)			
Frankliniella bispinosa (Morgan, 1913) [Thysanoptera: Thripidae]	Thrips	No. Feeds primarily in blooms. No evidence for presence on fruit.	No
Frankliniella fusca (Hinds, 1902) [Thysanoptera: Thripidae]	Tobacco thrips	No. Causes scarring to flowers and leaves (CABI 2007).	No
Frankliniella intonsa (Trybom, 1895) [Thysanoptera: Thripidae]	Taiwan flower thrips	Yes. Principally a pest of flowers and strawberries, but is reported to cause damage to developing nectarine fruit (CABI 2007).	Yes
Frankliniella minuta (Moulton, 1907) [Thysanoptera: Thripidae]	Minute flower thrips	No. Reported to cause damage during flowering, but no evidence for damage to, or presence on, fruit.	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Frankliniella occidentalis (Pergande, 1895) [Thysanoptera: Thripidae]	Western flower thrips	Yes. Feeding causes scarring on fruit (EPPO/CABI 1997d).	Yes
Frankliniella tritici (Fitch, 1855) [Thysanoptera: Thripidae]	Flower thrips	Yes. Feeding causes scarring on fruit (Funderbunk and Stavisky 2004)	Yes
Taeniothrips inconsequens (Uzel, 1895) [Thysanoptera: Thripidae]	Pear thrips	Yes. Feeding causes silver surface blemishes, russetting and distortion of fruit (Lewis 1997).	Yes
BACTERIA			
Erwinia amylovora (Burrill 1882) Winslow, Broadhurst, Buchanan, Krumwiede, Rogers and Smith, 1920 [Enterobacteriales: Enterobacteriaceae]	Fire blight of apple	No. Isolated natural incidences of the pathogen on *Prunus* species have only been reported as shoot blight under high inoculum pressure, but there is no evidence of infection of mature fruit (Mohan 2007; Mohan and Thomson 1996).	No
Xylella fastidiosa (Wells, Raju, Hung, Weisburg, Mandelco-Pauland, Brenner, 1987) [Xanthomonadales: Xanthomonadaceae]	Phoney peach disease; Pierce's disease; California vine disease; Anaheim disease	Yes. Spread by leafhoppers and enters the xylem of trees. Spreads systemically (Wells 1995) through the xylem (water transporting tissues). However, the bacterium is mainly found in the roots of peach trees and is only reported in very low levels in leaf and stem tissue if at all. It is unclear whether this bacterium can be isolated from fruit tissue and is therefore considered further.	Yes
FUNGI			
Apiosporina morbosa (Schwein.:Fr.) Arx [Dothideales: Venturaceae]	Black knot	No. This disease only affects the woody parts of the tree (Hickey 1995a).	No
Armillaria mellea (Vahl:Fr.) P. Kumm. [Agaricales: Armillariaceae]	Armillaria root rot	No. This fungus is known as a root pathogen and is not associated with the mature fresh harvested fruit of its hosts (Jones 1995b).	No
Armillaria gallica Marxmüller & Romagni [Agaricales: Armillariaceae]	Armillaria root rot	No. This soil-borne fungus is known as a root pathogen and is not associated with the mature fresh harvested fruit of its hosts (CABI 2007).	No
Armillaria ostoyae (Romagn.) Herink [Agaricales: Armillariaceae]	Armillaria root rot	No. This soil-borne fungus is known as a root pathogen and is not associated with the mature fresh harvested fruit of its hosts (Jones 1995b).	No
Armillaria NABSX (North American Biological Strain X – unnamed) [Agaricales: Armillariaceae]	Armillaria root rot	No. This soil-borne fungus is known as a root pathogen and is not associated with the mature fresh harvested fruit of its hosts (Jones 1995b).	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Blumeriella jaapii (Rehm) Arx Anamorph: *Phloeosporella padi* (Lib.) Arx [Helotiales: Dermateaceae]	Cherry leaf spot; Shot hole; Leaf spot	Yes. The primary host of this fungus is cherry, and fruit are only susceptible for a short period. Therefore, fruit infection is rare (Jones 1995a). It is unlikely, but not impossible, that this fungus would be present on mature fruit shipped to Australia.	Yes
Ceratocystiopsis alba (DeVay, R.W. Davidson & W.J. Moller) H.P. Upadhyay 1981 [Ophiostomatales: Ophiostomataceae]	Canker	No. Reported from bark tissue of *Prunus domestica* in California after mechanical injury by shaker harvesters (DeVay et al 1968). After initiating infection, the fungus grows on the exposed bark and xylem tissues and invades healthy bark tissues (DeVay et al 1968). It is unlikely this pathogen is associated with mature, fresh harvested stone fruit.	No
Ceriporia spissa (Schwein.) Rajchenberg [Polyporales: Hapalopilaceae]		No. Not common on US stone fruits. Generally, hosts are hardwoods (Farr and Rossman 2009).	No
Dendrophoma sp. [Anamorphic Xylariales]		No. Found on peaches in Oregon (Farr *et al.* 1989). Known to mainly infect limbs of hardwoods. Dendrophoma fruit rots are occasionally reported from strawberry. No evidence found for infection of stone fruit.	No
Fomes fomentarius (L.:Fr.) J. Kickx [Polyporales: Polyporaceae]	Trunk rot	No. Exists in living and dead hardwoods. Found in Oregon plums, rum cherries in North-Eastern states, and choke cherries in Washington (Farr and Rossman 2009).	No
Fomitopsis cajanderi (P. Karst.) Kotlaba & Pouzar [Polyporales: Fomitopsidaceae]	Brown cubical rot	No. Causes wood decay of stone fruit trees. Pathogen enters trees primarily through wounds that expose secondary xylem of sapwood or heartwood (Adaskaveg and Gilbertson 1995).	No
Fomitopsis pinicola (Sw.:Fr.) P. Karst. [Polyporales: Fomitopsidaceae]	Brown cubical rot	No. Wood decay pathogen that enters trees primarily through wounds (CABI 2007).	No
Fomitopsis rosea (Albertini & Schwein.:Fr.) P. Karst. [Polyporales: Fomitopsidaceae]	Brown pocket rot	No. Causes soft cubical rot on living and dead wood (Pegler and Waterston 1998b).	No
Ganoderma applanatum (Pers.) Pat. [Polyporales: Ganodermataceae]		No. Wood decay pathogen causing spongy heart and butt rot, and doubtful it is pathogenic to living tissues (Steyaert 1998).	No
Ganoderma brownii (Murrill) R.L. Gilbertson [Polyporales: Ganodermataceae]		No. A wood decay found in peach in California. Causes wood decay of stone fruit trees. Pathogen enters trees primarily through wounds that expose secondary xylem of sapwood or heartwood (Adaskaveg and Gilbertson 1995)	No
Ganoderma lucidum (Curtis : Fr.) P. Karst. 1881 [Polyporales: Ganodermataceae]		No. A wood rotting fungus associated with roots and trunks (Stayaert 1975; Hickman and Perry 2008; Futch *et al.* 2009). *Ganoderma* species can occur as saprophytic or opportunistic wound pathogens that invade or kill the sapwood, causing heart rot or butt rot (Futch *et al.* 2009). It is unlikely to be associated with fresh, mature harvested stone fruit.	No

Scientific Name	**Common Name(s)**	**Is the pest likely to be associated with mature, fresh harvested fruit?**	**Consider Further ?**
Gilbertella persicaria (E.D. Eddy) Hesseltine [Mucorales: Choanephoraceae]	Fruit rot	No. A post-harvest decay that occurs naturally in plant residues in the soil and can be vectored by nitidulid beetles and vinegar flies, which carry spores to injured fruit, and can therefore develop on mechanical or insect injuries on the fruit (Ogawa 1995). Fruit rot caused by *G. persicaria* is generally considered a problem only with over-ripe fruit or when sanitation practices are poor, although aerial dissemination of spores of *G. persicaria* from rotten peaches on the orchard floor has been reported to be uncommon (Ginting *et al.* 1996; Ritchie *et al.* 2005). Additionally, injured fruit is affected and which develops rapid and obvious symptoms, allowing for infected fruit to likely be culled at harvest. Irrespective, Ginting (1996) reported very few fruit with natural wounds become infected.	No
Gloeophyllum sepiarium (Wulfen:Fr.) P. Karst. [Polyporales: Gloeophyllaceae]	Brown rot	No. Affects the wood and can be a problem in timbers used for articles such as railway sleepers (Farr and Rossman 2009). A wood rot fungi that is not associated with the fruit.	No
Gloeoporus dichrous (Fr.) Bres [Polyporales: Meruliaceae]	Wood rot	No. Causes white rot in trees (Adaskaveg and Ogawa 1990), but is not associated with the fruit.	No
Heterobasidion annosum (Fr. :Fr.) Bref [Russulales: Bondarzewiaceae]	Root rot	No. *Heterobasidion annosum* produces mycelium beneath the bark of dead or infected roots, causing decay to roots and heartwood of living trees, primarily on coniferous trees, and less commonly on other hosts (Pegler and Waterston 1998a). Although Farr *et al*. (2008) reports this species in California on Prunus armeniaca, it is reported as a trunk rot. It is therefore unlikely this pathogen would be associated with mature, fresh harvested stone fruit in the export region and is not considered further.	No
Issatchenkia scutulata (Phaff, M.W. Mill. & M. Miranda) Kurtzman, M.J. Smiley & C.J. Johnson [Saccharomycetales: Saccharomycetaceae]	Sour rot	No. Found on nectarine and peach fruit in California (Michailides *et al.* 2004). Michailides *et al* (2004) reported decay lesions on nectarine and peach from orchards and packing houses in Tulare County in July 2001. Symptoms included decay lesions from the stem or stylar end of the fruit, leaking juices which dissolved the cuticle, epidermis and flesh, and distinct furrows were observed in the tissue. Decay lesions ranged in size from 0.5-3.0cm in the field and 30-55mm for *I. scutulata* experimentally. Given the obvious symptoms of infection, affected fruit would be culled during harvest and processing, and would not be exported. Furthermore, the authors noted that to the best of their knowledge, this was the first report of sour rot caused by *I. scutulata* of commercial peaches and nectarines in the field and post-harvest situations in California (Michailides *et al.* 2004).	No

Scientific Name	**Common Name(s)**	**Is the pest likely to be associated with mature, fresh harvested fruit?**	**Consider Further ?**
Kloeckera apiculata (Reess) Janke [Saccharomycetales: Saccharomycetaceae]	Post-harvest disease; Sour rot	No. Found on nectarine and peach fruit in California (Michailides *et al.* 2994). Michailides *et al* (2004) reported decay lesions on nectarine and peach from orchards and packing houses in Tulare County in July 2001. Symptoms included decay lesions from the stem or stylar end of the fruit, leaking juices which dissolved the cuticle, epidermis and flesh, and distinct furrows were observed in the tissue. Decay lesions ranged in size from 0.5-3.0cm in the field and 9-39mm for *K. apiculata* experimentally. Given the obvious symptoms of infection, affected fruit would be culled during harvest and processing, and would not be exported. Furthermore, the authors noted that to the best of their knowledge, this was the first report of sour rot caused by *K. apiculata* of commercial peaches and nectarines in the field and post-harvest situations in California (Michailides *et al* 2004).	No
Laetiporus sulphureus (Bull. :Fr.) Murrill [Polyporales: Fomitopsidaceae]	Heart rot	No. This pathogen is reported to occur on trunks, stumps and logs (van der Westhuizen 1998) and as causing brown rot of living and dead trees (Adaskaveg and Ogawa 1990). It is therefore unlikely to be associated with mature, fresh harvested fruit and is not considered further.	No
Lambertella pruni Whetzel, Zeller, & Dumont in Dumont [Helotiales: Rutstroemiaceae]	Fruit rot	No. On fruits and seedlings. Found in apricots in California, bird cherry in Oregon and common plum in California (Farr and Rossman 2009). *Lambertella pruni* is a post-harvest rot that affects damaged fruit which are likely to be culled during harvest and processing. Therefore, fruit likely to be infected with *L. pruni* are unlikely to be harvested or exported.	No
Leucostoma persoonii Höhn Anamorph: *Cytospora leucostoma* Sacc. [Diaporthales: Valsaceae]	Peach canker; Cytospora canker	No. Cankers form on the main trunk, branch crotches, scaffold limbs, and older branches. Branch or twig infections may produce leaf symptoms during the growing season (Biggs 1995). In *Prunus* sp. in Pacific Northwest states, though only on wood of infected hosts (Biggs 1995).	No
Mucor circinelloides Tiegh. [Mucorales: Mucoraceae]		No. *Mucor circinelloides* is not considered a post-harvest pathogen during cold storage at 0^oC (Michailides 1991). Additionally, with the exception of one report, *Mucor* species have not been reported to cause post-harvest decay of stone fruit in California (Michalides 1991). Furthermore, *Mucor* spp are reported to require wounding to initiate infection and mature fruit are more susceptible to infection (Michailides 1991).	No
Mucor piriformis A. Fisch. [Mucorales: Mucoraceae]	Fruit rot	No. With the exception of one report, *Mucor* species have not been reported to cause post-harvest decay of stone fruit in California (Michalides 1991). Where sporadic occurrences of this pathogen have been reported, it is believed that unsanitary practices during harvest and/or in the packing house have contributed significantly to storage decay (Michaildes 1991). Furthermore, *Mucor* spp are reported to require wounding to initiate infection and mature fruit are more susceptible to infection (Michailides 1991).	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Mucor racemosus Fresen. [Mucorales: Mucoraceae]	Storage rot	No. *Mucor racemosus* is not considered a post-harvest pathogen during cold storage at $0^{o}C$ (Michailides 1991). Additionally, with the exception of one report, *Mucor* species have not been reported to cause post-harvest decay of stone fruit in California (Michalides 1991). Furthermore, *Mucor* spp are reported to require wounding to initiate infection and mature fruit are more susceptible to infection (Michailides 1991).	No
Maireina marginata (McAlpine) W.B. Cooke [Agaricales: Tricholomataceae]	Twig blight	No. Found on dead twigs of living plants. Found in Oregon on almonds and peaches (Farr and Rossman 2009).	No
Nectria cinnabarina (Tode:Fr.) Fr. Anamorph: *Tubercularia vulgaris* Tode:Fr. [Hypocreales: Nectriaceae]	Twig blight; Dieback; Coral spot fungus	No. Coral spot fungus in temperate regions (Booth 1998). Occurs as a saprophyte on dead wood but can be a weak opportunistic wound parasite on various host (Missouri Botanical Garden 2009). Not associated with mature fruit of marketable quality.	No
Ophiostoma californicum (DeVay, R.W. Davidson & W.J. Moller) Georg Hausner, J. Reid & Klassen [Ophiostomatales: Ophiostounaceae]		No. Found in California on injured bark tissue of *Prunus domestica* (Devay *et al.* 1968; Farr and Rossman 2009). As *Ceratocystis californica* reported from bark tissue of *Prunus domestica* in California after mechanical injury by shaker harvesters (DeVay et al 1968). After initiating infection, the fungus grows on the exposed bark and xylem tissues and invades healthy bark tissues (DeVay et al 1968).	No
Oxyporus corticola (Fr. :Fr.) Ryvarden [Basidiomycetes: Hymenochaetales]	White rot	No. Associated with dead trees (Adaskaveg and Ogawa 1990), not living trees or fruit.	No
Oxyporus similis (Bres.) Ryvarden [Basidiomycetes: Hymenochaetales]	White rot	No. While recorded from *Prunus* in California, *Oxyporus* spp. occurred only at low frequencies and then only associated with lower limbs and wounding sites (Adaskaveg and Ogawa 1990). Not associated with fruit.	No
Passalora circumcissa (Sacc.) U. Braun Teleomorph: *Mycosphaerella cerasella* Aderhold [Mycosphaerellales: Mycosphaerellaceae]	Cercospora leaf spot; Shot hole; Leaf spot	Yes. Overwinters on the orchard floor in leaf debris. Causes early defoliation (Sztejnberg 1995). Shallow circular spots may also form on the fruit (Little 1987).	Yes (WA)
Pestalotia laurocerasi Westend. [Ascomycetes: Xylariales]		No. Presence in California is based on a single historic reference to apricot (Farr *et al.* 2007). There is no evidence to suggest this pathogen is likely to be associated with fresh stone fruit from the USA.	No
Phanerochaete arizonica Burdsall & R.L. Gilbertson [Meruliales: Phanerachaetaceae]	White rot	No. Found on hardwoods and in California on peach (Farr and Rossman 2009) Causes wood rots.	No
Phanerochaete velutina (DC. :Fr.) P. Karst. [Basidiomycetes: Polyporales]		No. Reported from peach in California (Adaskaveg and Ogawa 1990). Adaskaveg and Ogawa (1990) notes the association only with dead trees and causing a white rot. The pathogen is a wood decay fungus and therefore not likely to be associated with mature, fresh harvested fruit or the commercial crop.	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Phyllactinia guttata (Wallr. :Fr.) Lév. [Erysiphales: Erysiphaceae]	Powdery mildew	No. Presence in Washington state is based on a single, historic record. Although this species is noted as having a broad host range, records are primarily reported in filbert, hazelnut, birch, hornbeam and alder (Dugan and Glawe 2006; Kapoor 1967). There is no evidence to suggest that this pathogen is likely to be associated with fresh stone fruit from the USA.	No
Phyllosticta circumscissa Cooke [Botryosphaeriales: Botryosphaeriaceae]		No. There are few historic occurrences on Prunus in the US, notably as a leaf spot. It is unlikely to be associated with fresh, mature harvested stone fruit.	No
Phymatotrichopsis omnivora (Duggar) Hennebert [Pezizales: Rhizinaceae]	Root rot	No. The pathogen causes root rot to its hosts. It overseasons as sclerotia or mycelial strands on roots and resumes growth and colonisation of roots under favourable conditions (Lyda 1995). Mycelial strands can radiate through the soil to find roots from adjacent trees (Lyda 1995). It is therefore unlikely this pathogen would be associated with mature, fresh harvested fruit.	No
Plicaturopsis crispa (Pers.:Fr.) D. Reid [Polyporales: Atheliaceae]		No. Primarily found on twigs and branches of hardwoods and conifers (Farr et al 2009) and occurs as a wood decay on dead wood/branches of its hosts (Grand and Vernia 2004). It is therefore unlikely to be associated with mature, fresh harvested stone fruit.	No
Podosphaera clandestina (Wallr.:Fr.) Lév. Anamorph: *Oidium crataegi* Grognot. [Erysiphales: Erysiphaceae]	Hawthorn powdery mildew	Yes. Apricot, cherry, nectarine, peach and plum are susceptible to hawthorn powdery mildew (Grove 1995). Fruit infections result in large economic losses (Grove 1995).	Yes
Podosphaera tridactyla (Wallr.) de Bary Anamorph: *Oidium passerinii* G. Bertol. [Erysiphales: Erysiphaceae]	Cherry powdery mildew	Yes. Apricot, cherry, nectarine and plum are susceptible to plum powdery mildew. Fruit infections result in large economic losses (Grove 1995). Fruit and leaves can both be infected (Grove 1995).	Yes (WA)
Rhodosticta quercina J.C. Carter [Anamorphic Phyllachoraceae]	President plum canker	No. Branches and limbs of plum trees are girdled by cankers. Brown leaves indicate the presence of cankers. Perennial cankers on older trees are often associated with injuries resulting from sunburn or shot-hole borers (*Scolytus rugulosus* Ratz.) (DeVay 1995). Affects the inner bark tissues.	No
Sistotrema brinkmannii (Bres.) J. Erikss. [Polyporales: Sistotremataceae]	No common name but usually associated with wood	No. Reported by Ullrich and Raper (1975) to causes wood rots and is therefore not likely to be associated with mature, fresh harvested fruit.	No
Stereum ochraceoflavum (Schwein.) Ellis [Russulales: Stereaceae]		No. *Stereum ochraceoflavum* is reported as a wood-decay fungus occurring on dead twigs and branches of hardwood species, primarily Quercus (Gibson 2007; Afyon et al 2005). Although Farr *et al.* (2009) records this species on *Prunus persica*, it is reported on wood and from South Carolina. It is unlikely this pathogen would be associated with fresh, mature harvested fruit in the export region.	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Taphrina pruni Tul. [Taphrinales: Taphrinaceae]	Leaf blister; Plum pockets; Bladder plum	Yes. Occurs on European plum. Affects leaves, stems and fruit of *Prunus* species. Symptoms on fruit are more obvious and prevalent than those on leaves or shoots. Fruit distort and enlarge, with spongy or hollow cankers, with or without pits. Disease development is similar to that of peach leaf curl (Hickey 1995b).	Yes (WA)
Taphrina pruni-subcordatae (Zeller) Mix [Taphrinales: Taphrinaceae]	Witches' broom	No. Reported by (Farr and Rossman 2009) as being on common plum in Oregon, and Klamath (Pacific) plum in California, Colorado and Oregon, but this pathogen is considered to be only a pest of the Klamath plum. Unlikely to be associated with imported domestic plum fruit.	No
Tyromyces galactinus (Berk.) J. Lowe [Polyporales: Polyporaceae]		No. On hardwoods, found in common plum in Oregon and *Prunus* sp. in New York and Oregon (Farr and Rossman 2009). Causes wood rots and is not likely to be associated with mature, fresh harvested fruit.	No
Valsa ceratosperma (Tode :Fr.) Maire [Diaporthales: Valsaceae]	Canker	No. This pathogen is reported to be associated with dead or dying twigs and branches of numerous woody angiosperms (Hayova and Minter 1998). It is primarily a pathogen of apple, found occasionally on pear and quince, and primarily causes cankers around fruit scars, twig stubs, branch crotches, and sites of mechanical injury or winter injury to the bark (Biggs 1993). It is therefore unlikely this pathogen would be associated with mature, fresh harvested fruit.	No
Valsaria insitiva (Tode) Ces. & De Not. Anamorph: *Cytospora cincta* Sacc. [Diaporthales: Valsaceae]	Perennial canker of peach; Canker; Dieback	No. Cankers form on the main trunk, branch crotches, scaffold limbs, and older branches. Branch or twig infections may produce leaf symptoms during the growing season (Biggs 1995)	No
Verticillium albo-atrum Reinke & Berthier [Anamorphic Phyllachorales]	Verticillium wilt	No. Chambers (1959) reports this species from potato and tomato with a question mark against the report for tomato. We note DAFWA's comment that Shivas (1989) lists this organism as doubtful in WA, however, in the absence of information demonstrating its absence, consideration must be given to existing reports. Furthermore, DAFWA has previously assessed this pathogen in Poole et al (2003) in its assessment of pests and pathogens associated with stone fruit from eastern Australia. In this assessment, this pathogen was considered to be a root pathogen and not likely to be associated with the importation pathway, citing Gubler (1995) as a supporting reference. Biosecurity Australia has also reviewed Gubler (1995) and also considers this organism is unlikely to be associated with mature, fresh harvested fruit as it is a soil inhabitant surviving in the roots of infected trees. Transmission is noted as being through transplanting diseased plants, windblown soils and propagation knives. This pathogen is therefore not considered further.	No
PHYTOPLASMAS			
Candidatus Phytoplasma pruni	X-disease	No. Spread is by phloem feeding vectors and by grafting (Kirkpatrick *et al.* 1995). Transmission through fruit or seed is not known from *Prunus.*	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Candidatus Phytoplasma ulmi	Peach yellows	No. Fruits produced on diseased limbs develop prematurely (Kirkpatrick 1995). Spread is by the plum leafhopper (*Macropsis trimaculata* (Fitch)) and by grafting (Kirkpatrick 1995). Transmission through fruit or seed is not known from *Prunus.*	No
STRAMINOPILA			
Phytophthora syringae (Kleb.) Kleb. [Peronosporales: Pythiaceae]	Canker; Brown rot; Crown & root rot	No. Soil-borne disease. Infection is initiated in root, crown, trunk, or scaffold tissues and cankers are present. Leaves become sparse, small and chlorotic. Fruits on affected trees may be undersized, highly coloured and sunburned. Dieback can occur and exposed bark can be invaded by bark-boring insects (Browne and Mircetich 1995). Not directly associated with the fruit.	No
Pythium sylvaticum W.A. Campb. & J.W. Hendrix [Pythiales: Pythiaceae]		No. *Pythium sylvaticum* reports provided by UKNCC (2009) were all soil isolations. Garzón *et al.* (2007) reports an isolation of this species on *Prunus persica* in the USA in 1966, but no mention is made to the source region within the US. Spencer (2005) notes its distribution in both Idaho and Washington, however, *Prunus* is not reported as a host. Like other *Pythium* species, this fungus is soil-borne, causing damping off of seedlings and is transmitted through contaminated soil, organic matter (oospores), and water (sporangia) (Spencer 2005).	No
VIROIDS			
Apple scar skin viroid		No. Primarily a pathogen of apple and pear (CABI 2007; Németh 1986), with only limited reports in stone fruit from Xinjiang, China (Zhao and Niu 2008a). Transmission is by grafting and budding and there is no known vector, and no evidence of seed transmission (CABI 2007; Howell *et al.* 1998; Németh 1986). It is unlikely to be associated with fresh mature harvested fruit in the export region.	No
Peach latent mosaic viroid	Peach blotch Peach calico	No. Transmitted by budding and grafting. Peach is a host. Natural symptoms include deformed leaves, spotted small deformed fruit, bud and shoot necrosis (Foster 1995).	No
VIRUSES			
American plum line pattern virus ICTV 00.010.0.02.002	APLPV	No. Many records are unconfirmed or misidentifications of other viruses with Californian records referring to similar symptoms caused by Prunus necrotic ringspot virus (CABI 2007). This virus is not reported to be seed-borne and grafting is the only known mode of transmission (Mink 1995b); Nemeth 1986). It is unlikely to be associated with fresh mature stone fruit in the export region.	No
Apricot ring pox Syn: Apricot pit pox	Cherry twisted leaf; Apricot ring spot	Yes. An undetermined, graft transmissible agent causes this disease, but no vector has been identified. Symptoms appear in fruit, but the number of fruit affected each year can vary greatly (Waterworth 1995).	Yes (WA)
Asteroid spot virus Syn: Peach Asteroid Spot Agent		No. Causes deformed fruit, leaf spots and discolouration (Foster 1995). Considered a minor pathogen that is transmissible by budding and grafting. Seed transmission is not known. Fruit is not considered a pathway for spread.	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Cherry green ring mottle virus		No. Fruit from infected trees may be bitter and have necrotic pitting, but there is no known mode of transmission associated with fruit. This pathogen is transmitted by grafting and neither spread by a vector or through seed is known (CABI 2009).	No
Cherry mottle leaf trichovirus ICTV 76.0.1.T.DE.1 Syn: Prunus virus 1		No. Occurs naturally in bitter cherry in the northwestern US and British Columbia. From the reservoir host, the virus is carried by the vector bud mite (*Eriophyes inaequalis* Wilson & Oldfield) to sweet cherry, peach and apricot (Hansen and Oldfield 1995). No records to suggest transmission through seed or fruit.	No
Cherry rasp leaf nepovirus ICTV 18.0.3.T.003 Syn: Flat apple virus	Cherry rasp leaf	No. The virus causes enations of leaves, often restricted to the lower parts of the tree (EPPO/CABI 1997q). While it can be isolated from the sap of trees, there is no evidence that it has been isolated from fruit. Transmitted only by its nematode vector or by mechanical inoculation (EPPO/CABI 1997q).	No
Cherry rusty mottle virus		No. Occurs primarily in cherries, though apricot, peach and plum are noted as susceptible (Nemeth 1986; Mink 1995a). Only a slow natural spread is reported from infected trees to neighbouring healthy trees in sweet cherry orchards (Mink 1995a; Nemeth 1986). Transmission occurs through the movement and propagation of infected planting material (Mink 1995a; Nemeth 1986). It is unlikely to be associated with fresh, mature harvested stone fruit.	No
Cherry virus A		No. Occurs primarily in cherries, with few reports of its natural occurrence in other hosts, and the available literature suggests that it is uncertain whether it can be associated with any specific symptoms in its hosts (Barone and Alioto 2006; Svanella-Dumas *et al.* 2005). Additionally, it is reported as a graft-transmissible agent (Svanella-Dumas *et al.* 2005; Brunt *et al.* 1996). It is unlikely to be associated with fresh, mature stone fruit.	No
Peach mosaic virus	Peach mosaic	No. Peach mosaic is highly infectious. Vector is the peach bud mite, *Eriophyes insidiosus* (Keifer & Wilson), which feeds and reproduces on developing leaf primordia within the bud. Peach mosaic is known to spread naturally via the vector from peach to peach, apricot, and almond and from wild plum to peach. Fruit can be deformed and unmarketable as the fruit surface along the suture side becomes rough before the stone-hardening stage (Hansen 1995). There is no evidence of seed transmission and fruit are not considered a pathway for the spread of the virus.	No
Peach mule's ear Syn: Almond bud failure		No. Transmitted by budding and grafting. Hosts include almond and peach. Natural symptoms include erect leaves, bud failure, bare branches, shoot dieback, deformed fruit and lower yields (Foster 1995).	No
Peach stubby twig virus		No. Transmitted by budding and grafting. Hosts include peach and nectarine. Natural symptoms include chlorotic and deformed leaves, thick twigs, bud failure and small fruit (Foster 1995). No evidence of seed transmission.	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Peach wart virus Syn: Peach blister virus		No. Wart-like outgrowths develop on the fruit surfaces or in a restricted region around the stylar end or along the suture of the young fruit. Affected fruit can be small and misshapen. Appears to have no effect on vegetative growth and development of infected peach trees. Peach wart is caused by an unidentified graft-transmissible agent (Uyemoto 1995). Peach is a natural host of the pathogen (Uyemoto 1995). Not found to be seed transmissible (Uyemoto 1995).	No
Plum pox potyvirus ICTV 57.0.1.0.054 *Prunus* virus 7 Sharka virus	Plum pox; Sharka	Yes. Causes serious losses in plum, peach, nectarine and apricot. Important method of spread is via diseased plant material and this accounts for much of the rapid spread observed within European countries. *Plum pox potyvirus* is extremely difficult to eradicate once established. The virus can be spread by aphids and infection is often confined to one or two limbs of a tree. Considerable spread can occur from new disease foci before infections are recognised (Adams 1995). Virus can be isolated from fruit and/or seed. There have been recent reports of aphids being able to transmit the virus from infected fruit (Gildow *et al.* 2004).	Yes
Prunus diamond canker virus		No. Transmitted by budding and grafting. Prune is a host. Natural symptoms include trunk and branch cankers, rough bark and tree decline (Foster 1995).	No
Tobacco necrosis viruses: *Chenopodium necrosis virus* *Olive mild mosaic virus* *Tobacco necrosis virus A* *Tobacco necrosis virus D* Tobacco necrosis virus Nebraska isolate		Yes. Tobacco necrosis viruses (TNVs) have been isolated from apricot in the US (Uyemoto and Gilmer 1972). Virus particles released from plant debris and acquired in soil by zoospores of chytrid fungi (*Olpidium* spp.) may be transmitted to suitable hosts (Uyemoto 1981; Spence 2001; CABI 2009). Necroviruses may also be transmitted in soil water without a vector (Lommel *et al*. 2005).	Yes
Tomato ringspot nepovirus Syn: Peach yellow bud mosaic virus Prune brown line Prunus stem pitting	ToRSV	No. Natural spread of this virus in orchards and nurseries results directly from transmission by nematode vectors, including the dagger nematodes *Xiphinema americanum* Cobb, *X. rivesi* Dalmasso and *X. californicum* Lamberti & Bleve-Zacheo. The virus can be transmitted by grafting and budding. In infested sites, the nematode and virus can persist for years on roots of infected perennial and herbaceous plants. The virus is seed-borne in several weed hosts (Gonsalves 1995), but no mention is made of seed transmission in *Prunus* spp.	No

Table A3: Potential for pathway associated pests to establish in Australia and have economic consequences

Scientific Name	Common Name(s)	Potential for Establishment and Spread	Potential for Consequences	Consider Further ?
ACARI (Mites)				
Tarsonemus smithi Ewing, 1939 [Acari: Tarsonemidae]	Tarsonemid mite	Yes. Distributed globally (Nucifora and Vacante 2004) in environments similar to Australia.	No. While some tarsonemid mites are reported to be important phytophagous pests on some crops, this species is considered to be a fungivore. Not associated with any damage to plants or other adverse effects.	No
Tetranychus canadensis (McGregor, 1950) [Acari: Tetranychidae]	Hawthorne spider mite, Canadian spider mite	Yes. Distributed throughout the United States and Canada (Baker and Tuttle 1994) as well as in the middle East, Africa and Poland (Jeppson *et al.* 1975). Present in a range of climates and environments similar to areas of Australia.	Yes. Feeding on the underside of leaves causes leaves to turn rusty brown and may also cause leaf drop (Jeppson *et al.* 1975). Defoliation would affect the vitality and fruit yield of trees. Also affects ornamental plants and crops such as barley (Jeppson *et al.* 1975).	Yes
Tetranychus mcdanieli McGregor, 1931 [Acari: Tetranychidae]	McDaniel spider mite	Yes. Wide host range and distributed across North America in environments similar to Australia (Hoyt and Beers 1993; Roy *et al.* 2005)	Yes. Mites and webbing may form in the leaves and calyx end of the fruit (Hoyt and Beers 1993). Can cause fruits to fail to colour and size properly in heavily infested trees, with lowered fruit yield the following year (Caprile *et al.* 2009b).	Yes
Tetranychus pacificus (McGregor, 1919) [Acari: Tetranychidae]	Pacific spider mite	Yes. Wide host range includes Australian domestic crops. Distributed in a variety of environments across North America with similarities to Australia (CABI 2007).	Yes. Damage caused by high populations feeding on leaves can adversely affect tree vitality and crop yield (CABI 2007).	Yes
Tetranychus turkestani Ugarov & Nikolski, 1937 [Acari: Tetranychidae]	Strawberry spider mite	Yes. Wide host range and distributed globally in a variety of environments similar to Australia. (Midgeon and Dorkeld 2006).	Yes. One of the most widespread and serious pest of a range of agricultural crops (Jeppson *et al. 1975)*	Yes
DIPTERA (Flies)				
Rhagoletis completa Cresson, 1929 Synonym: *Rhagoletis suavis* (Loew) [Diptera: Tephritidae]	Walnut husk fly; Walnut husk maggot	Yes. Distributed in western US and Europe in similar environments to Australia (CABI 2007) .	Yes. Eggs laid in fruit, maggots feed on fruit leading to unmarketable fruit (CABI 2007).	Yes

Scientific Name	Common Name(s)	Potential for Establishment and Spread	Potential for Consequences	Consider Further ?
Rhagoletis pomonella (Walsh, 1867) [Diptera: Tephritidae]	Apple maggot	Yes. Wide host range and distributed in a variety of environments across North America with similarities to Australia (CABI 2007).	Yes. Eggs laid in fruit, maggots feed on fruit leading to unmarketable fruit (CABI 2007).	Yes
HEMIPTERA (Aphids, leafhoppers, mealybugs, psyllids, scales, true bugs, whitflies)				
Closterotomus norvegicus (Gmelin, 1788) Synonym: *Calocoris norvegicus* (Gmelin, 1788) [Hemiptera: Miridae]	Potato bug	Yes. Wide host range and distributed globally in environments similar to Australia, suggests potential for establishment and spread (Bentley *et al.* 2006g; Ferguson *et al.* 1997; Schroeder *et al.* 1998.	Yes. Adults feed on fruit and seed crops and can lead to severe economic losses (Bentley *et al.* 2006g; Schroeder *et al.* 1998).	Yes (WA)
Diaspidiotus forbesi (Johnson, 1896) Synonym: *Quadraspidiotus forbesi* (Johnson, 1896) [Hemiptera: Diaspididae]	Forbes scale	Yes. Wide host range and distributed across US in environments similar to Australia, suggests potential for establishment and spread (Guillebeau *et al.* 2006; Miller and Davidson 2005).	Yes. Causes by feeding on sap in twigs, branches and fruit (Grantham 2006). Trees may become weakened and die (Grantham 2006). Reported as a serious armoured scale pest (Miller and Davidson 2005).	Yes
Diaspidiotus juglansregiae (Comstock, 1881) Synonym: *Quadraspidiotus juglansregiae* (Comstock, 1881) [Hemiptera: Diaspididae]	Walnut scale	Yes. Present in California (Dreistadt *et al.* 2007a), which has similar climatic conditions to many areas of Australia.	Yes. Feeds on plant juices. This causes loss of vigour, dieback of infested plant parts, and cracking of bark (Bentley *et al.* 2009i).	Yes
Diaspidiotus ostreaeformis (Curtis, 1843) [Hemiptera: Diaspididae]	Oystershell scale; Pear oyster scale	Yes. Wide host range and distributed globally, found in Tas., Vic. and NSW suggest potential for spread into WA (APPD 2009; CABI 2007).	Yes. Infests mostly the bark on stems and branches of the trees. Sometimes it can be found on the fruits, where it causes red spot (CABI 2007). In cases of heavy infestation the branches of the trees can die (CABI 2007).	Yes (WA)
Lygus elisus van Duzee, 1914 [Hemiptera: Miridae]	Pale legume bug; Lucerne plant bug	Yes. Wide host range with many generations per year (Bentley *et al.* 2006g).	Yes. Eggs laid in fruit and adults feed on fruit which can lead to severe economic losses (Bentley *et al.* 2006g; Mueller *et al.* 2005).	Yes
Lygus hesperus Knight, 1917 [Hemiptera: Miridae]	Western tarnished plant bug	Yes. Wide host range, many generations per year and distributed across western US in environments similar to those found in Australia, suggests potential for establishment and spread (Bentley *et al.* 2006g; Mueller *et al.* 2005).	Yes. Eggs laid in fruit and adults feed on fruit which can lead to severe economic losses (Bentley *et al.* 2006g).	Yes

Scientific Name	Common Name(s)	Potential for Establishment and Spread	Potential for Consequences	Consider Further ?
Lygus lineolaris (Palisot de Beauvois, 1818) [Hemiptera: Miridae]	Tarnished plant bug	Yes. Wide host range and distributed in a variety of environments across central and Northern America with similarities to Australia, suggests potential for establishment and spread (Bostanian *et al.* 2005; CABI 2007).	Yes. Both nymphs and adults feed by sucking juices from leaf and flower buds, flowers and seeds. Feeding on fruit can cause malformation of fruit, abnormal growth habits, necrosis, abscission of fruiting structures and reduced marketability. (Bostanian *et al.* 2005; CABI 2007).	Yes
Parlatoria oleae (Colvée, 1880) [Hemiptera: Diaspididae]	Olive parlatoria scale	Yes. Presence in Qld. and NSW suggest potential for spread and establishment in Australia (CSIRO 2004).	Yes. All parts of the host plant, except the roots, are attacked. Fruit feeding can cause marking and fruit deformation, reducing fruit marketability (CABI2009).	Yes (WA)
Phenacoccus aceris (Signoret, 1875) [Hemiptera: *Pseudococcidae*]	Apple mealybug	Yes. A very broad host range, including all deciduous fruit and nut trees (apple, cherry, pear, plum, apricot, hazelnut), small fruit (grape, currant, gooseberry, blueberry) many shade trees (maple, oak, birch, willow, ash, linden, elm, rowan) and various ornamentals (cotoneaster, pyracantha, hawthorn, quince, spirea) (Beers 2007). All of these plants are widely distributed in Australia. It is present in US states where climatic conditions similar to those in Australia exist. Second instar nymphs overwinter in cocoons under bark or in bark cracks in colder northern regions (Beers 2007). It is likely that this species could establish in Australia.	Yes. Apple mealybug is a known vector of little cherry virus 2 a virus (Raine *et al.* 1986) which is regulated in British Columbia. The virus has been widespread and devastating in the Kootenay (British Columbia) cherry growing region (Beers 2007; Rott & Jelkmann 2001). It is also a known vector of Grapevine leafroll-associated virus-1 and -3 (GLRaV-1 and -3) in France where it is considered as becoming a serious pest (Sforza *et al.* 2003).	Yes
Pseudaulacaspis pentagona (Targioni Tozzetti, 1886) [Hemiptera: Diaspididae]	Peach white scale	Yes. Wide host range, global distribution and presence in NSW and Qld. suggests potential for establishment and spread in WA (CABI 2007) Erkiliç and Uygun 1997) .	Yes. Heavy infestations are often found as thick crusts on tree trunks and older branches in temperate regions, and rarely on the roots. The leaves and fruits are not usually infested. Severe infestations can cause branches or trees to die. (CABI 2007; Erkiliç and Uygun 1997) .	Yes (WA)
Pseudaulacaspis prunicola (Maskell) [Hemiptera: Diaspididae]	White prunicola scale			
Pseudococcus calceolariae (Maskell, 1879) [Hemiptera: Pseudococcidae]	Citrophilus mealybug	Yes. Wide host range, globally distribution and presence in eastern Australia and Tasmania suggests potential for establishment and spread in WA (CABI 2007; Gullan 2000) .	Yes. Mealybugs produce honeydew that serves as a substrate for the development of sooty mould which discolours the fruit (CABI 2007).	Yes (WA)

Scientific Name	Common Name(s)	Potential for Establishment and Spread	Potential for Consequences	Consider Further ?
Pseudococcus comstocki (Kuwana, 1902) [Hemiptera: Pseudococcidae]	Comstock mealybug	Yes. Distributed globally in a variety of environments similar to Australia, suggests potential for establishment and spread (CABI 2007; Grafton-Cardwell *et al.* 2008).	Yes. Feeds on fruit leaves and stems. Mealybugs produce honeydew that serves as the substrate for the development of sooty mould which prevents photosynthesis in addition to making the plant unsightly (CABI 2007; Grafton-Cardwell *et al.* 2008).	Yes
Pseudococcus maritimus (Ehrhorn, 1900) [Hemiptera: Pseudococcidae]	Grape mealybug	Yes. The grape mealybug is present in California, where conditions similar to those in Australia exist. It is likely that this species could establish in Australia.	Yes. Mealybugs feed on sap and produce honeydew. Feeding directly damages plants and sooty mould growth on honeydew can reduce the marketability of fruit.	Yes
LEPIDOPTERA (Butterflies, Moths)				
Anarsia lineatella Zeller, 1839 [Lepidoptera: Gelechiidae]	Peach twig borer moth	Yes. Wide host range, global distribution within environments similar to Australia and former presence in Qld. suggest potential for establishment and spread within Australia (CABI 2007; Gencsoylu *et al.* 2006; Pickel *et al.* 2006c).	Yes. Feeds on fruit reducing marketability. (CABI 2007; Gencsoylu *et al.* 2006; Pickel *et al.* 2006c) .	Yes
Archips argyrospila (Walker, 1863) [Lepidoptera: Tortricidae]	Fruit-tree leafroller	Yes. Wide host range and distributed across North America in environments similar to Australia, suggests potential for establishment and spread (Bentley *et al.* 2006a; Bentley *et al.* 2006b; Deland *et al.* 1993) .	Yes. Larvae feed on leaves and fruit. Fruit damage reduces marketability. (Bentley *et al.* 2006a; Bentley *et al.* 2006b; Hollingsworth 2007) .	Yes
Archips podana (Scopoli, 1763) [Lepidoptera: Tortricidae]	Great brown twist moth	Yes. Wide host range and distributed in US and Europe with similar environments to Australia, suggests potential for establishment and spread (CABI 2007; Safonkin and Triseleva 2005) .	Yes. Larvae feed on fruit reducing marketability (CABI 2007).	Yes
Archips rosana (Linnaeus, 1758) [Lepidoptera: Tortricidae]	European leafroller	Yes. Wide host range distributed across Europe, localised in North America in environments similar to those in Australia, suggests potential for establishment and spread (CABI 2007).	Yes. Surface feeding damage to young fruitlets may result in reduced marketability (CABI 2007).	Yes
Argyrotaenia citrana (Fernald, 1889) [Lepidoptera: Tortricidae]	Orange tortrix	Yes. Wide host range, localised to Pacific Northwest states, suggests potential for establishment and spread (Bentley *et al.* 2009d; CABI 2007; Coates *et al.* 2009a; Walker and Welter 2004) .	Yes. Larvae feed on leaves, buds, and the surface of fruit, causing severe damage as well as contamination with their excrement resulting in unmarketable fruit. Low populations can cause significant damage. Important pest of apples (Bentley *et al.* 2009d; CABI 2007; Coates *et al.* 2009a; Walker and Welter 2004).	Yes

Scientific Name	Common Name(s)	Potential for Establishment and Spread	Potential for Consequences	Consider Further ?
Choristoneura rosaceana (Harris, 1841) [Lepidoptera: Tortricidae]	Oblique banded leafroller	Yes. Wide host range, distributed across North America with similar environments to Australia, suggests potential for establishment and spread (Bentley *et al.* 2006d;CABI 2007; Coates *et al.* 2009b; Wilkinson *et al.* 2004) .	Yes. The fruit are scarred and distorted by early feeding reducing marketability. Fruit contamination during harvesting can lead to further economic losses. Major pest of apple (Bentley *et al.* 2006d; CABI 2007; Coates *et al.* 2009b; Wilkinson *et al.* 2004).	Yes
Cydia latiferreana (Walsingham, 1879) [Lepidoptera: Tortricidae]	Filbertworm	Yes. Distributed across North America with similar environments to Australia, suggests potential for establishment and spread (Curtis *et al.* 1992; Dohanian 1940).	Yes. Larvae bore into fruit, chief pest of filberts (Curtis *et al.* 1992; Dohanian 1940).	Yes
Cydia pomonella (Linnaeus, 1758) [Lepidoptera: Tortricidae]	Codling moth	Yes. Established in NSW Qld., Vic., SA and Tas. suggests potential for establishment and spread in WA (CABI 2007).	Yes. Larvae damage developing shoots and fruit. Severe damage can occur causing a reduction in marketability. Serious pest of apple and pear (CABI 2007; Caprile *et al.* 2009c; Lacey *et al.* 2006).	Yes (WA)
Grapholita molesta (Busck, 1916) [Lepidoptera: Tortricidae]	Oriental fruit moth	Yes. Wide host range, distributed globally present in all states except WA and NT suggests potential for establishment and spread (Barcenas *et al.* 2005; Bentley *et al.* 2006h; CABI 2007; Gencsoylu *et al.* 2006).	Yes. Larvae eat and bore into fruit reducing marketability. Major pest of peach (CABI 2007; Bentley *et al.* 2006h; Gencsoylu *et al.* 2006).	Yes (WA)
Grapholita packardi Zeller, 1875 Synonym: *Cydia prunivora* (Zeller, 1875) [Lepidoptera: Tortricidae]	Cherry fruitworm	Yes. Wide host range distributed across the US and localised in Canada in environments similar to Australia, suggests potential for establishment and spread (Barcenas *et al.* 2005; CABI 2007).	Yes. Larvae eat fruit resulting in reduction in marketability (Barcenas *et al.* 2005; CABI 2007).	Yes
Grapholita prunivora (Walsh, 1868) Synonym: *Cydia prunivora* (Walsh, 1868) [Lepidoptera: Tortricidae]	Lesser apple fruitworm; Plum moth	Yes. Distributed across US and Canada in environments similar to Australia, suggests potential for establishment and spread (Barcenas *et al.* 2005; CABI 2007).	Yes. Larvae eat fruit and excrement build in fruit reducing marketability (CABI 2007).	Yes
Pandemis pyrusana Kearfott, 1907 [Lepidoptera: Tortricidae]	Apple pandemis; Pandemis leafroller	Yes. Wide host range and distributed across North America in environments similar to Australia, suggests potential for establishment and spread (Caprile *et al.* 2009d; Jones *et al.* 2005).	Yes. Feeds on fruit, resulting in scarring, distortion and causing reduction in fruit marketability. Key pest of apple (Caprile *et al.* 2009d; Jones *et al.* 2005).	Yes

Scientific Name	Common Name(s)	Potential for Establishment and Spread	Potential for Consequences	Consider Further ?
Platynota stultana Walsingham, 1884 [Lepidoptera: Tortricidae]	Orange tortrix; Omnivorous leafroller	Yes. Wide host range, distributed across US, in environments similar to those in Australia, suggests potential for establishment and spread (Bentley *et al.* 2006c; Bentley *et al.* 2009e; CABI 2007).	Yes. Feeds on fruit. Young fruit may be destroyed, and scars on older fruit will reduce marketability. Important pest on many commodities (Bentley *et al.* 2006c; Bentley *et al.* 2009e; CABI 2007).	Yes
THYSANOPTERA (thrips)				
Frankliniella intonsa (Trybom, 1895) [Thysanoptera: Thripidae]	Taiwan flower thrips	Yes. Wide host range and distributed globally in environments similar to Australia, suggests potential for establishment and spread (CABI 2007; Jones 2005).	Yes. Feeds on fruit and lays eggs in fruit reducing marketability. Can be vector for economically important viruses (CABI 2007; Jones 2005).	Yes
Frankliniella occidentalis (Pergande, 1895) [Thysanoptera: Thripidae]	Western flower thrips	Yes. This thrips has a wide host range, is distributed globally and has a limited distribution in Australia, indicating that suitable environments exist in Australia for this thrips to establish (CABI 2007; Davidson *et al.* 2006; Jones 2005).	Yes. Major pest and can be responsible for epidemics of tomato spotted wilt. Feeds on leaves and flowers (CABI 2007; Davidson *et al.* 2006; Jones 2005; Stavisky *et al.* 2002).	Yes
Frankliniella tritici (Fitch, 1855) [Thysanoptera: Thripidae]	Flower thrips	Yes. Wild host range and distributed across North America in environments similar to Australia, suggests potential for establishment and spread (Stavisky *et al.* 2002; University of Illinois 2004).	Yes. Major pest and can cause epidemics of tomato spotted wilt. Feeds on leaves and flowers (Stavisky *et al.* 2002; University of Illinois 2004).	Yes
Taeniothrips inconsequens (Uzel, 1895) [Thysanoptera: Thripidae]	Pear thrips	Yes. Wide host range and distributed globally in environments similar to Australia, suggests potential for establishment and spread (CABI 2007; Rieske and Raffa 2003).	Yes. Adults and larvae feed on buds, flowers, young fruit, fruit stalks and leaves resulting in reduced marketability. *Taeniothrips inconsequens* has also been implicated as a carrier of pear blight (*Bacillus amylovorus*) (CABI 2007).	Yes
BACTERIA				
Xylella fastidiosa (Wells, Raju, Hung, Weisburg, Mandelco-Pauland, Brenner, 1987) [Xanthomonadales: Xanthomonadaceae]	Phoney peach disease; Pierce's disease; California vine disease; Anaheim disease	Yes. This bacterium has been isolated from fruit and seeds of other crops (i.e. citrus) and seed transmission has been reported (Alderz *et al.* 1989; Li *et al.* 2003). Hosts exist in Australia and endemic xylem-feeders could potentially vector the bacterium.	Yes. The most severe symptoms typically occur on grapevines, and a wide variety of other hosts are also susceptible. May cause death or severe decline in susceptible hosts (Alderz *et al.* 1989; Li *et al.* 2003).	Yes

Scientific Name	Common Name(s)	Potential for Establishment and Spread	Potential for Consequences	Consider Further ?
FUNGI				
Blumeriella jaapii (Rehm) Arx Anamorph: *Phloeosporella padi* (Lib.) Arx [Helotiales: Dermateaceae]	Cherry leaf spot; Shot hole; Leaf spot	Yes. Suitable hosts, particularly cherry, are grown in Australia. The environmental conditions are therefore likely to be suitable for this fungus. *Blumeriella jaapii* has previously been recorded and subsequently eradicated from Australia.	Yes. This fungus can severely affect leaves and occasionally fruit resulting in economic losses and increased production costs (Jones 1995a).	Yes
Passalora circumcissa (Sacc.) U. Braun Teleomorph: *Mycosphaerella cerasella* Aderhold [Mycosphaerellales: Mycosphaerellaceae]	Cercospora leaf spot; Shot hole; Leaf spot	Yes. Suitable hosts are present in Australia (Farr and Rossman 2009).	Yes. Infection can cause spots and holes in leaves and premature defoliation (Little 1987).	Yes (WA)
Podosphaera clandestina (Wallr.:Fr.) Lév. Anamorph: *Oidium crataegi* Grognot. [Erysiphales: Erysiphaceae]	Hawthorn powdery mildew	Yes. Rain and wind disperse the fungus suggesting potential for spread (Grove 1995).	Yes. Most serious pre-harvest disease of cherry in Washington State (Grove 1998; Grove and Boal 1991). Infection common on foliage though can be economically devastatng if occurs on fruit (Grove 1998).	Yes (WA)
Podosphaera tridactyla (Wallr.) de Bary Anamorph: *Oidium passerinii* G. Bertol. [Erysiphales: Erysiphaceae]	Cherry powdery mildew	Yes. Distributed across the globe in environments similar to those in Western Australia suggest potential for establishment and spread (CABI 2007).	Yes. Infects leaves, requires fungicidal control (CABI 2007).	Yes (WA)
Taphrina pruni Tul. [Taphrinales: Taphrinaceae]	Leaf blister; Plum pockets; Bladder plum	Yes. Distributed across the globe in environments similar to those in Western Australia, including some states of Australia, suggesting potential for establishment. Water can disperse the fungus, suggesting the potential for spread (EPPO 2004b).	Yes. Can infect leaves and shoots. Fruit infection results in unmarketable fruit (EPPO 2004b).	Yes (WA)
VIRUSES				
Apricot ring pox Syn: Apricot pit pox	Cherry twisted leaf; Apricot ring spot	No. The disease is transmitted by grafting and there is no known vector (Bodine and Reeves 1951; Nemeth 1986; Hansen and Mink 1995).	Not assessed	No

Scientific Name	Common Name(s)	Potential for Establishment and Spread	Potential for Consequences	Consider Further ?
Plum pox potyvirus ICTV 57.0.1.0.054 *Prunus* virus 7 Sharka virus	Plum pox; Sharka	Yes. Found in several *Prunus* spp. hosts in a variety of environments similar to Australia, indicating the potential for establishment and spread. Aphids are suitable vectors for this virus. (EPPO/CABI 2004; Gildow *et al.* 2004).	Yes. Infects fruit, severely reducing financial yield available (EPPO/CABI 2004).	Yes
Tobacco necrosis viruses: *Chenopodium necrosis virus* *Olive mild mosaic virus* *Tobacco necrosis virus A* *Tobacco necrosis virus D* Tobacco necrosis virus Nebraska isolate		Yes. Tobacco necrosis virus strains are established in Australia (Teakle 1988). TNVs infect common vegetable crop plants, ornamental plants and tree species (Brunt and Teakle 1996; CABI 2009; Zitikaite and Staniulis 2009). TNVs are transmitted by *Olpidium* spp. (Rochon *et al*. 2004; Sasaya and Koganezawa 2006) and these vectors occur in Australia (McDougall 2006; Maccarone *et al.* 2008).	Yes. Tobacco necrosis viruses cause rusty root disease of carrot, Augusta disease of tulip, stipple streak disease of common bean, necrosis diseases of cabbage, cucumber, soybean and zucchini and ABC disease of potato (Uyemoto 1981; Smith *et al*. 1988; Xi *et al*. 2008; Zitikaite and Staniulis 2009).	Yes

Appendix B. Australia's biosecurity policy framework

Australia's biosecurity policies

The objective of Australia's biosecurity policies and risk management measures is the prevention or control of the entry, establishment or spread of pests and diseases that could cause significant harm to people, animals, plants and other aspects of the environment.

Australia has diverse native flora and fauna and a large agricultural sector, and is relatively free from the more significant pests and diseases present in other countries. Therefore, successive Australian Governments have maintained a conservative, but not a zero-risk, approach to the management of biosecurity risks. This approach is consistent with the World Trade Organization's (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement).

The SPS Agreement defines the concept of an 'appropriate level of protection' (ALOP) as the level of protection deemed appropriate by a WTO Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory. Among a number of obligations, a WTO Member should take into account the objective of minimising negative trade effects in setting its ALOP.

Like many other countries, Australia expresses its ALOP in qualitative terms. Our ALOP, which reflects community expectations through Australian Government policy, is currently expressed as providing a high level of sanitary and phytosanitary protection, aimed at reducing risk to a very low level, but not to zero.

Consistent with the SPS Agreement, in conducting risk analyses Australia takes into account as relevant economic factors:

- the potential damage in terms of loss of production or sales in the event of the entry, establishment or spread of a pest or disease in the territory of Australia
- the costs of control or eradication of a pest or disease
- and the relative cost-effectiveness of alternative approaches to limiting risks.

Roles and responsibilities within Australia's quarantine system

Australia protects its human[8], animal and plant life or health through a comprehensive quarantine system that covers the quarantine continuum, from pre-border to border and post-border activities.

Pre-border, Australia participates in international standard-setting bodies, undertakes risk analyses, develops offshore quarantine arrangements where appropriate, and engages with our neighbours to counter the spread of exotic pests and diseases.

[8] The Australian Government Department of Health and Ageing is responsible for human health aspects of quarantine.

At the border, Australia screens vessels (including aircraft), people and goods entering the country to detect potential threats to Australian human, animal and plant health.

The Australian Government also undertakes targeted measures at the immediate post-border level within Australia. This includes national co-ordination of emergency responses to pest and disease incursions. The movement of goods of quarantine concern within Australia's border is the responsibility of relevant state and territory authorities, which undertake inter- and intra-state quarantine operations that reflect regional differences in pest and disease status, as a part of their wider plant and animal health responsibilities.

Roles and responsibilities within the Department

The Australian Government Department of Agriculture, Fisheries and Forestry is responsible for the Australian Government's animal and plant biosecurity policy development and the establishment of risk management measures. The Secretary of the Department is appointed as the Director of Animal and Plant Quarantine under the *Quarantine Act 1908* (the Act).

There are three groups within the Department primarily responsible for biosecurity and quarantine policy development and implementation:

- Biosecurity Australia conducts risk analyses, including IRAs, and develops recommendations for biosecurity policy as well as providing quarantine advice to the Director of Animal and Plant Quarantine and AQIS
- AQIS develops operational procedures, makes a range of quarantine decisions under the Act (including import permit decisions under delegation from the Director of Animal and Plant Quarantine) and delivers quarantine services and
- Product Integrity, Animal and Plant Health Division (PIAPH) coordinates pest and disease preparedness, emergency responses and liaison on inter- and intra-state quarantine arrangements for the Australian Government, in conjunction with Australia's state and territory governments.

Roles and responsibilities of other government agencies

State and territory governments play a vital role in the quarantine continuum. Biosecurity Australia and PIAPH work in partnership with state and territory governments to address regional differences in pest and disease status and risk within Australia, and develop appropriate sanitary and phytosanitary measures to account for those differences. Australia's partnership approach to quarantine is supported by a formal Memorandum of Understanding that provides for consultation between the Australian Government and the state and territory governments.

Depending on the nature of the good being imported or proposed for importation, Biosecurity Australia may consult other Australian Government authorities or agencies in developing its recommendations and providing advice.

As well as a Director of Animal and Plant Quarantine, the Act provides for a Director of Human Quarantine. The Australian Government Department of Health and Ageing is responsible for human health aspects of quarantine and Australia's Chief Medical Officer within that Department holds the position of Director of Human Quarantine. Biosecurity Australia may, where appropriate, consult with that Department on relevant matters that may have implications for human health.

The Act also requires the Director of Animal and Plant Quarantine, before making certain decisions, to request advice from the Environment Minister and to take the advice into account when making those decisions. The Australian Government Department of the Environment, Water, Heritage and the Arts (DEWHA) is responsible under the *Environment Protection and Biodiversity Conservation Act 1999* for assessing the environmental impact associated with proposals to import live species. Anyone proposing to import such material should contact DEWHA directly for further information.

When undertaking risk analyses, Biosecurity Australia consults with DEWHA about environmental issues and may use or refer to DEWHA's assessment.

Australian quarantine legislation

The Australian quarantine system is supported by Commonwealth, state and territory quarantine laws. Under the Australian Constitution, the Commonwealth Government does not have exclusive power to make laws in relation to quarantine, and as a result, Commonwealth and state quarantine laws can co-exist.

Commonwealth quarantine laws are contained in the *Quarantine Act 1908* and subordinate legislation including the Quarantine Regulations 2000, the *Quarantine Proclamation 1998,* the *Quarantine (Cocos Islands) Proclamation 2004* and the *Quarantine (Christmas Island) Proclamation 2004*.

The quarantine proclamations identify goods which cannot be imported, into Australia, the Cocos Islands and or Christmas Island unless the Director of Animal and Plant Quarantine or delegate grants an import permit or unless they comply with other conditions specified in the proclamations. Section 70 of the *Quarantine Proclamation 1998,* section 34 of the *Quarantine (Cocos Islands) Proclamation 2004* and section 34 of the *Quarantine (Christmas Island) Proclamation 2004* specify the things a Director of Animal and Plant Quarantine must take into account when deciding whether to grant a permit.

In particular, a Director of Animal and Plant Quarantine (or delegate):

- must consider the level of quarantine risk if the permit were granted, and
- must consider whether, if the permit were granted, the imposition of conditions would be necessary to limit the level of quarantine risk to one that is acceptably low, and
- for a permit to import a seed of a plant that was produced by genetic manipulation – must take into account any risk assessment prepared, and any decision made, in relation to the seed under the Gene Technology Act and
- may take into account anything else that he or she knows is relevant.

The level of quarantine risk is defined in section 5D of the *Quarantine Act 1908*. The definition is as follows:

> reference in this Act to a *level of quarantine risk* is a reference to:
> (a) the probability of:
> (i) a disease or pest being introduced, established or spread in Australia, the Cocos Islands or Christmas Island; and
> (ii) the disease or pest causing harm to human beings, animals, plants, other aspects of the environment, or economic activities; and
> (b) the probable extent of the harm.

The Quarantine Regulations 2000 were amended in 2007 to regulate keys steps of the import risk analysis process. The Regulations:

- define both a standard and an expanded IRA
- identify certain steps which must be included in each type of IRA
- specify time limits for certain steps and overall timeframes for the completion of IRAs (up to 24 months for a standard IRA and up to 30 months for an expanded IRA)
- specify publication requirements
- make provision for termination of an IRA and
- allow for a partially completed risk analysis to be completed as an IRA under the Regulations.
-

The Regulations are available at www.comlaw.gov.au.

International agreements and standards

The process set out in the *Import Risk Analysis Handbook 2007* is consistent with Australia's international obligations under the SPS Agreement. It also takes into account relevant international standards on risk assessment developed under the International Plant Protection Convention (IPPC) and by the World Organisation for Animal Health (OIE).

Australia bases its national risk management measures on international standards, where they exist and when they achieve Australia's ALOP. Otherwise, Australia exercises its right under the SPS Agreement to apply science-based sanitary and phytosanitary measures that are not more trade restrictive than required to achieve Australia's ALOP.

Notification obligations

Under the transparency provisions of the SPS Agreement, WTO Members are required, among other things, to notify other members of proposed sanitary or phytosanitary regulations, or changes to existing regulations, that are not substantially the same as the content of an international standard and that may have a significant effect on trade of other WTO Members.

Risk analysis

Within Australia's quarantine framework, the Australian Government uses risk analyses to assist it in considering the level of quarantine risk that may be associated with the importation or proposed importation of animals, plants or other goods.

In conducting a risk analysis, Biosecurity Australia:

- identifies the pests and diseases of quarantine concern that may be carried by the good
- assesses the likelihood that an identified pest or disease or pest would enter, establish or spread, and
- assesses the probable extent of the harm that would result.

If the assessed level of quarantine risk exceeds Australia's ALOP, Biosecurity Australia will consider whether there are any risk management measures that will reduce quarantine risk to achieve the ALOP. If there are no risk management measures that reduce the risk to that level, trade will not be allowed.

Risk analyses may be carried out by Biosecurity Australia's specialists, but may also involve relevant experts from state and territory agencies, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), universities and industry to access the technical expertise needed for a particular analysis.

Risk analyses are conducted across a spectrum of scientific complexity and available scientific information. An IRA is a type of risk analysis with key steps regulated under the Quarantine Regulations 2000. Biosecurity Australia's assessment of risk may also take the form of a non-regulated analysis of existing policy or technical advice to AQIS. Further information on the types of risk analysis is provided in the *Import Risk Analysis Handbook 2007*.

Appendix C. Glossary

Additional declaration	A statement that is required by an importing country to be entered on a phytosanitary certificate and which provides specific additional information pertinent to the phytosanitary condition of a consignment (FAO 2004).
Animal and Plant Health Inspection Service	A division of the United States Department of Agriculture.
Appropriate level of protection	The level of protection deemed appropriate by the Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory (WTO 1995).
Area	An officially defined country, part of a country or all or parts of several countries (FAO 2004).
Biosecurity Australia	A prescribed agency within the Australian Government Department of Agriculture, Fisheries and Forestry. Biosecurity Australia provides science-based quarantine assessments and policy advice that protects Australia's favourable pest and disease status and enhances Australia's access to international animal and plant related markets.
Consignment	A quantity of plants, plant products and/or other articles being moved from one country to another and covered, when required, by a single phytosanitary certificate (a consignment may be composed of one or more commodities or lots) (FAO 2004).
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO 2004).
Endangered area	An area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss (FAO 2004).
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO 2004).
Establishment	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO 2004).
Establishment potential	Likelihood of the establishment of a pest.
Fresh	Living; not dried, deep-frozen or otherwise conserved (FAO 2004).
Fruits and vegetables	A commodity class for fresh parts of plants intended for consumption or processing and not for planting (FAO 2004).
Host	A species of plant capable, under natural conditions, of sustaining a specific pest.
Import Permit	Official document authorising importation of a commodity in accordance with specified phytosanitary requirements(FAO 2004).
Import Risk Analysis	An administrative process through which quarantine policy is developed or reviewed, incorporating risk assessment, risk management and risk communication.
Infestation (of a commodity)	Presence in a commodity of a living pest of the plant or plant product concerned. Infestation includes infection (FAO 2004).
Inspection	Official visual examination of plants, plant products or other regulated articles to determine if pests are present and/or to determine compliance with phytosanitary regulations (FAO 2004).
Intended use	Declared purpose for which plants, plant products, or other regulated articles

	are imported, produced, or used (FAO 2004).
Interception (of a pest)	The detection of a pest during inspection or testing of an imported consignment (FAO 2004).
International Plant Protection Convention	As deposited with FAO in Rome in 1951 and subsequently amended (FAO 2004).
International Standard for Phytosanitary Measures	An international standard adopted by the Conference of the Food and Agriculture Organisation, Interim Commission on phytosanitary measures or the Commission on phytosanitary measures, established under the IPCC (FAO 2004).
Introduction	The entry of a pest resulting in its establishment (FAO 2004).
Lot	A number of units of a single commodity, identifiable by its homogeneity of composition, origin etc., forming part of a consignment (FAO 2004).
National Plant Protection Organisation (NPPO)	Official service established by a government to discharge the functions specified by the IPPC (FAO 2004). (DAFF is Australia's NPPO).
Official control	The active enforcement of mandatory phytosanitary regulations and the application of mandatory phytosanitary procedures with the objective of eradication or containment of quarantine pests or for the management of regulated non-quarantine pests (FAO 2004).
Pathway	Any means that allows the entry or spread of a pest (FAO 2004).
Pest	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2004).
Pest categorisation	The process for determining whether a pest has or has not the characteristics of a quarantine pest or those of a regulated non-quarantine pest (FAO 2004).
Pest Free Area (PFA)	An area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained (FAO 2004).
Pest Risk Analysis (PRA)	The process of evaluating biological or other scientific and economic evidence to determine whether a pest should be regulated and the strength of any phytosanitary measures to be taken against it (FAO 2004).
Pest risk assessment (for quarantine pests)	Evaluation of the probability of the introduction and spread of a pest and of the associated potential economic consequences (FAO 2004).
Pest risk management (for quarantine pests)	Evaluation and selection of options to reduce the risk of introduction and spread of a pest (FAO 2004).
Phytosanitary Certificate	Certificate patterned after the model certificates of the IPPC (FAO 2004).
Phytosanitary measure	Any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO 2004).
Phytosanitary regulation	Official rule to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests, including establishment of procedures for phytosanitary certification (FAO 2004).
Polyphagous	Feeding on a relatively large number of host plants from different plant families.
Protected area	A regulated area that an NPPO has determined to be the minimum area

	necessary for the effective protection of an endangered area (FAO 2004).
Quarantine pest	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO 2004).
Regulated article	Any plant, plant product, storage place, packing, conveyance, container, soil and any other organism, object or material capable of harbouring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved (FAO 2004).
Restricted risk	'Restricted' risk estimates apply to situations where risk management measures are used.
Spread	Expansion of the geographical distribution of a pest within an area (FAO 2004).
SPS Agreement	WTO Agreement on the Application of Sanitary and Phytosanitary Measures (Yee *et al.* 2006).
Stakeholders	Government agencies, individuals, community or industry groups or organisations, whether in Australia or overseas, including the proponent/applicant for a specific proposal.
Systems approach(es)	The integration of different pest risk management measures, at least two of which act independently, and which cumulatively achieve the appropriate level of phytosanitary protection (FAO 2004).
Unrestricted risk	'Unrestricted' risk estimates apply in the absence of risk management measures.

Appendix D. References

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