Australian Government

Biosecurity Australia

Draft Import Risk Analysis Report for Fresh Stone Fruit from California, Idaho, Oregon and Washington

April 2008

Cite this report as:
Biosecurity Australia (2008), Draft Import Risk Analysis Report for Fresh Stone Fruit from California, Idaho, Oregon and Washington. (Biosecurity Australia: Canberra).

Submissions

This draft import risk analysis (IRA) report has been issued to give all interested parties an opportunity to comment and draw attention to any scientific, technical, or other gaps in the data, misinterpretations and errors. Any comments should be submitted to Biosecurity Australia within the comment period stated in the related Biosecurity Australia Advice on the Biosecurity Australia website. The draft IRA report will then be revised as necessary to take account of the comments received and a provisional final IRA report will be released at a later date.

Comments on the draft IRA report should be submitted to:

Plant Biosecurity
Biosecurity Australia
GPO Box 858
CANBERRA ACT 2601
AUSTRALIA

Telephone: +61 2 6272 5094
Facsimile: +61 2 6272 3307
Email: plant@biosecurity.gov.au

Internet: www.biosecurityaustralia.gov.au

Contents

Tables

Figures

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.
USDA	The United States Department of Agriculture.
Vic.	Victoria.
WA	Western Australia.
WTO	World Trade Organization.

Summary

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

The draft report proposes that the importation of stone fruit to Australia from California, Idaho, Oregon and Washington be permitted, subject to a range of quarantine measures.

The draft report has identified a number of quarantine pests that require risk management measures to reduce the quarantine risks to a very low level in order to achieve Australia's appropriate level of protection (ALOP). These pests include apple maggot, four fruit boring moths, leafrollers, mealybugs and thrips.

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 draft report proposes that the same quarantine measures adopted under existing policy would be used to manage oriental fruit moth associated with stone fruit from the USA. These measures include pest free areas or methyl bromide fumigation. The draft report also proposes that the existing measures for oriental fruit moth would provide effective risk management for cherry fruitworm and the lesser apple fruitworm, which are closely related to oriental fruit moth.

A number of potential quarantine measures have been identified for apple maggot and peach twig borer, including irradiation, fumigation with methyl bromide, cold treatment, or the establishment of pest free areas. The USA will need to provide further information to scientifically support quarantine measures to manage these two pests.

The proposed quarantine measures for leafrollers, mealybugs and thrips include visual inspection by the relevant agency in the USA (Animal and Plant Health Inspection Service) and the Australian Quarantine and Inspection Service. If any pests are detected, fumigation with methyl bromide will be required.

Two pests, oriental fruit moth and citrophilus mealybug, which are present in eastern Australia, have been identified as quarantine pests for Western Australia only. The proposed quarantine measures take account of these regional differences for Western Australia.

This draft report contains details of the risk assessments for all the quarantine pests and proposed quarantine measures in order to allow interested parties to provide comments and submissions to Biosecurity Australia within the consultation period.

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* located on the Biosecurity Australia website www.biosecurityaustralia.gov.au.

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 (US). 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 US 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 US 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 US 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 US 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

In accordance with the International Plant Protection Convention, this technical component of a plant IRA is termed a 'pest risk analysis' (PRA). 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 2007a) and ISPM 11: *Pest Risk Analysis for Quarantine Pests, including analysis of environmental risks and living modified organisms* (FAO 2004b).

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 2007b). A pest is 'any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products' (FAO 2007b).

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. 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 2007b).

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.

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.

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, the need for new pest risk assessments was investigated.

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 2007b).

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 identified in Stage 1 require a pest risk assessment. The categorisation process examines, for each pest, whether the criteria in the definition for a quarantine pest are satisfied. 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 2007b).

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

- identity of the pest;
- presence or absence in the PRA area;
- regulatory status;
- potential for establishment and spread in the PRA area; and
- 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 2004b). 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 various 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; and

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;
- 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; and
- 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); and
- 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 2004b). 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; and
- 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 2004b). 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; and
- 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 illustrate the boundaries of the descriptors. The standardised likelihood descriptors and the associated indicative probability ranges provide guidance to the risk analyst and promote consistency between different risk analyses. However, probabilities are not used in qualitative PRAs.

Table 2.1: Nomenclature for qualitative likelihoods

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

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 2007b), and ISPM 11 (FAO 2004b).

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

- Plant life or health; and
- Other aspects of the environment.

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

- Eradication, control, etc.;
- Domestic trade;
- International trade; and
- 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.

Values were translated into a qualitative impact score (A–G) using Table 2.3.

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

	Geographic level			
Impact score	**Local**	**District**	**Regional**	**National**
G	Major significance	Major significance	Major significance	Major significance
F	Major significance	Major significance	Major significance	Significant
E	Major significance	Major significance	Significant	Minor significance
D	Major significance	Significant	Minor significance	Indiscernible
C	Significant	Minor significance	Indiscernible	Indiscernible
B	Minor significance	Indiscernible	Indiscernible	Indiscernible
A	Indiscernible	Indiscernible	Indiscernible	Indiscernible

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.

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 been shifted 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.

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/or 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/or 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 2004b) 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. These risk management measures will form the basis of the phytosanitary regulations in the 'Import Conditions' section of the final IRA report.

3 Stone fruit industry information

3.1 The US stone fruit industry

3.1.1 Production statistics

Based on figures provided in 'Noncitrus Fruit and Nuts 2006 Summary' (National Agriculture Statistics Service 2007), there was approximately 291 thousand acres of stone fruit production, excluding cherries, in the US in 2006. The total yield from this area was approximately 1.493 million metric tonnes (1.646 million US tons). Of this production, 61 per cent of the yield was comprised of peaches, 14 per cent nectarines, 12 per cent prunes, 10 per cent plums and 3 per cent apricots. Approximately half of the peach crop and 30 per cent of the apricot crop was utilised in fresh markets. The total value of stone fruit production in 2006 was estimated at US$1.011 billion.

California is the most important state for stone fruit production, having approximately half (63 000 acres) of the US 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 (11 500 acres), New Jersey (7 200 acres) and Texas (5 800 acres). Idaho, Oregon and Washington are together reported to have approximately 4 350 acres of peach production. In contrast, the other important stone fruit crop, sweet cherries, is strongly represented in Washington (30 000 acres) and Oregon (12 000 acres), along with California (28 000 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 has 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 temperatures observed for the San Joaquin Valley (Figure 3-1).

The climate in both of these regions can be described as Mediterannean, 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.

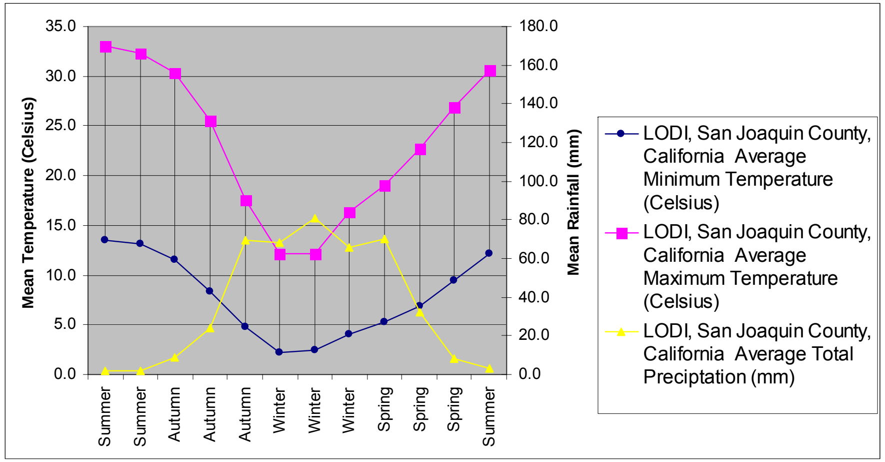

Figure 3-1 Average monthly minimum and maximum temperatures and average precipitation for Lodi, San Joaquin Valley, California, USA. (1961-1990)

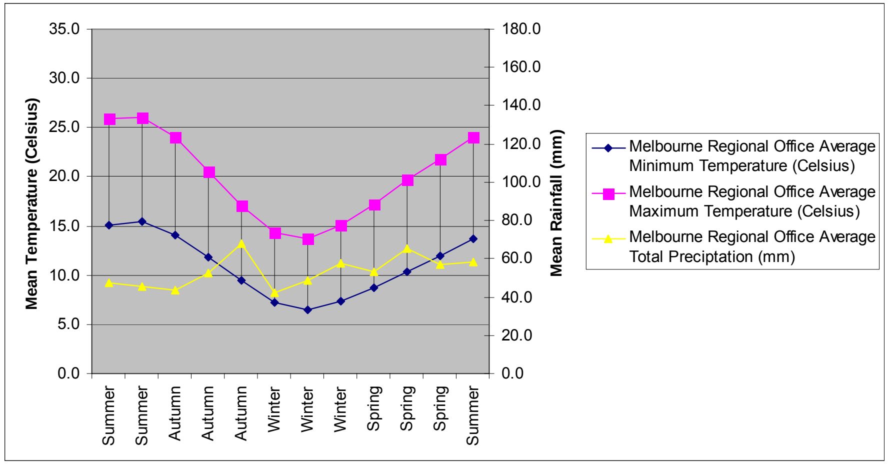

Figure 3-3 Average monthly minimum and maximum temperatures and average precipitation for Melbourne, Victoria, Australia. (1961-1990)

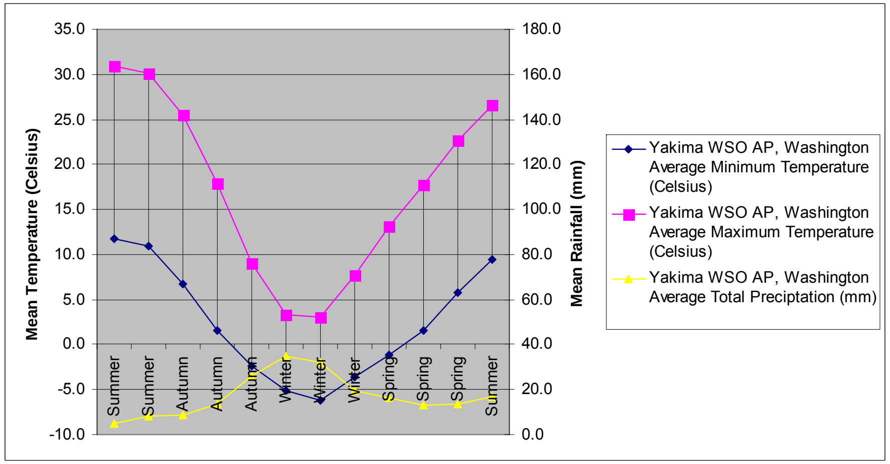

Figure 3-2 Average monthly minimum and maximum temperatures and average precipitation for Yakima WSO, Washington, USA. (1946-2007)

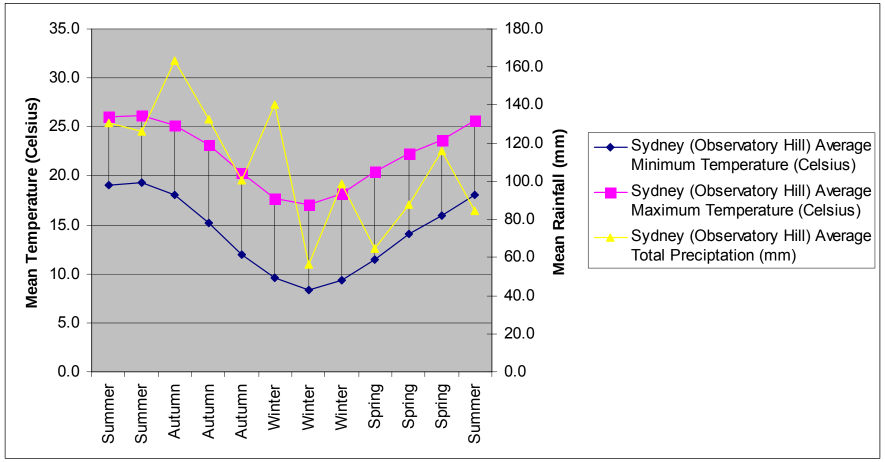

Figure 3-4 Average monthly minimum and maximum temperatures and average precipitation for Observatory Hill, Sydney, New South Wales, Australia. (1961-1990)

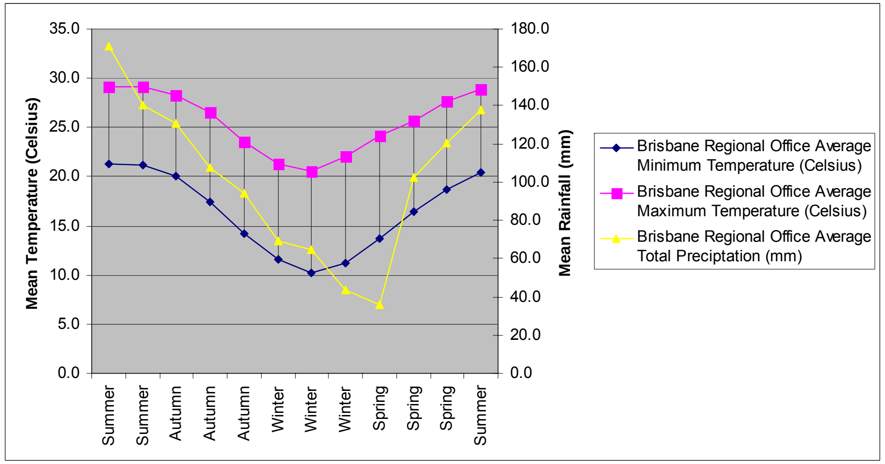

Figure 3-5 Average monthly minimum and maximum temperatures and average precipitation for Brisbane, Queensland, Australia. (1961-1990)

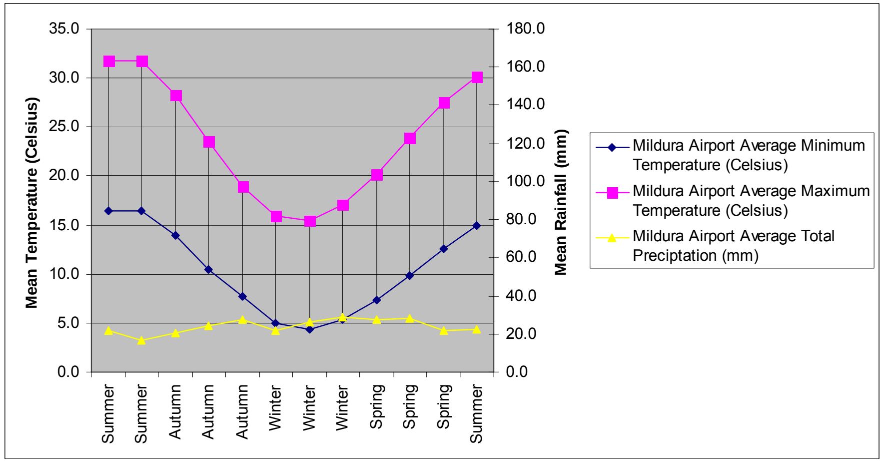

Figure 3-7 Average monthly minimum and maximum temperatures and average precipitation for Mildura airport, Victoria, Australia. (1961-1990)

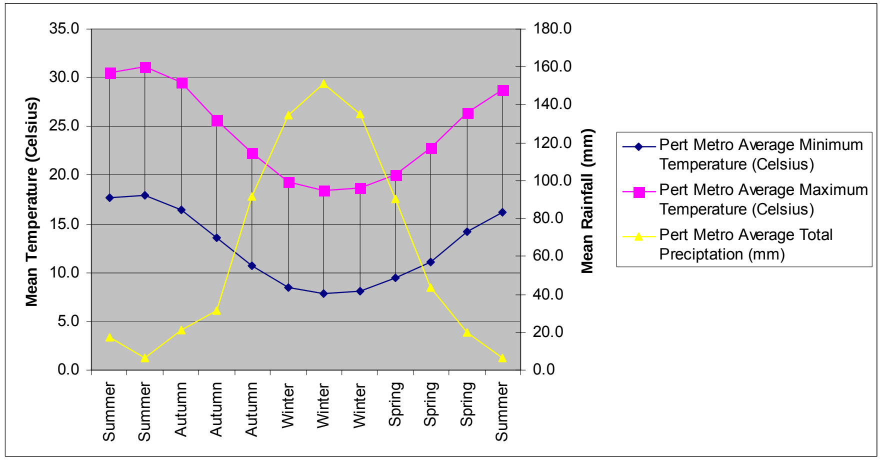

Figure 3-6 Average monthly minimum and maximum temperatures and average precipitation for Perth, Western Australia, Australia. (1961-1990)

3.1.3 Exports

According to the Foreign Agricultural Service (Foreign Agricultural Service 2005), the US is the world's third largest exporter of peaches and nectarines, the second largest exporter of plums and the third largest exporter of apricots. In 2004, US exports of peaches and nectarines were valued at US$100 million, plums and prunes valued at US$39.6 million, and apricots valued at US$13.3 million.

The US exports stone fruit to Canada, Mexico as well as 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 packinghouses 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 US.

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 could influence the presence of stone fruit pests on the harvested, and ultimately exported, commodity.

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 control 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 a minor pest that is not present in all orchards.

Common practice in both states is 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 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.

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 dumped 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 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.

Grading operations followed which included both a manual grading for damaged/deformed fruit and removal of any leaf trash. 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 were then directed to appropriate packing lines.

The notable exception to this process was the packing of 'peento' peaches which are also known as saucer or donut peaches. The flat nature of these peaches prevents them passing through normal processing and grading operations and were instead hand graded and packed directly from field bins.

A final quality assurance measure for commercial stone fruit is the grading standards as legislated in the US Code of Federal Regulations 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'.

<u>Apricots</u>
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.

<u>Nectarines</u>
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.

<u>Peaches</u>
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.

<u>Plums/Prunes</u>
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 (Ackerman 2007; California Tree Fruit Agreement 2007a; Curtis *et al.* 1992). 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 will be transported to Australia via ship or air (Ackerman 2007). This travel is estimated to take between 1 and 3 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, 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. *nectarina*): 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 2007b).

Plums (*Prunus domestica*): 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. 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 2006). 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 2006; 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 2006). 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.

Historically, stone fruit from the eastern states has been prohibited access into Western Australia due to concerns about the fungi that causes brown rot (*Monilinia fructicola* and *M. laxa*). However, the presence 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 42 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 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]
Mealybugs [Hemiptera: Pseudococcidae]	
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 argyrospilus (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
Anamorph: *Phloeosporella padi* (Lib.) Arx	
Passalora circumscissa Sacc. U. Braun	Cercospora leaf spot [WA]
Podosphaera clandestina (Wallr.:Fr) Lev	Powdery mildew
Podospharea tridactyla (Wallr.) de Bary	Cherry powdery mildew [WA EP]
Taphrina pruni Tula	Plum pockets [WA EP]
Viruses	
Apricot ring pox	Apricot ring pox
Plum pox *potyvirus*	Plum pox virus

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 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, 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 three 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 (Bentley *et al.* 2006o; Hollingsworth 2007; Seemüller and Schneider 2004). This disrupts a plant's ability to photosynthesise and consequently reduces the vitality of the plant and therefore the size of the fruit (Hollingsworth 2007).

Adult spider mites range from 0.25 to 0.5 mm long and the accurate identification of each species can prove to be difficult, often relying on examination of male genitalia (Hollingsworth 2007). 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 (Bentley *et al.* 2006o; Hollingsworth 2007). Overwintering females emerge in early spring in California (around March) and lay eggs on the underside of leaves (Pickel *et al.* 2006j). The eggs typically hatch within four to six days (Hollingsworth 2007) and adult female spider mites lay eggs continually until they die. A complete life cycle is completed within 1-3 weeks (Hollingsworth 2007).

All *Tetranychus* species are capable of both sexual reproduction and parthenogenesis, with unfertilised females producing only male offspring (Helle and Pijnacker 1985). A complete life cycle is one to three weeks (Hollingsworth 2007), with many overlapping generations in summer (Bentley *et al.* 2006o).

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 (PDI 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.* 2006o), while two-spotted mite and McDaniel spider mite are reported in Washington (Hollingsworth 2007).
- 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.* 2006o). 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 (Bentley *et al.* 2006o; Hollingsworth 2007). However, spider mites are highly mobile and have the capacity to move onto all parts of the plant (Bentley *et al.* 2006o).
- Pacific spider mite has been observed in the webbing in the stem cavity of nectarines culled in packinghouse processes in California, confirming that spider mites do migrate onto fruit (Curtis *et al.* 1992).

Processing of fruit in the packinghouse

- 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 packinghouse 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 in-field 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; Yokoyama and Miller 1999).
- Transport of fruit to Australia would be either by air freight or by sea freight and would result in fruit being in transit from a few days up to three weeks.
- Female spider mites overwinter and can survive sub-zero temperatures (Rabbinge 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 (PDI 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 packinghouse 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 **LOW**.

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 including *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.
- 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).
- Spider mites predominantly disperse within and between host plants through crawling (Kennedy and Smitley 1985). Adult female spider mites can also be observed being carried on air currents. While there is the potential for long range transport on wind currents, aerial dispersal is generally initiated at high population densities, and is entirely passive once airborne (Kennedy and Smitley 1985). Most mites therefore, fall out of the air currents after only a short distance (Kennedy and Smitley 1985). 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 short dispersal range, and the lack of suitable leaf material on deciduous hosts for a predominant portion of the import period.
- 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 on page 17. 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 in Australia (Bolland *et al.* 1998).
- 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 is 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 supported by the knowledge 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). Therefore, 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.
- Spider mites have many generations per year and each female can lay up to 100 eggs (Sabelis 1985b). This increases the ability of the mite to establish populations in small 'windows of opportunity' when conditions are suitable.
- Populations can start from a single mated female (Sabelis 1985b). 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. The likelihood of this occurring is not clear.
- If populations established from a large number of individuals, the 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).

Cultural practices and control measures

- Spider mite populations are usually kept low by predators, either natural or introduced (Ohlendorf 2000; Sabelis 1985a). 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 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

- These species have been reported from a variety of environments in North America, inlcluding California and the Pacific Northwest states (Bentley *et al.* 2006o; 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 2007).
- Higher fecundity rates and reduced development times have been reported with increasing temperatures and humidities in some *Tetranychus* species (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 interstate quarantine control on the movement of nursery stock and other plant material could reduce the rate of spread between states, but would be of limited use within states where control measures may not be applied.
- 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°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 on page 16.

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 on page 19. 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 recorded as being 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. 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 on page 19, 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 on page 20.

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 and Miller 1997; Yokoyama *et al.* 1992). It is also present in the Pacific Northwest states. Fruit oviposition 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 1997k). Walnut husk fly has also been reported to attack some *Prunus* species, in particular peach (Boyce 1934). 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.* 2005b). 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.* 2005b).

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.* 2005b). 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.* 2005b). Most emerge in the following summer as adults, but some pupae remain in the soil for two years or more (Bentley *et al.* 2005b).

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 **EXTREMELY 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 and Miller 1993; Yokoyama and Miller 1996; Yokoyama *et al.* 1992), 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. 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.
- While established in Italy, Switzerland and Germany, walnut husk fly is not listed as a pest of stone fruit in those countries (EPPO/CABI 1997k). 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 packinghouse

- 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 (Yokoyama and Miller 1993).

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 by either air freight or sea freight and would result in fruit being in-transit from a few days up 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 1997k; Yokoyama *et al.* 1992).
- Pupae may remain in the soil for two years or more (Bentley *et al.* 2005b).
- 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 corresponds to 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).
- 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, 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 on page 17. The overall probability of entry for walnut husk fly is estimated to be **EXTREMELY 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* L.) 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.

Suitability of the environment

- Warmer conditions are more favourable to the development of walnut husk fly, as determined in laboratory studies (Kasana and AliNiazee 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 (EPPO 2004a; New Zealand Ministry of Agriculture and Forestry 2000). 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.
- 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 (Christenson and Foote 1960). Females lay 200-400 eggs in a lifetime (Christenson and Foote 1960).
- Walnut husk fly 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 and Miller 1994; Yokoyama *et al.* 1992).
- 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 1960).

Cultural practices and control measures

- As an internal pest of the fruit, current insecticide spray regimes are not expected to have any impact on the establishment of walnut husk fly in Australia.
- 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 (EPPO 2004a; New Zealand Ministry of Agriculture and Forestry 2000). 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.
- There are similar environments in Australia that would be suitable for its spread.

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 (EPPO/CABI 1997k). The dispersal ranges fo 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 on page 16.

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 **EXTREMELY 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 on page 19. 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 sector, producing around 300 tonnes of nuts in 2003 (Adem 2003). Nectarine and peach production is a larger industry, but is likely to have only limited impacts by this pest.
Any other aspects of the environment	**A** — Indiscernible at the local level. Walnut husk fly has a small host range and would be unlikely to have effects on the environment apart from direct damage to 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.* 2005b). 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. 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.
Domestic trade	**C** — Significant at the district 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 district 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 on page 19, 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 on page 20.

Unrestricted risk estimate for walnut husk fly	
Overall probability of entry, establishment and spread	**Extremely 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 (*Crataegeus* spp.) (CABI 2007; Caprile *et al.* 2006c; Weems Jr and Fasulo 2002). This pest has also adapted to other commercial fruit hosts including peach, apricot and plum (CABI 2007; Caprile *et al.* 2006c; Fisher and Olsen 2002; Weems Jr and Fasulo 2002).

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 (Caprile *et al.* 2006c; Weems Jr and Fasulo 2002). They have clear wings marked with four characteristic oblique black bands (Caprile *et al.* 2006c; Weems Jr and Fasulo 2002). 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 (Caprile *et al.* 2006c; Weems Jr and Fasulo 2002). 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 (Caprile *et al.* 2006c; Weems Jr and Fasulo 2002).

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 (Aluja *et al.* 2001). The principal injury to the fruit is caused by burrowing larvae that feed on the flesh of the fruit (Caprile *et al.* 2006c). 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.* 2006c). 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.**

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 (CABI 2007; Fisher and Olsen 2002; Weems Jr and Fasulo 2002).
- Although the natural host is hawthorn (*Crataegeus* spp.) and the main commercial host is apple (*Malus domestica*) (CABI 2007; Caprile *et al.* 2006c; Weems Jr and Fasulo 2002), this pest has also adapted to other commercial fruit hosts including peach, apricot and plum (CABI 2007; Weems Jr and Fasulo 2002).
- 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 is 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 packinghouse

- 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 packinghouse processes.

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 by either air or sea freight and would result in fruit being in-transit from a few days up 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 Fasulo 2002) and this is accepted by some regulatory agencies (Hallman 2004b). 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.
- Infested fruit would need to be discarded in a location where apple maggot could potentially pupate. Fruit that are discarded into household trash or compost bins are likely to degrade

quickly and become unsuitable for larvae to complete development. 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).

- 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.
- The 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 on page 17. The overall probability of entry for apple maggot is estimated to be **LOW**.

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 (CABI 2007; Caprile *et al.* 2006c; Weems Jr and Fasulo 2002). 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 (CABI 2007; Caprile *et al.* 2006c; Weems Jr and Fasulo 2002). Other alternative hosts include Japanese rose and sour cherry (Weems Jr and Fasulo 2002).
- Suitable hosts are present in Australia and are widespread. 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 where conditions are similar to areas of Australia suggests that the environmental conditions in Australia 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 (Aluja *et al.* 2001). Therefore it is possible that both sexes of the species can eventuate from fruit or fruit scraps and that mating partners can be found.
- A single mated female is capable of laying enough eggs to establish a population. Even a single infested fruit could contain enough larvae for a population to establish in Australia, providing that the larvae can find a suitable pupation site (Weems Jr and Fasulo 2002).
- 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 is polyphagous and has a wide host range in a range of environments worldwide. This suggest 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*) 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 (CABI 2007; Caprile *et al.* 2006c).
- Currently, there are not any effective and/or selective traps used to detect *R. pomonella.* Ammonium carbonate traps have been trialled 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 (FAO 2005; 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). 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 Australia. This suggests that the apple maggot could spread within Australia.
- The broad host range of the apple maggot (CABI 2007; Caprile *et al.* 2006c; Weems Jr and Fasulo 2002) 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 since 1979 (Foote *et al.* 1993).
- 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 Table 2.2 on page 16.

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 on page 19. 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. The apple maggot 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. The apple maggot has a wide host range which includes apple, hawthorn and stone fruit. Some of these commercial hosts constitute major horticultural markets in Australia and given their size and distribution, the introduction of apple maggot could cause considerable damage to these industries.
Any other aspects of the environment	**A** — Indiscernible at the local level. There are no known direct consequences of the apple maggot on other aspects of the environment.
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	**D** — Significant at the district level. The introduction of the apple maggot into commercial production areas may have a significant effect as interstate trade restrictions may be imposed to limit the spread of this pest on a range of commodities (e.g. fruit, ornamentals, trees, shrubs and stone fruit).
International Trade	**D** — Significant at the district level. The presence of the apple maggot in commercial production areas of a range of commodities (e.g. fruit, ornamentals, trees, shrubs and stone fruit) may have a significant effect at the district 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 on page 19, 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 on page 20.

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.

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, but there is only one generation per year of potato bug in California (Pickel *et al.* 2006g).

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; Ogawa *et al.* 1995).

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 packinghouse.
- 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.
- It is noted that nymphs are not commonly seen in orchards, 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 (CABI 2007; Pickel *et al.* 2006g).

Processing of fruit in the packinghouse

- All harvested stone fruit is washed and brushed/defuzzed following harvest. These actions would almost certainly remove the highly mobile adults, 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; Yokoyama and Miller 1999).
- Transport of fruit to Australia would be by either air freight or sea freight and would result in fruit being in-transit from a few days up 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 (PDI 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.* 2005).
- 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 tree nurseries, 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 on page 17. 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 **MODERATE.**

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).
- 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) and eastern Mediterranean (Israel, Turkey), as well as being introduced to Tasmania (Schuh 2006).

- Pale legume bug is present throughout western Canada, Alaska, western US (California, Oregon, Idaho, Nevada) and northern Mexico (Mueller *et al.* 2005) (CABI 2007) (Mueller *et al.* 2003).
- Western tarnished plant bug is predominantly distributed throughout western US (California, Arizona, Nevada, Washington) and Mexico (Esfaki and Cunningham 1987) (Mueller *et al.* 2003).
- Tarnished plant bug occurs in all Canadian provinces, the continental US and most of the states of Mexico, as well as El Salvador and Guatemala (Dixon and Fasulo 2006).
- 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). Thus, while *Lygus* spp. are not known from Australia, other Mirid pheromones may reduce the ability of exotic *Lygus* spp. to find a mate.
- 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 to 150 eggs, which are laid singly in a sheltered location and hatch in 7-12 days (Dixon and Fasulo 2006). It takes approximately 15 to 25 days for nymphs to develop into adults during summer, with reproduction starting when adults are about 1 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. 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 treatments 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; Snodgrass and Scott 1988).

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.* 2006g).

- 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

- The tarnished plant bug is 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 parasitoids would play in Australia.

Presence of natural barriers

- Natural barriers such as deserts or mountain ranges, may effectively limit the movement of plant bugs beyond specific regions.
- 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 able to 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).

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

- Potential hosts for plant bugs include fruit and vegetation.
- 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 on page 16.

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 on page 19. 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 caused $37 million in control and yield loss in 2002 (Williams 2003). The western tarnished plant bug has the largest economic impact of any cotton pest in California, with an estimated yield loss of 42,000 bales in 2001 (CDFA 2002). 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 most important Lygus pest in the west (Scott 1997) and is a frequent pest of many important crops including cotton (Barlow *et al.* 1999). 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).
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 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. 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 on page 19, 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 on page 20.

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**

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 (Dreistadt *et al.* 2007; 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; McClure 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; McClure 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 metamorphosis, remaining legless and immobile on the host plant (Rosen 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 (Rosen 1990). The mature male is seldom seen and is rarely more 1 mm in length (Rosen 1990). The 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 (Rosen 1990; 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 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, but is also known to infest cherries and peaches in North America (Kosztarab 1996). There are two generations per year (Davidson and Miller 1990), with mated females overwintering (Kosztarab 1963). 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 (Zahradník 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 packinghouse 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 2006). 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; Zahradník 1990).

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 **VERY 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 rare in California and walnut scale is only considered a minor pest (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 packinghouse 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 a problem (Dreistadt *et al.* 2007).
- 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. Scales other than San Jose scale are controlled as part of the management program.
- 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 packinghouse

- The washing and brushing/defuzzing process would likely dislodge a number of scales on the surface of fruit. Any crawlers present would be easily dislodged, while sessile stages that are firmly attached to the fruit may remain.
- 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 on nectarines after packinghouse procedures was 32 per 100 000 which compares with 13 San Jose scale per 100 000 fruit (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). Sea transport would take approximately three weeks while air transport less than one week.

- 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, scales insects are firmly attached to their host and are usually incapable of independent movement (Carver *et al.* 1991).
- The principal dispersive stages of scale insects are the first instar crawlers (Carver *et al.* 1991). 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 dipsersed by wind (Carver *et al.* 1991). First instar crawlers of *Icerya seychellarum* can disperse up to 3.5 km (Hill 1980) and *A. aurantii* crawlers have been recorded dispersing up to 312 m from an infested lemon orchard (Willard 1974). Although long dispersal distances have been reported for some crawler species, 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). 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 on page 17. 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 2007). This is generally true of other scale species where overwintering hosts and alternative hosts are important sources of infestation in orchards (HortResearch 2007). 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), producing eggs over a period of 2–3 months. This may result in a large population increase (HortResearch 2007).
- The number of generations per year depends on the species and environmental conditions. Walnut scale has one or more generations per year, depending on environmental conditions. Olive parlatoria scale and peach white scale have from 2–5 generations per year depending on the environmental conditions (Watson 2006).
- Mated females of these scales lay over 100 eggs (Watson 2006) which would be sufficient to start a population.
- 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.* 2007).

- 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

- Peach white scale is found in New South Wales, 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 within Australia.
- 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).

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 from one district, state or region to another if unaided 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.

Potential for movement with commodities, conveyances or vectors

- Movement of infested planting material or produce is the main way by which armoured scales have been introduced to other countries. 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 on page 16.

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 on page 19. 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 2007). 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 (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	**A** – 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, of concern to all of Australia, 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 on page 19, 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 on page 20. 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:

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 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 (Ben-Dov 1994; Miller *et al.* 2002).

Mealybugs are so-called as many species secrete a mealy or powdery wax 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 number of nymphal (immature instar) stages before undergoing a final moult into the adult form (Williams 2004). In at least some species, the late instars may be non-feeding and this is particularly true for male mealybugs (Williams 1991). 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 pinkish colour and ranges from 2.5–5.5mm long while the adult female citrophilus mealybug is a darker purple-red colour and 4–5mm long (CABI 2007; Spangler and Agnello 1991). 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 (Ben-Dov 1994). The Comstock mealybug is generally associated with apples and pears 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 (Smith *et al.* 2006).
- The potential for viable mealybug eggs, nymphs or adults to remain associated with fruit after harvesting, packinghouse 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 packinghouse

- 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 is either by air freight or sea, taking 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 affinis*), 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 was 19 days at 0°C, but required 77 days at 4°C. 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 2000), 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 (Williams 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 vegetative 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 on page 17. 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. A wide range of suitable hosts (e.g. apples, citrus, grapes, mango and pineapple) would be available in Australia for the mealybugs assessed here (Ben-Dov 1994).
- While only the crawlers and adult males are considered the significant dispersive stages (Williams 1991), the high reproductive capacity of mealybugs (Williams and Watson 1988) 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.* 2006q).
- 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). 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 suggest 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 2006).

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.
- 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 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 2000; Williams 2004). Some species of mealybugs may be carried by ants to new host plants (Beardsley *et al.* 1982; Carter 1962).

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 on page 16.

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 on page 19. 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 red marks on the skin where mealybugs have been feeding (McLaren *et al.* 1999). Mealybugs can reduce plant vigour and crop yield (Williams and Watson 1988).
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.
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 on page 19, 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 on page 20.

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: Gelechidae)

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 1997a). The larvae can damage growing shoots causing shoot strike or feed directly on the fruit (Pickel *et al.* 2006e). The larvae bore into the fruit and feed just below the skin (Pickel *et al.* 2006e).

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.* 2006e). Pupation normally occurs in protected places on the tree and the first generation adults subsequently emerge from April to May each year. There are two or more generations per year (Pickel *et al.* 2006e).

Oval shaped eggs are initially white before turning a yellowish-orange colour and may be laid on twigs, leaves or fruit (CABI 2007; Pickel *et al.* 2006e). The juvenile larvae is white with a black head, while the mature larvae is around 10mm long and a reddish-brown colour with distinctive light bands around the body (Pickel *et al.* 2006e). 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 2006d; Bentley *et al.* 2006k; Coates and Van Steenwyk 2006c; Pickel *et al.* 2006e). The risk posed by peach twig borer is that eggs or larvae 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.* 2006e). 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 hosts and associated fruit 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.* 2006k; Pickel *et al.* 2006e). 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 1997a; Pickel *et al.* 2006e).

- Fruit are highly susceptible, particularly from colour break to harvest (Coates and Van Steenwyk 2006c; Pickel *et al.* 2006e). 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 would be hard to detect 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; Curtis *et al.* 1992; Gencsoylu *et al.* 2006; Weakley *et al.* 1990). This conflict may be due to pesticide spray timing (Curtis *et al.* 1992; Weakley *et al.* 1990).
- Secondary rots can often follow initial tunnelling causing further damage to the fruit (Curtis *et al.* 1992). Secondary rots may be detected during harvest.

Processing of fruit in the packinghouse

- 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.* 2006e).
- 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.* 2006e).
- Microbial breakdown can occur in infested fruit and such fruit may be detected during packinghouse procedures (Curtis *et al.* 1991; Curtis *et al.* 1992).
- Trials undertaken in California determined that the incidence of peach twig borer on nectarine, following packinghouse 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; Yokoyama and Miller 1999). Transport of fruit to Australia would be either by air freight or by sea, taking 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.* 2006e).
- 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.* 2006e).
- 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 from the port of entry 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 (Bentley and Day 2006d; EPPO/CABI 1997a). These hosts are present in Australia.
- Two separate distribution pathways exist. The first is when the peach twig borer remains on the fruit distributed to the consumer. After consumption the consumer would dispose of the fruit and the pest. The larvae would remain feeding on the fruit until development is completed and would then pupate. The disposed environment may be household compost or landfill and may have fruit and a possible host 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.
- The second distribution pathway involves the larvae maturing 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 1997a). 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 on page 17. 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 1997a).

Suitability of the environment

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

Reproductive strategy and the potential for adaptation

- Peach twig borer has up to four generations per year depending on climate (Ahmad 1988; Brunner and Rice 1984).
- Eggs are laid singly and laboratory studies have shown that females lay an average of 130 eggs each (McElfresh and Millar 1993; Pickel *et al.* 2006e).
- 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 rapidly develops 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 (Bentley *et al.* 2006k; Coates and Van Steenwyk 2006c; Pickel *et al.* 2006e). Organic treatment can be achieved using sprays of *Bacillus thuringiensis* and *Saccharopolyspora spinosa*, as well as mating disruption (Bentley *et al.* 2006k; Coates and Van Steenwyk 2006c; Pickel *et al.* 2006e).
- Suitable control measures and pheromone disruption is not applied in Australia for this pest 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. There are similar environments in Australia that would be suitable for its spread.
- The comparatively warmer Australian environment may provide a larger choice of suitable habitats for peach twig borer to spread in Australia.

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 nursery stock and fruit 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.
- Peach twig borers do not require a vector for their spread because they are capable of independent flight.

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 on page 16.

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 on page 19. 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 is recorded as being capable of causing direct damage to its stone fruit host plants. Globally this species is a major pest of stone fruit (Bentley *et al.* 2006k; Coates and Van Steenwyk 2006c; EPPO 2004b; Pickel *et al.* 2006e).
Any other aspects of the environment	**A** — Indiscernible at the local level. There are no known direct consequences of peach twig borer on the natural or built environment.
Indirect Impacts	**Estimate and Justification**
Eradication, control, etc.	**D** — Significant at the district level. Establishment of this pest would require additional chemical treatment which would increase production costs (Bentley *et al.* 2006k; Coates and Van Steenwyk 2006c; Pickel *et al.* 2006e). 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.
Domestic trade	**D** — Significant at the district level. The presence of this pest in commercial production areas is likely to result in intrastate and interstate trade restrictions on stone fruit, leading to a potential loss of markets and significant industry adjustment.
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 (Bentley *et al.* 2006k; Coates and Van Steenwyk 2006c; EPPO 2004b; Pickel *et al.* 2006e). 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.
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. However, 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 on page 19, 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 on page 20.

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 argyrospilus (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 (Yokoyama and Miller 1999; Yokoyama *et al.* 1999; Zhou *et al.* 2001).

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.* 2006b; Bentley *et al.* 2006c; Bentley *et al.* 2006g; Bentley *et al.* 2006i) (Bentley *et al.* 2006e). 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.* 2006b; Bentley *et al.* 2006c; Bentley *et al.* 2006i). The distribution and abundance of leafrollers 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.* 2006g; Bentley *et al.* 2006h).

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 (Bentley *et al.* 2006g; Bentley *et al.* 2006h). Larvae that hatch from this generation of eggs can cause significant damage to stone fruits. 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 (Bentley *et al.* 2006i; Coates and Van Steenwyk 2006b). 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.* 2006g; Bentley *et al.* 2006h; Pickel *et al.* 2006d).

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 (Bentley *et al.* 2006g; Bentley *et al.* 2006h; Curtis *et al.* 1992; Weires and Riedl 1991).
- 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.* 2006g; Bentley *et al.* 2006j).
- Egg masses are laid in clusters on the upper surface of host leaves and fruit (Yokoyama and Miller 1999). 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.* 2006b; Bentley *et al.* 2006c; Bentley *et al.* 2006i).
- 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 are therefore likely to be rejected during sorting (Curtis *et al.* 1992; Pickel *et al.* 2006d; Yokoyama and Miller 1999).
- 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 packinghouse (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 packinghouse (Bentley *et al.* 2006h).

Processing of fruit in the packinghouse

- Eggs, larvae and adults on the external surface of the fruit are likely to be removed by washing and defuzzing/brushing of fruit.

- Sorting and grading would remove some fruit that are contaminated with external larvae or webbing indicating infestation (Pickel *et al.* 2006d), particularly when webbing remains on the stem end of fruit where defuzzing rollers can no 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 packinghouse procedures (Curtis *et al.* 1991; Curtis *et al.* 1992).
- Incidence of omnivorous leafroller after packinghouse 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, taking 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 (PDI 2003), indicating that leafroller larvae can survive cold storage.
- Leafrollers can survive packinghouse and transport procedures. AQIS inspectors intercepted live leafrollers on fresh apricots in 2006, from New Zealand (DAFF 2006) demonstrating that leafrollers can survive packinghouse procedures and in-transit cold storage.

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 primarily 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; Kearns *et al.* 2004).
- Pupation may occur during transport and live adult leafrollers could emerge soon after consignments arrive in Australia. 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 from the port of entry 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. 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 from the port of entry 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 on page 17. 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; Miller and Hodges 1995; 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 (AliNiazee and Stafford 1972; Atkins Jr *et al.* 1957; Curtis *et al.* 1992; Yokoyama and Miller 1999).
- Many of these leafroller host families 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 those of Australia. 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 one or more overlapping generations a year depending on latitude and climate. Generally warmer climates reduce the generation time for these 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 (Shorey *et al.* 1996; Webster and Carde 1982; Webster and Carde 1984).
- Female omnivorous leafrollers mate only once, although other leafrollers are capable of mating more times (Webster and Carde 1982; Webster and Carde 1984).
- Variation in fecundity (between 100–600 eggs per female) is determined by weather conditions, and the quality of host plants (Safonkin and Triseleva 2005; Smirle 1993).
- 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 (Croft and Hull 1991; Dunley *et al.* 2006; Smirle *et al.* 2002; Smirle *et al.* 2003a; Smirle *et al.* 2003b; Smirle *et al.* 1998; Vakenti *et al.* 1984).

Cultural practices and control measures

- The pest control practices recommended by the University of California, Davis, (Bentley *et al.* 2006c), recognise the impact of chemical sprays for other pests has on leafroller populations.
- Organic control can be achieved using *Bacillus thuringiensis* and *Saccharopolyspora spinosa* sprays and pheromone traps (Bentley *et al.* 2006g; Bentley *et al.* 2006g; Bentley *et al.* 2006h; McLaren *et al.* 1999; Pickel *et al.* 2006d).
- Conventional insecticides may be successful in controlling leafroller populations but resistance is developing to some chemicals in some areas (Croft and Hull 1991; Dunley *et al.* 2006; Meagher and Hull 1986; Smirle *et al.* 2002; Smirle *et al.* 2003a; Smirle *et al.* 2003b; Smirle *et al.* 1998; Vakenti *et al.* 1984).
- 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. 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 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 independent flight, thus allowing for unassisted movement between areas. Adults 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 stone fruit trees 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.
- Movement restrictions exist for fruit within Australia due to fruit fly concerns, but these restrictions apply to specific areas. Therefore, while spread with fruit may be tempered by these restrictions, the effect may be minimal.
- 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 on page 16.

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 on page 19. 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 are recorded as being capable of causing direct damage to host plants. 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).
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. Native plants or amenity plants that serve as hosts may be affected by these species leading to some impact to host plants.
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 azinphosmethyl 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. If these leafrollers become established in Australia it is likely to result in intrastate and interstate trade restrictions on many commodities such as pome fruit and stone fruit, leading to a potential loss of markets and significant industry adjustment.
International Trade	**D** — Significant at the district level. The presence of these leafrollers in commercial production areas of a wide range of horticultural commodities (e.g. apricots, nectarines, peaches, plums) may limit access to overseas markets where these pests are not present.
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 on page 19, 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 on page 20. 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 in the risk assessment presented here.

Filbertworm is recognised as a pest of stone fruit production in California and the Pacific Northwest states (APHIS 2002c; APHIS 2007; Curtis *et al.* 1992). 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 umarketable (EPPO 1999). Heavy infestations in untreated orchards can result in losses of up to 80 %, however stone fruit are not seen as important hosts in terms of economic damage (English 2001; EPPO 1999; Tree Fruit Research and Extension Centre 2008). Filbertworm is recognised as an important pest of filberts (hazelnuts). However, filbertworm can also infest stone fruit (AliNiazee 1983c; Barnes 1991; Curtis *et al.* 1991; 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 (CABI 2007; Hollingsworth 2007). The female moth lays eggs singly on or near hazelnuts (Dohanian 1940). Mature larvae are whitish 12-15 mm in length (CABI 2007; Hollingsworth 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 1983c).

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, it is considered to be infrequent or unlikely to occur (APHIS 2002c; APHIS 2007).
- 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 packinghouse

- Entrance holes would normally be present in infested fruit, as would frass and gummy exudates from the fruit (Curtis *et al.* 1991).
- 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 can occur on infested fruit and such fruit may be detected during packinghouse procedures (Curtis *et al.* 1991; Curtis *et al.* 1992).
- The incidence of filbertworm on nectarine after packinghouse 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 packinghouse procedures.

Pre-export and transport to Australia

- Fruit is stored at around 1°C (Curtis *et al.* 1992; Yokoyama and Miller 1999). Transport would either be by sea transport or by air freight and would take from a few days up to three weeks.
- Complete mortality of codling moth eggs was achieved after 14 days at 0°C (Yokoyama and Miller 1989). Mature larvae are far more tolerant of cold temperatures, with 21 days at 0°C achieving only 30% mortality of fifth stage instars (Yokoyama and Miller 1989). 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; Howell and Schmidt 2002). 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 1983a; Howell 1991).
- Hosts for filbertworm are hazelnuts, but may infest stone fruit, oaks and pomegranate (AliNiazee 1983c; Curtis *et al.* 1992; Davis *et al.* 1983; Dohanian 1940; Harper *et al.* 2000). Hazelnuts are a small commercial industry in Australia, but stone fruit is a relatively large industry and host trees may also be found in back yard planting 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 on page 17. 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 (AliNiazee 1983c; Curtis *et al.* 1992; Davis *et al.* 1983; Dohanian 1940; 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 may also be found in some suburban areas, 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).
- 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 1983b; Hollingsworth 2007). Chemical treatment is the major method of control (AliNiazee 1983c).
- 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 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 on page 16.

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 on page 19. 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 1983c; 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.
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 on page 19, 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 on page 20. 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. 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 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 sufficiently different to justify a separate consideration. 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 distinguish 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 (Barcenas *et al.* 2005; 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 (Barcenas *et al.* 2005; Mallampalli and Isaacs 2002; Tomlinson Jr 1951). It can be a serious pest on cherry (Hoerner and List 1952). The adult moth has a wingspan of about 6–8mm (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 posed by these moths is that eggs or larvae may be present on or in imported fruit and result 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 **MODERATE.**

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

Harvesting fruit for export

- Infestation by oriental fruit moth in stone fruit affects both the shoots and fruit (Gencsoylu *et al.* 2006; Rothschild and Vickers 1991). 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 activity of cherry and lesser apple fruitworm larvae are considered to be similar to the oriental fruit moth (Barcenas *et al.* 2005; Brown 1953; Hoerner and List 1952; Tomlinson Jr 1951).
- Internally feeding larvae eject droppings (frass) outside the fruit (Bentley *et al.* 2006j). Most fruit with internally feeding larvae would show external damage or the presence of frass and therefore may be rejected during harvesting (Bentley *et al.* 2006j; Curtis *et al.* 1992; Yokoyama and Miller 1999).

Processing of fruit in the packinghouse

- 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 packinghouse 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 to Australia would be by either air freight or sea freight, taking approximately one 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.

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 (Brown 1953; Hoerner and List 1952). If the eggs or larvae 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 imported into Australia. 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.
- 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 (Brown 1953; Hoerner and List 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 (Neven and Mantey 2004; Rothschild and Vickers 1991). 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 (Davis *et al.* 1983; Gentry *et al.* 1974; Pfeiffer and Killian 1988; Roelofs and Carde 1974; Roelofs *et al.* 1969). After mating, eggs will be laid on a suitable host plant.
- 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 on page 17. 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

- Host plants for cherry fruit worm and lesser apple fruitworm are similar to oriental fruit moth and these plants are widespread throughout Australia (Hoerner and List 1952; Mantey *et al.* 2000). Hosts include apples, blueberries, cherries, crab apple, hawthorn, oak, peaches, plums, and roses (Chapman and Lienk 1971; Weires and Riedl 1991).

Suitability of the environment

- The moths in this assessment are 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

- 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 (Dustan 1964; Smith and Summers 1948). 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, though field recordings are lower than 100 (Roberts *et al.* 1978; Rothschild and Vickers 1991; 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).
- Lesser apple fruitworm has similar mating patterns as oriental fruit moth (Neven 2004). In laboratory experiments lesser apple worm laid up to 136 eggs though the average per female was 42 (Neven 2004).

Cultural practices and control measures

- Similar pheromones as used for oriental fruit moth are also effective against lesser apple fruitworm (El-Sayed 2008).
- Pheromone disruption is effective against lesser apple fruitworm and cherry fruitworm (Davis *et al.* 1983; Gentry *et al.* 1974; Pfeiffer and Killian 1988; Roelofs *et al.* 1969; Willson and Trammel 1975). 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 California and the Pacific Northwest states and across North America where climatic conditions are similar to those of Australia.

Presence of natural barriers

- The long distances existing 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, other host plants such as apples, blueberries, hawthorn, oak and roses may provide opportunities for these pests to find suitable sites to colonise between major production areas.

Potential for movement with commodities, conveyances or vectors

- Commodities infested by *Grapholita* moths primarily include fruit and nursery stock (Canadian Food Inspection Agency 2007; Virginia Tech 2008). These commodities are moved within states and between states which would assist the spread of these pests.
- 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, while 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.
- Larvae that feed internally could be distributed through the wholesale or retail trade of stone fruit.

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 on page 16.

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 on page 19. 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 are considered pests of minor importance in stone fruit (Brown 1953; Hoerner and List 1952), but may cause greater impacts in Australia where established natural enemies are not present and different chemical and cultural control practices may result in these species having a greater impact. 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 1 000 tonnes (Australian Bureau of Statistics 2006). 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. 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	**D** — Significant at the district 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.
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 on page 19, 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 on page 20. 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 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 and Phillips 2001). They show a general preference for immature, succulent plant tissue and feed by puncturing host tissue and sucking the exuded cell contents (Agnello 1996; Antonelli 2003; Dreistadt and Phillips 2001).

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 (Kumm 2002; Lewis 1973).

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 (Baker 2002; Hoover 2002a; Kumm 2002; McDonald *et al.* 2000; Mound 2005b). 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 (Dreistadt and Phillips 2001; Smith and Van Driesche 2003).

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 (Dreistadt and Phillips 2001; Smith and Van Driesche 2003). 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 and Phillips 2001). Leaves may become mottled, dwarfed and distorted with browned or wilted leaf margins and may drop prematurely (Agnello 1996; Antonelli 2003; Booth 1999; Dreistadt and Phillips 2001; Hoover 2002a; Smith and Van Driesche 2003). 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 1996). Thrips have been detected in packinghouse culls of nectarines in California (Curtis *et al.* 1992) and have regularly been detected in stone fruit imported from New Zealand (PDI 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 2002; EPPO/CABI 1989; EPPO/CABI 1997g; EPPO/CABI 1999). All three thrips species are associated with stone fruit production in one or more of the exporting states (Agnello 1996; APHIS 2002c; Booth 1999; EPPO/CABI 1989; EPPO/CABI 1997g; EPPO/CABI 1999).
- 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 (Dreistadt and Phillips 2001; Hoover 2002a). Any thrips species present on fruit may be difficult to detect during harvesting.
- Eggs are typically deposited onto leaves or buds (Dreistadt and Phillips 2001), 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 and Phillips 2001).
- Symptoms of infestation include scarred leaf, flower and fruit surfaces (Booth 1999; Dreistadt and Phillips 2001). Damage to fruits may be obvious, but would not be a reliable indicator when culling fruit at harvest.

Processing of fruit in the packinghouse

- 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 (Agnello 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 and Phillips 2001).
- Post-harvest grading, washing, brushing and packing procedures are likely to cull symptomatic fruit and leaf material. It is likely that packinghouse 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 or sea freight and would result in fruit being in transit from a few days to up 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 and Phillips 2001). Assisted distribution with nursery stock or other commodities would be important for long distance spread (Dreistadt and Phillips 2001; Hoover 2002a).
- 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 (Dreistadt and Phillips 2001; Morse and Hoddle 2006).

- 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 on page 17. 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 2005b). However the thrips species considered under this assessment have a wide host range (Dreistadt and Phillips 2001).
- *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 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 (APPD 2006; Clift and Tesoriero 2002; Morse and Hoddle 2006).

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 1996; Baker 2002; 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 Van Driesche 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 (Baker 2002; Hoover 2002a; Kumm 2002;

McDonald *et al.* 2000). 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 1996; Kumm 2002).
- The wide host range in a range of environments worldwide suggest 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 1996; EPPO 2004b; Hoover 2002a). 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 and Phillips 2001).
- 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).
- Although most thrips species are sensitive to broad spectrum, pre-bloom insecticides, 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 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 (Dreistadt and Phillips 2001; Morse and Hoddle 2006).
- 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 (Dreistadt and Phillips 2001; Hoover 2002a; Morse and Hoddle 2006).

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 on page 16.

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 on page 19. 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 (McLaren and Walker 1998). 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 pests.

Based on the decision rules described in Table 2.4 on page 19, 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 on page 20. 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 (Newman *et al.* 2004; Newman *et al.* 2004; 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 (Costa *et al.* 2004; Hendson *et al.* 2001; Hernandez-Martinez *et al.* 2007; Mizell *et al.* 2003; Wichman and Hopkins 2002). However, 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 (Almeida and Purcell 2003). 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). The main factors limiting the distribution and persistence of *X. fastidiosa* are cold winter temperatures and suitable overwintering vectors (Hopkins 1989; Redak *et al.* 2004).

Xylella fastidiosa is restricted to xylem tissues of infected hosts 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; Ogawa *et al.* 1995; Purcell and Hopkins 1996; Purcell and Hopkins 1996; Wells 1995). 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 (Bevan 2000; Newman *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. Commonly, symptoms are typical of water stress (Purcell and Hopkins 1996). Most commonly, leaves are scorched, scalded, chlorotic, or necrotic (Ogawa *et al.* 1995; 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 (CABI 2007; Ogawa *et al.* 1995; Purcell and Hopkins 1996; Purcell and Hopkins 1996; Wells 1995). 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 and Hopkins 1996). 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 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

- *Xylella fastidiosa* is primarily found in tropical and subtropical regions of the Americas and its distribution corresponds to the distribution of its principal vectors, the glassy-winged sharpshooter (*Homalodisca vitripennis*) and the blue-yellow sharpshooter (*Oncometopia nigricans*). 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 never been intercepted with table grape imports from the US (DAFF 2006). 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, flesh 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 would be 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 are likely to be culled during the harvest process.
- 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 2007).

Processing of fruit in the packinghouse

- 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. However, 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 by either air freight or sea freight and would result in fruit being in-transit from a few days up to three weeks.
- Experimental data on the temperature-dependent growth and survival of *X. fastidiosa* 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 plants after 5 days at 5°C.
- Cold temperatures are detrimental to *X. fastidiosa*, and while temperatures below 10°C have been shown to reduce bacterial numbers in grapes (Hopkins and Purcell 2002), cold storage of stone fruit may not 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.
- Nearly any xylem feeding insect is a potential vector of *X. fastidiosa* (EPPO/CABI 1997m), which includes leafhoppers and spittlebugs.
- 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 the *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 low bacterial levels are likely to be present in symptomless fruit, there are potentially insufficient numbers of viable bacteria within the commodity for effective acquisition by suitable vectors upon entry (Costa *et al.* 2004; Hopkins 1989; Hopkins and Purcell 2002; Purcell and Hopkins 1996; Wells 1995)

- Known important vectors of *X. fastidiosa* in North America are absent in Australia. However, nine species of Cercopidae and thirteen species of Cicadellinae that are present in Australia (Fletcher and Lariviere 2006c; Liang and Fletcher 2002), could potentially vector the bacterium given its non-specific vector relationship. These potential vectors could enable the distribution of *X. fastidiosa* given they are highly mobile and prevalent throughout the eastern states of Australia.

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 on page 17. 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 and potentially any xylem feeding insect could vector the bacterium and provide a means for the establishment of *X. fastidiosa* in Australia (Almeida *et al.* 2005; Hopkins and Purcell 2002).
- 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. However, minimum incubation periods vary according to the host (Hill and Purcell 1995; 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 or 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. However, asymptomatic fruit may contain insufficient numbers of *X. fastidiosa* for effective vector acquisition (Li *et al.* 2003; 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 (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, thereby enabling the rapid spread of the bacterium (Almeida *et al.* 2005).
- *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 Ceropidae 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 and Lariviere 2006c; 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 on page 16.

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 on page 19. 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.

Conclusion – consequences

Based on the decision rules described in Table 2.4 on page 19, 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 on page 20.

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 1995). *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).

Symptoms of cherry leaf spot initially appear as small purple coloured spots on the upper surfaces of leaves in late spring or early summer. 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 (Jones 1995). 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 1995).

The fungus overwinters in fallen leaves and fruiting structures (apothecia) develop during spring as the temperature increases (Jones 1995). During rainy periods, ascospores are discharged from the apothecia for distances up to half a meter (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 when they unfold. After an initial period of high susceptibility, leaves become increasingly resistant with age (Jones 1995). Soon after lesions develop on leaves, conidia are produced, which are another important infective stage. 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 stonefruit 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 from New South Wales and South Australia, but these incursions were eradicated (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 (Pscheidt 2007) (Farr *et al.* 1989).
- The primary host for *B. jaapii* is cherries, but there is a single record for apricots being infected (Farr *et al.* 1989). 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 ,cherries, nor for any hosts (Smith *et al.* 2006).
- 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 2007a).
- 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.
- Cherry leaf spot is primarily a leaf pathogen and fruit infection rarely occurs (Jones 1995). Fruit are only susceptible to infection for a short period of time (Jones 1995).

Processing of fruit in the packinghouse

- 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 by either air freight or sea freight and would result in fruit being in-transit from a few days up 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 **VERY 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 which would be susceptible to infection.
- 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 1995), 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 1995). Cherries may be grown in suburban areas and ornamental *Prunus* species are sold by nurseries in Australia as amenity plants (Flemings Nurseries 2008). 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 on page 17. 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 (Farr *et al.* 1989). However, apart from cherries, suitable hosts are not common in Australia.
- All commercially grown cultivars of cherry are susceptible to *B. jaapii*, although sour cherry is the most susceptible (Jones 1995). The less susceptible sweet cherry is grown commercially in Australia and ornamental cherries are sold as amenity plants (Flemings Nurseries 2008).

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 environment 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 1995).

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 1995).
- 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 1995).

Cultural practices and control measures

- The use of fungicides is effective in controlling *B. jaapii* provided resistance does not develop (Jones 1995; McManus *et al.* 2007). Copper fungicides are especially useful in controlling *B. jaapii* (Jones 1995; McManus *et al.* 2007; Ogawa *et al.* 1995). 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 on page 16.

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 has been assessed according to the methods described in Table 2.3 on page 19. 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 will result in fruit that fail to mature normally (Jones 1995). However, the host range of *B. jaapii* is limited and the effects of this fungus will be restricted. Crop losses 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.

Conclusion – consequences

Based on the decision rules described in Table 2.4 on page 19, 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 on page 20.

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.) Cercospora leaf spot [WA]

Passalora circumscissa primarily causes disease on *Prunus* hosts, with late maturing stone fruit varieties being particularly susceptible (Sztejnberg 1995). The fungus is most prevalent on cherry but is also found on almonds, blackthorn, plums and peaches (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, its presence is usually 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 (APDD 2006). 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 2002c). 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 packinghouse

- 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 air or sea freight and would result in fruit being in transit from a few days up 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 on page 17. 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, and South Australia (APDD 2006). Suitable hosts would be present in Western Australian
- *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 (APDD 2006). 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 (APDD 2006)) 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.
- *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 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 on page 16.

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 has been assessed according to the methods described in Table 2.3 on page 19. 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 on page 19, 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 on page 20.

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 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 Plum 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. Different powdery mildew fungi can cause similar diseases on different hosts and some plants are susceptible to more than one species (Henry Doubleday Research Association 2007). 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 (EPPO 2004b; Grove 1995).

Powdery mildews reproduce both sexually and asexually, and require living plant tissue to grow and survive (Moorman 2005). Fungi can overwinter in infected buds as conidia or as cleistothecia on plant detritus (Cooperative Research Centre for Viticulture 2004; Grove 1995; Xu and Robinson 2000). Overwintered cleistothecia release ascospores from asci during spring rains which initiate new infections in spring (Teviotdale *et al.* 2001). 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; Ogawa *et al.* 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) The time taken from the establishment of new infections to production of new conidia can be 5-12 days (Cooperative Research Centre for Viticulture 2004). Cleistothecia take approximately 90 days to mature and are present during the more advanced stages of infection (Cooperative Research Centre for Viticulture 2004). They produce ascospores when wet which are dispersed by wind and water splash (Cooperative Research 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 (Cooperative Research Centre for Viticulture 2004; Grove 1995). 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 are associated with commodities in production areas. In Australia, *P. clandestina* has only been detected on *Crataegeus* hosts in NSW, Tas., and Vic. (APDD 2006). *Podosphaera tridactyla* is more widely distributed throughout Australia (ACT, NSW, SA, Tas., Vic. and Qld.) and detections have all been on *Prunus* hosts (APDD 2006). Based on its distribution in Australia, *P. tridactyla* is of concern to Western Australia. 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.

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). *Podosphaera clandestina* is known to occur on *P. avium* in at least five widely dispersed states (Iowa, North Carolina, Pennsylvania, South Dakota, and Washington) and has caused severe financial losses to growers in Washington (Farr *et al.* 1989; 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 (APDD 2006; 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 however fruits can also be affected (Grove 1995; Khairi and Preece 1975; Mukerji 1968). 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. Symptomatic host material is likely to be removed during routine harvesting and grading operations due to obvious symptoms.

Processing of fruit in the packinghouse

- 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 by either air freight or sea freight and would result in fruit being in transit from a few days up to three weeks.
- *Podosphaera* species can overwinter as conidia or cleistothecia and therefore cold storage during transport is unlikely to eliminate fungal spores.

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 are sensitive to extreme heat and direct sunlight (Moorman 2005). Mycelium, conidiophores and conidia on discarded fruit may be damaged or killed by environmental conditions.
- The fungus is an obligate parasite and requires living plant tissue in order to grow and reproduce (Moorman 2002). Conidia are also short lived and therefore any fungus on infected fruit would have limited time available for growth and sporulation (Silverside 2001).
- The germination rate of conidia decreases as the soluble solid (brix) content increases and therefore ripe fruit may not be suitable for germination and growth of conidia (Chellemi and Marois 1992; Farr *et al.* 1989). 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^{o}C. The shortest latency period occurred at temperatures from 21°C to 25°C, while the longest latency occurred at 10°C (Xu and Robinson 2000).
- Conditions would also need to be suitable for the transfer of conidia to a susceptible host. Normally, spores are dispersed by water splash and wind. However, this would need to occur before fruit desiccates and the fungus dies.

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 on page 17. 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*, *Crataegeus*, *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 Crataegeus (Hawthorn) hosts in Victoria, New South Wales and Tasmania and no records for infections on Prunus have been documented (APDD 2006).

Suitability of the environment

- *Podosphaera clandestina* is associated with stone fruits throughout the California, Idaho, Oregon and Washington regions in the US where conditions are similar to those in parts of Australia (APDD 2006; APHIS 2002b; Farr *et al.* 1989).
- Powdery mildews proliferate in warmer climates and prefer low relative humidity conditions during the day and high relative humidity at night (Moorman 2005). 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 (Xu and Robinson 2000). 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 (*Crataegeus* spp.)(APDD 2006), 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 conidia and/or cleistothecia and infect newly emerging leaves in spring (Fisher and Wicks 2003; Grove 1995; Xu and Robinson 2000). Conidia or ascospores are dispersed by wind and germinate on leaf, stem or fruit surfaces on susceptible hosts, increasing the inoculum potential (Grove 1995; Ogawa *et al.* 1995; Teviotdale *et al.* 2001; Teviotdale *et al.* 2001; Xu and Robinson 2000).
- In Australia, *P. clandestina* on hawthorn can germinate in conditions with a temperature range of 5-25^{o}C down to 50% relative humidity (Xu and Robinson 2000). 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 and the short lived conidia have a limited timeframe for spread and infection of new hosts.
- Powdery mildews are capable of producing large numbers of spores from overwintered cleistothecia on infected plant material. The time from germination to formation of new conidia may be as short as 24-48 hours (Cooperative Research Centre for Viticulture 2004; 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 (EPPO

2004b; Grove 1995; Henry Doubleday Research Association 2007; Moorman 2005; Ogawa *et al.* 1995; Teviotdale *et al.* 2001).
- Specific fungicides are required to control powdery mildew fungi (Teviotdale *et al.* 2001).
- Fungicides are applied to control *Podosphaera tridactyla* and *Sphaerotheca 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 *Crataegeus* species in NSW, Tas., and Vic. (APDD 2006) 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 thin walled conidia are relatively short lived under ambient conditions and 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. 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 on page 16.

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 on page 19. The justification for these ratings is provided below:

Impact scores for powdery mildew fungi	
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 these fungi is likely to be tempered 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 diseases on host plants are unlikely to be required as existing management measures are in place to control other powdery mildew pathogens are likely to be effective in controlling these fungi. Fungicide applications are specific to powdery mildew infections and thus additional spray programs may be necessitated 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 these pathogens are 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 occur due to fungicide applications of other pathogens.

Based on the decision rules described in Table 2.4 on page 19, 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 on page 20. 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]

4.16.1 Previous policy

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 in the risk assessment presented here.

4.17 Apricot ring pox

The species examined in this risk assessment is:

Apricot ring pox Causal agent unknown

Apricot ring pox virus was first described on apricot in Colorado in 1942 and renamed in 1943 (Bodine and Kreutzer 1942). It is also known as apricot ring spot and apricot pit pox (Ogawa *et al.* 1995). The causal agent of apricot ring pox has not yet been identified (Németh 1986). The virus is closely related to the cherry leaf twisted virus and may be the same casual agent (Németh 1986; Ogawa *et al.* 1995).

The virus can infect apricot, plum and cherry (Lott and Keane 1960; Ogawa *et al.* 1995; Wagnon *et al.* 1961). The pathogen infected many trees in Colorado and Washington states in the 1930s, but has not been of significance in recent times (Németh 1986; Ogawa *et al.* 1995; USDA 1951).

The symptoms of apricot ring pox are displayed on fruit, leaves and twigs (Németh 1986; Ogawa *et al.* 1995). Leaf symptoms can range from mild chlorotic ring patterns to large chlorotic and necrotic patterns and shot holes (Ogawa *et al.* 1995; Pine 1966). Fruit symptoms include small purplish and possibly necrotic spots on the surface of the fruit and deep necrosis extending to the pit in severe cases (Ogawa *et al.* 1995; Pine 1966). Fruit symptoms usually present a few weeks before fruit maturity (Németh 1986; Pine 1966). The disease can cause premature fruit drop (USDA 1951). Twig symptoms are are mild and often difficult to detect (Németh 1986), but are expressed as necrosis(Pine 1966). Some apricot cultivars are seriously affected, whereas others are symptomless (Ogawa *et al.* 1995).

The virus can be transmitted via grafting. Natural spread has also been reported although the vector for the spread is unknown (Németh 1986; Ogawa *et al.* 1995; USDA 1951).

The risk posed by apricot ring pox is that infected fruit could enter and lead to the establishment of apricot ring pox in Australia.

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 apricot ring pox will arrive in Australia on fruit that has undergone standard 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:

Harvesting fruit for export

- Infected apricot fruit of some varieties display obvious symptoms of infection (Ogawa *et al.* 1995). However, some apricot varieties, as well as other stone fruit varieties, can act as symptomless hosts for the virus (Ogawa *et al.* 1995; Simonds 1951).

- Symptoms in fruit can include black pox or rings on the fruit. Fruit displaying clear symptoms may be culled at harvest.
- This pathogen appears to be minor in the stone fruit production regions in the exporting states.

Processing of fruit in the packinghouse

- After harvest, fruit is washed and brushed/defuzzed. This process would not remove any pathogen inside of the fruit.
- Post-harvest grading and packing procedures would very likely remove any symptomatic fruit, but asymptomatic fruit would pass through these processes.

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 sea freight, taking from a few days to three weeks.
- It is unknown what effects, if any, cold treatment would have on the presence of apricot ring pox.

Probability of distribution

The probability that apricot ring pox, 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 has been determined to be **LOW**.

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

- Research has suggested that apricot ring pox is not transmitted by seed (Cochran and Calavan 1957). While only a limited number of seeds were tested, this indicated that this pathogen is either not seed transmitted or possibly only transmitted at low rates.
- While apricot ring pox can spread within orchards (Ogawa *et al.* 1995), no vector has been identified and there is no evidence that fruit is a pathway for the spread of this virus.
- Infected fruit arriving in Australia would be distributed for commercial sale.
- Infected fruit displaying symptoms would likely be disposed of before sale and would be considered unmarketable.
- Most fruit waste would be discarded into domestic waste which would limit the opportunity for potential vectors to acquire the virus. Any remaining waste that is disposed of into the environment would have a limited period of time before saprophytic fungi decompose the fruit.
- Apricot ring pox can infect multiple *Prunus* hosts. These hosts are present in Australia and could be in the vicinity of discarded fruit.

Overall probability of entry (importation x distribution)

The overall probability of entry for apricot ring pox is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2 on page 17. The overall probability of entry for apricot ring pox virus is assessed to be **EXTREMELY LOW**.

4.17.2 Probability of establishment

The probability that apricot ring pox, having been distributed in a viable state to a suitable host, will establish a persistent population 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

- Apricot ring pox infects apricot, plum and cherry. All of which are present in Australia.
- The vector for spreading apricot ring pox virus is unknown.

Suitability of the environment

- Apricot ring pox is found within the Pacific Northwest states. The environment (for example, suitability of climate, soil, pest and host competition) in Australia would therefore be suitable for the establishment of these species.

Reproductive strategy and the potential for adaptation

- Apricot ring pox is able to replicate in its host and to potentially build up large pathogen levels.
- The disease usually displays symptoms one year after graft inoculation (Németh 1986; Wagnon *et al.* 1961).
- A few strains of apricot ring pox, with differing severity, have been described suggesting potential for adaptation (Nyland and Thomas 1959).
- In theory, a single infective unit would be sufficient to infect and establish within a plant.

Cultural practices and control measures

- Control measures to stop the spread of apricot ring pox involve the destruction of infected plants and the use of disease free propagating material (Ogawa *et al.* 1995; USDA 1951). Such control measures would not be practiced in Australia unless infected trees were identified.

4.17.3 Probability of spread

The probability that apricot ring pox, 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 **MODERATE**.

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

Suitability of natural and/or managed environment

- Apricot ring pox is found within the Pacific Northwest states. The environment (for example, suitability of climate, soil, pest and host competition) in Australia is similar and would therefore be suitable for the spread of this species.

Presence of natural barriers

- Apricot ring pox is limited to its host. A vector is required to move the virus to new hosts. This could include grafting of host material or transmission by an arthropod.

Potential for movement with commodities, conveyances or vectors

- The transportation of infested stone fruit trees would aid the movement of apricot ring pox within orchards and into new areas. Nursery stock for which there are no restrictions is the most important pathway for long distance spread. As the vector for apricot ring pox is unknown, information about potential vectors of the apricot ring pox in Australia is also unknown.
- Apricot ring pox can be naturally spread within orchards, but the agent for spread has not been identified (Németh 1986). Plant feeding arthropods are present in Australia, some of which are known to vector plant viruses. There is potential that suitable vectors for apricot ring pox exist in Australia.
- Seed transmission of apricot ring pox is reported as not occurring (Cochran and Calavan 1957), although it may only occur at very low transmission rates.

Intended use of the commodity

- The hosts of apricot ring pox are primarily used for fruit production, nursery stock and possibly as amenity trees in urban environments. Restrictions on the movement of nursery stock would reduce the opportunity for this virus to spread.

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 on page 16.

The overall likelihood that apricot ring pox 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 apricot ring pos virus in Australia have been assessed according to the methods described in Table 2.3 on page 19. The justification for these ratings is provided below:

Impact scores for apricot ring pox virus	
Direct Impacts	**Estimate and Justification**
Plant life or health	**D** — Significant at the district level. This syndrome is considered to be one of minor significance in the US (USDA 1951). The virus can cause decline in the health of a tree, including chlorotic spots on leaves which later turn necrotic and fall out. Susceptible varieties can have severe damage to fruit making them unmarketable.
Any other aspects of the environment	**A** — Unlikely to be discernible at the local level. There are no known consequences of apricot ring pox on other aspects of the environment.
Indirect Impacts	**Estimate and Justification**
Eradication, control, etc.	**D** — Significant at the district level. If apricot ring pox were to establish in Australia, control strategies would likely be required. In the US, removal of infected trees and removal of wild host trees in the vicinity is recommended (Ogawa *et al.* 1995). While the costs of control could be large, the syndrome is of minor concern in the US and may similarly be of minor concern in

	Australia.
Domestic trade	B — Minor at the local level. The presence of apricot ring pox in commercial production areas may have an effect at the local level due to any resulting interstate trade restrictions on *Prunus* hosts, but fruit is not recognised as a pathway for the spread of this virus so stringent quarantine measures are unlikely.
International Trade	**B** — Minor at the local level. The presence of apricot ring pox in commercial production areas may have some impacts due to changed in quarantine conditions for exported fruit. However, due to the low importance placed in this syndrome and the unknown means for natural transmission, any such trade restrictions are likely to be minor.
Environment	**A** — Unlikely to be discernible at the local level. Control measure for apricot ring pox are unlikely to have any impacts on the environment.

Conclusion – consequences

Based on the decision rules described in Table 2.4 on page 19, 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.**

Unrestricted risk

Unrestricted annual risk is the result of combining annual 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 on page 20.

Unrestricted risk estimate for apricot ring pox	
Overall probability of entry, establishment and spread	**Extremely Low**
Consequences	**Low**
Unrestricted annual risk	**Negligible**

As indicated, the unrestricted annual risk for apricot ring pox has been assessed as '**negligible**, which meets Australia's ALOP. Therefore, specific risk management measures are not recommended for apricot ring pox.

4.18 *Plum pox potyvirus*

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

The *plum pox potyvirus* (PPV) is the causative agent of plum pox (sharka) disease, a devastating affliction of *Prunus* species. PPV is a member of the genus *Potyvirus* in the Potyviridae family. Plum pox is considered one of the most economically important diseases of stone fruit (EPPO/CABI 2004; Németh 1994). The disease reduces fruit quality and can cause premature fruit drop, resulting in large yield losses (EPPO/CABI 2004; Németh 1994). This disease has only been recorded in Pennsylvania, Michigan and New York State in the US and from the neighbouring Canadian state of Ontario. In association with state inspection agencies, APHIS has implemented measures to trace, eradicate and monitor plum pox in these regions. However, the spread of this pathogen in the US and concerns over US domestic movement restrictions have justified a detailed risk assessment.

The virus particles are flexuous rods approximately 700 x 11nm (EPPO/CABI 2004). The particles contain a single single-stranded positive sense RNA molecule approximately 9800 base pairs long (López-Moya *et al.* 2000). The entire open-reading frame is translated to yield three viral proteins (Brunt *et al.* 1996; Semmens *et al.* 1992).

Six distinct strains of PPV have been identified based on serological and nucleic acid tests, D, M, EA, C, W and Rec (Myrta *et al.* 2006). PPV-D is the Dideron strain infecting mainly apricot and plum and is the common strain in Western Europe (Pasquini and Barba 1996). Nearly all American PPV isolates are also PPV-D (Gildow *et al.* 2004; James *et al.* 2003; Smiley and Gerson 1995). This strain is considered less virulent and spreads slower than other strains, due to less efficient aphid transmission (Gildow *et al.* 2004; Pasquini and Barba 1996). PPV-M is the Marcus strain and is common in southern and eastern Europe and is especially damaging in peach orchards (Pasquini and Barba 1996). This strain is spread very quickly via aphid vectors. PPV-EA is the El Amar strain that was isolated from apricot (Pasquini and Barba 1996) and has a distribution limited to Egypt (Glasa *et al.* 2006; Myrta *et al.* 2006; Van Steenwyk *et al.* 2004). PPV-C is the Cherry strain and is the only known strain to infect cherry species, including sour and sweet cherries (Fanigliulo *et al.* 2003; Nemchinov and Hadidi 1996; Prado 1991). PPV-W is an isolated strain from Ontario, Canada, believed to be imported from Eastern Europe (James *et al.* 2003). PPV-Rec is a group of strains that are recombinations between D and M strains (Glasa *et al.* 2004). These strains are found in Europe and are aphid transmissible (Glasa *et al.* 2004).

Transmission of the virus can occur through grafting and most strains are non-persistently transmissible by aphids (Garrison 2001; Gildow *et al.* 2004; Glasa *et al.* 2004; Labonne *et al.* 1995; Stabler 1941). Evidence of aphid transmission from infected fruit has also been presented (Gildow *et al.* 2004). Transmission through seed is less certain, with some research determining that seed transmission does not occur (Duliæ Markoviæ and Rankoviæ 1996; Myrta *et al.* 1998; Pasquini *et al.* 2000; Thomidis and Karajiannis 2003), while other evidence suggests that the W strain is seed transmissible, though this has not yet been tested (James *et al.* 2003). It is possible that seed transmission may only be at extremely low rates.

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.* 2000).

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 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:

- Plum pox virus has only been reported from restricted areas within the US. This includes the states of Pennsylvania, Michigan and New York. These outbreaks are subject to ongoing monitoring and eradication efforts (Johanns 2007). These controls have effectively contained the outbreak in Pennsylvania.
- National monitoring for PPV in the US has focussed on nursery stock, budwood trees and rootstock trees, as these are the most likely avenue for the long distance spread of the virus (Poe 2002).
- Official controls are in place for the movement of nursery stock for shost species from these areas and are legislated in the *Code of Federal Regulations* (APHIS 2002a).
- Fruit have been demonstrated as a potential pathway for the movement of PPV (Gildow *et al.* 2004; Wallis *et al.* 2005). However, fruit are a much lower risk than nursery stock.
- As all of the risk pathways for plum pox virus have not been regulated, there is a small possibility that the virus could enter the exporting states. However, California and the Pacific Northwest states are major producers of stone fruit in the US, the total volume of stone fruit entering these states from the eastern US is expected to be small.
- The ongoing freedom from plum pox virus in the exporting states is supported by national surveys, coupled with moniroting by crop scouts in commercial orchards, would aid in the early detection of PPV in the exporting states.

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 are likely to be culled during harvest, asymptomatic fruit or fruit with mild symptoms are likely to escape detection.

Processing of fruit in the packinghouse

- 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 would potentially pass this process and be packed for export to Australia.

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 by either air freight or sea freight and would result in fruit being in-transit from a few days up to three weeks.

- Fruit can be used for virus sampling procedures if stored for a month or less at 4°C (EPPO/CABI 2004; Gildow *et al.* 2004). Therefore, it is unlikely that cold storage treatment during transport would be sufficient to 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:

- Distribution of the virus to a susceptible host could occur in two ways. Firstly, infected seed could germinate and give rise to an infected plant. Secondly, an aphid that is a vector for the virus could feed on infected fruit and transmit the virus to a host plant.
- There is some uncertainty over the role of seed transmission in the spread of the virus. Some reports state that seed transmission does not occur (Duliæ Markoviæ and Rankoviæ 1996; Myrta *et al.* 1998; Pasquini *et al.* 2000; Thomidis and Karajiannis 2003), while other research has provided anecdotal evidence that seed transmission could occur (James *et al.* 2003). Seed transmission of PPV may only occur at very low rates.
- Evidence of aphids acquiring the virus from infected fruit and transmitting it to adjacent host plants (Gildow *et al.* 2004; Wallis *et al.* 2005) is likely to represent the most important method of fruit mediated spread of PPV. For vector transmission to occur, aphids must feed on the fruit. After feeding, aphids would be able to transmit the virus to new plants until the aphid moults (Pfeiffer 2003), although other authors suggest that most potyviruses will only be transmitted for a short period of time (Wallis *et al.* 2005).
- 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 Unites 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 2007c). 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 percentage of all imported fruit.
- The importance of weed hosts is not clear. A large number of herbaceous plants are reported as hosts of PPV, including *Chenopodium* spp. (goosefoot), *Nicotiana* sp. (tobacco), *Pisum sativa*. (pea), and *Sonchus* sp. (sow thistle) (Llacer 2006). While these are recognised as less important than mature stone fruit trees in the case of epidemics, they may provide 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 on page 17. The overall probability of entry for PPV is assessed to be **EXTREMELY LOW**.

4.18.2 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 is not capable of infecting cherry but efficiently infects apricot and plum (Pasquini *et al.* 2000; Wallis *et al.* 2005). Apricot and plum are common trees within Australia.
- Aphid vectors present within Australia that are capable of transmitting the virus from infected fruit to healthy plants include *Myzus persica* and *Aphis spiraecola* (CSIRO 2005; Gildow *et al.* 2004).

Suitability of the environment

- PPV is found within the Eastern and Great Lake states of the US (Michigan, Pennsylvania and New York State) and not within the Pacific Northwest states. 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, suggesting that the virus would be able to establish in Australia.

Reproductive strategy and the potential for adaptation

- The virus is a single stranded RNA molecule that replicates within cells, then spreads to uninfected cells.
- Multiplication of the virus within an infected plant does not require any external factors.
- The vector aphid *Myzus persicae* is capable of acquiring 40-2000 copies of the virus by feeding on infected plants (Olmos *et al.* 2005).
- Virus can be acquired by *Myzus persicae* after five minutes of feeding on infected peach seedlings (Olmos *et al.* 2005).
- Presumably this range is capable of infecting new plants but in theory a single copy of the virus would be sufficient.
- PPV is a single stranded virus (+ve sense RNA) with no capacity to 'proof-read' the copied genetic material. This has lead to high mutation rates that may favour adaptation of the virus to new conditions or hosts. Many viable mutations within the same plant have been observed (Jridi *et al.* 2006).
- The presence of recombinant viral strains is also evidence for adaptation of the D and M strains of the virus (Glasa *et al.* 2004).

Cultural practices and control measures

- Plants found to be infected with PPV can be destroyed, but this is an action taken after PPV is suspected or confirmed. No such 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.
- While quarantine conditions restrict the movement of fruit within Australia to some extent, there is no specific monitoring or testing that would detect fruit infected with PPV.

4.18.3 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 is 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 environment (for example, suitability of climate, soil, pest and host competition) in temperate areas of Australia is similar to areas where the virus is prevalent and would therefore be suitable for the spread of this species.

Presence of natural barriers

- PPV is practically limited to its host plant unless transferred by vectors or mechanical inoculation.

Potential for movement with commodities, conveyances or by other vectors

- The spread of PPV would be facilitated by either insect vectors such as the green peach aphid (*Myzus persicae*) or the spiraea aphid (*Aphis spiraecola*) (CSIRO 2005; Gildow *et al.* 2004). Other endemic aphids may also be able to transmit PPV.
- Movement by insect vectors would be most important for the short range spread of PPV. While aphid vectors may be able to transmit the virus until their next moult (Pfeiffer 2003), the total distance an aphid would move in that time is likely to be limited. Thus aphids, would be important for spreading the virus between nearby trees or other host plants.
- 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.

4.18.4 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 on page 16.

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**.

4.18.5 Consequences

The consequences of the establishment of PPV in Australia have been assessed according to the methods described in Table 2.3 on page 19. The justification for these ratings is provided below:

Impact scores for plum pox virus	
Direct Impacts	**Estimate and Justification**
Plant life or health	**F** — Significant at the national level. This virus is considered to be one of the most important viruses affecting stone fruit

	(Németh 1994). Direct damage to plant health includes the development of blotches or chlorotic rings on leaves, although the severity of these symptoms can vary between host species and cultivar (EPPO/CABI 2004) Fruit symptoms include blotches or rings on immature fruit that later develop into distinct depressions. Depending on the host plant, internal fruit symptoms include browning of the flesh in isolated areas, although this may also involve widespread browning and necrosis of the flesh and saturation with gum through to the seed (EPPO/CABI 2004). Apricot fruit can develop a lumpy appearance. In some cases infected fruit will drop prematurely. Crop losses can be as high as 80% in some species. Replanting is the only option for trees and it may take six years for trees to reach productive capacity.
Any other aspects of the environment	**A** — In discernable at the local level. PPV can affect other, non-commercial, hosts that may be present in the native environment, or in urban and suburban areas as amenity plants. However, the impact on these alternative hosts is likely to be insignificant.
Indirect Impacts	**Estimate and Justification**
Eradication, control, etc.	**E** — Significant at the regional level. Eradication efforts to eliminate PPV will rely on the early detection and ability to remove all host plants in the vicinity. The United States Department of Agriculture reported costs of US $40 million for the destruction of trees over 1600 acres of commercial orchards in Pennsylvania following the detection in four counties (USDA 2007).
Domestic trade	**D** — Significant at the district 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 plum pox virus established in any region of Australia.
International Trade	**E** — Significant at the regional level. While plum pox virus 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	**A** — In discernable at the local level. There is unlikely to be any major changes to current pesticide spray regimes should plum pox virus establish in Australia. Any indirect effects on the environment are unlikely to be noticeable.

Conclusion – consequences

Based on the decision rules described in Table 2.4 on page 19, 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.**

4.18.6 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 on page 20. 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.

4.19 Risk assessment conclusion

As stated previously, pests for which policy already exists have not been re-assessed in this risk assessment. 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 draft IRA report for fresh, mature stone fruit California and the Pacific Northwest 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 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 mcdanieli* *Tetranychus pacificus* *Tetranychus turkestani*	Moderate	Low	Low	High	Moderate	Low	Low	Very Low
Diptera (fruit flies)								
Rhagoletis completa	Extremely Low	Low	Extremely Low	High	Moderate	Extremely Low	Low	Negligible
Rhagoletis pomonella	Moderate	Moderate	Low	High	Moderate	Low	High	Moderate
Hemiptera (mealybugs, plant bugs, scales)								
Lygus elisus *Lygus Hesperus* *Lygus lineolaris* *Closterotomus norvegicus* WA	Very Low	Moderate	Very Low	Moderate	Moderate	Very Low	Moderate	Very Low
Diaspidiotus forbesi *Diaspidiotus juglansregiae* *Parlatoria oleae* WA *Pseudaulacaspis pentagona* WA	Very Low	Low	Very Low	High	Moderate	Very Low	Low	Negligible
Pseudococcus comstocki *Pseudococcus maritimus*	High	Moderate	Moderate	High	High	Moderate	Low	Low
Lepidoptera (butterflies, moths)								
Anarsia lineatella	Moderate	Low	Low	High	High	Low	Moderate	Low

Archips argyrospilus *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*	Moderate	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	Very 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								
Apricot ring pox	Extremely Low	Low	Extremely Low	High	Moderate	Extremely Low	Low	Negligible
Plum pox potyvirus	Extremely Low	Low	Extremely Low	High	High	Extremely Low	High	Very Low
WA: a species identified as a quarantine pest for the state of Western Australia only								

5 Pest risk management

Risk management describes the process of identifying and implementing measures to mitigate the risks so as to meet Australia's ALOP. Pest risk management evaluates and selects options for measures to reduce the risk of entry, establishment or spread of quarantine pests for Australia where they have been assessed to have an unrestricted risk estimate above Australia's ALOP. In calculating the unrestricted risk, existing commercial production practices in California, Idaho, Oregon or Washington have already been considered, as have post-harvest cleaning and packing of fruit. Therefore any measures applied will be in addition to existing production practices.

It is important to note that the unrestricted risk estimates have only taken into account pre-export production practices and on-arrival minimum border procedures used by relevant government agencies such as AQIS. The minimum on-arrival procedures performed by AQIS for fresh produce include inspection of a randomly selected sample of 600 units of fruit in a consignment (covered by a single Phytosanitary certificate), verifying documentation such as Phytosanitary certificate, Import Permit and any shipping documents. In the case of stone fruit, one inspection unit is defined as one fruit. In the case of precleared shipments, this inspection is done in the country of origin and is not repeated on-arrival in Australia.

The purpose of the 600 unit quarantine inspection is to determine whether any potential quarantine pests are associated with the consignment. Biometrically, if no pests are detected by the inspection, this size sample achieves a 95% confidence level that not more than 0.5% of the units in the consignment are infested or infected. The level of confidence depends on each fruit in the consignment having about the same likelihood of being affected by a quarantine pest and the inspection technique being able to reliably detect quarantine pests in the sample. In the event of on-arrival or preclearance inspection, if no live pests are detected in the inspection sample, the consignment is considered to be practically free from pests and would be released for export/cleared from quarantine.

In order to have the least trade restrictive measures, evaluation of risk management options started with consideration of whether this 600 unit inspection would be capable of detecting whether a consignment is infested with a quarantine pest that would require a specific treatment. If there are specific risk mitigation measures identified in the protocol to manage the risks by quarantine pests on the pathway, depending on the measure, interception of live or dead quarantine pests at the preclearence inspection or at the on-arrival inspection may trigger rejection of the consignment from export (under preclearance arrangements) or from entering Australia (on-arrival inspection).

The remedial actions or treatments for consignments (subject to preclearance 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 revealed for that specific pest.
Remedial actions could include:

- withdrawing the consignment from export (if quarantine pests are detected during preclearance inspection)
- re-export of the consignment (following on-arrival inspection)
- destruction of the consignment (for on-arrival inspection)
  or

- treatment of the consignment and re-inspection to ensure that the pest risk has been addressed (both preclearance and 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 mitigation strategy put in place against that pest in the protocol.

It should be emphasised that inspection (preclearance or on-arrival) is not a measure that mitigates the risk of a pest. It is the pre-agreed risk mitigation measures such as mandatory preshipment treatments, area freedom, inspection and certification, that would minimise a pest risk. Inspection is only the verification process whether the consignment has been subjected to the risk mitigation measures identified in the protocol agreement.

In this section, Biosecurity Australia has identified risk management measures that may be applied to consignments of stone fruit sourced from California, Idaho, Oregon and Washington. In some cases, detailed efficacy data on treatments is not available for the quarantine pests identified and would need to be provided by the exporting country before these treatments can be finalised and final import conditions developed. Finalisation of the quarantine conditions may be undertaken with input from AQIS and the Australian states and territories as appropriate.

5.1 Risk management measures for quarantine pests

The pest risk analysis identified the following pests, or groups of pests, as having an unrestricted risk above Australia's appropriate level of protection:

Scientific Name	Common Name	Unrestricted Risk
Rhagoletis pomonella	Apple maggot	Moderate
Pseudococcus comstocki *Pseudococcus maritimus* *Pseudococcus calceolariae* [WA EP]	Comstock mealybug Grape mealybug Citrophilus mealybug	Low Low Low
Anarsia lineatella	Peach twig borer	Low
Archips argyrospilus *Archips podana* *Archips rosana* *Argyrotaenia citrana* *Choristoneura rosaceana* *Pandemis pyrusana* *Platynota stultana*	Fruit-tree leafroller Great brown twist moth European leafroller Orange tortrix Oblique banded leafroller Pandemis leafroller Omnivorous leafroller	Low Low Low Low Low Low Low
Grapholita packardi *Grapholita prunivora* *Grapholita molesta*[WA EP]	Cherry fruitworm Lesser apple fruitworm Oriental fruit moth	Low Low Low
Frankliniella occidentalis [EP] *Frankliniella tritici* *Frankliniella intonsa* *Taeniothrips inconsequens*	Western flower thrips Flower thrips Taiwan flower thrips Pear thrips	Low Low Low Low
[EP]: A pest which has been assessed previously and for which existing policy is being applied [WA]: A pest of regional concern to Western Australia only		

5.1.1 Mealybugs, leafrollers and thrips

Mealybugs, leafrollers 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 only considered a quarantine pest for Western Australia. Therefore, quarantine actions for citrophilus melaybug need only be applied for exports destined for Western Australia.

Visual inspection and remedial action

Various mealybug, leafroller and thrips species have been considered in previous import risk analyses and policy extensions undertaken by Biosecurity Australia. These external pests, which are relatively large, can easily be detected by trained quarantine inspectors. Therefore, the standard 600 unit quarantine inspection undertaken by AQIS would be effective at identifying consignment 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 leafrollers, mealybugs and thrips to a very low level.

Remedial action, if required, would be 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 propose, providing that it provides an equivalent level of protection

The consignment would not be released from quarantine until the remedial action has been undertaken.

5.1.2 Apple maggot.

Apple maggot was assessed to have an unrestricted risk estimate of moderate, so risk management measures are required.

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 was not detected, apple maggot could enter, establish and spread within Australia.

Apple maggot has not previously been considered in other import policies and so no previously approved quarantine measures exist for this pest. Potential mitigation measures for apple maggot could include methyl bromide fumgiation, establishment of pest free areas, cold temperature disinfestation, a systems approach based on a combination of measures, or irradiation. However, development of final import conditions will be dependant on APHIS providing additional scientific information supporting the efficacy of treatments against apple maggot that reduce the level of risk in line with Australia's ALOP.

The use of ionising treatments, such as gamma rays and x-rays for quarantine purposes is recognised as a potential mitigation measure for all arthropod pests. The International Standards for Phytosanitary Measures Publication Number 18, *'Guidelines for the use of irradiation as a phytosanitary measure'*, outlines a number of considerations that can be made in accepting irradiation as a phytosanitary measures.

Research into the efficacy of irradiation against apple maggot has been conducted and indicated that a dose of 57 Gray was effective at preventing pupation when third instar larvae were exposed (Hallman 2004b). Apple maggot pupates outside of the fruit (Dean and Chapman 1973; Weems Jr and Fasulo 2002), so any apple maggot found in export fruit would be either in the egg or larval stage. Larvae treated at 57 Gray would be prevented from emerging as adults and thus post no quarantine risk. Such a treatment could be used for quarantine purposes..

Currently, irradiated stone fruit is not permitted to be sold in Australia due to regulations managed by Food Standards Australia New Zealand (FSANZ). However, application may be made to FSANZ by any interested stakeholder to change the *Australia New Zealand Food Standards Code* to allow stone fruit or other fruits treated with irradiation for phytosanitary purposes to be sold in Australia. Information on these applications can be viewed at the FSANZ web site[1].

5.1.3 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 is a serious pest of stone fruit production that bores into the flesh and feeds just below the skin. Feeding damage can include breaks in the skin of the fruit and post-harvest rots. Fully grown larvae are around 12 mm long (Pickel *et al.* 2006e). Eggs are minute and may be laid on fruit. The eggs are oval shaped and only 0.2 mm wide by 0.4 mm long (CABI 2007). Visual inspection by trained quarantine inspectors would be expected to detect late infestations of peach twig borer, but eggs or early infestations may escape detection. Therefore, Biosecurity Australia does not recommend that visual inspection of fruit be relied upon as a measure to detect potential infestations by peach twig borer. Due to the difficulty of detecting eggs and early instar larvae, an additional measure known to be effective against the difficult to detect egg and early larval stage of peach twig borer will be required.

Peach twig borer has not previously been considered in other import policies and no previously approved quarantine measures exist for this pest. Potential mitigation measures for peach twig borer could include methyl bromide fumigation, establishment of pest free areas, cold temperature disinfestation, irradiation, or a systems approach based on a combination of measures. However, development of final import conditions will be dependant on APHIS providing additional scientific information supporting the efficacy of treatments against peach twig borer that reduce the level of risk in line with Australia's ALOP.

---

[1] http://www.foodstandards.gov.au/standardsdevelopment/

5.1.4 *Grapholita* moths

The *Grapholita* moths were assessed to have an unrestricted risk estimate of low, so risk management measures are required.

Three moths of the genus *Grapholita* were identified as requiring quarantine measures: *G. molesta* (oriental fruit moth), *G. packardi* (cherry fruitworm), and *G. prunivora* (lesser apple fruitworm). Of the three moths, oriental fruit moth has already been considered in detail in a previous IRA. Additionally, oriental fruit moth is only a pest of quarantine concern to Western Australia

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.

Oriental fruit moth

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 International Standards for Phytosanitary Measures Publication No. 22 *Requirements for the establishment of areas of low pest prevalence* (FAO, 2005).

Trapping data for oriental fruit moth that demonstrates low pest numbers will require additional or different criteria for recognition of areas of low pest prevalence. Application for recognition of areas of low pest prevalence in the exporting states would be assessed by Biosecurity Australia in consultation with DAFWA.

Other Grapholita moths

As pest free areas, pest free places of production and pest free production sites are accepted for oriental fruit moth, in principle, similar quarantine measures could be developed for cherry fruitworm and lesser apple fruitworm. Should information be presented in support of these approaches be presented by APHIS, it would be considered by Biosecurity Australia.

Trapping data that demonstrates low pest numbers will require additional or different criteria for recognition of areas of low pest prevalence. Application for recognition of areas of low pest prevalence in exporting areas would be assessed by Biosecurity Australia in consultation with the Australian states and territories.

Methyl bromide fumigation

Methyl bromide fumigation is a measure that might be applied to manage the risk posed by *Grapholita* moths. The fumigation treatment schedules set out below are those currently outlined to reduce the risk of importation of oriental fruit moth on stone fruit from New Zealand below Australia's ALOP. These measures are considered to provide sufficient protection against the risks of importing the three *Grapholita* moths assessed here.

It is proposed that where fumigation with methyl bromide is utilised as the measure for *Grapholita* moths, it must be carried out for duration of 2 hours according to the specifications below:

- $32g/m^3$ at a fruit pulp temperature of 21ºC or greater
- $40g/m^3$ at a fruit pulp temperature of 16ºC or greater or
- $48g/m^3$ at a fruit pulp temperature of 10ºC or greater

It is proposed that fruit should not be fumigated if the pulp temperature is below 10ºC and that fumigations should 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 (gh/m^3).

The objective of these procedures is to provide a measure that will reduce the risk of the importation of *Grapholita* moths to a level that will meet Australia's appropriate level of protection.

Other measures for Grapholita moths

Other potential mitigation measures for *Grapholita* moths could include cold temperature disinfestation, irradiation, or a systems approach based on a combination of measures. However, development of final import conditions will be dependant on APHIS providing additional scientific information supporting the efficacy of treatments against *Grapholita* moths that reduce the level of risk in line with Australia's ALOP.

Irradiation treatments for oriental fruit moth have been researched, showing that an absorbed dose of 232 Gray prevents adult emergence of final instar larvae (Hallman 2004a). Therefore, a minimum absorbed dose of 232 Gray could be used as the basis of a quarantine treatment for oriental fruit moth. Prevention of adult emergence would provide quarantine security from exotic pests. Confirmation of the efficacy of this against other *Grapholita* species would be required.

Currently, irradiated stone fruit is not permitted to be sold in Australia due to regulations managed by FSANZ. However, application may be made to FSANZ by any interested stakeholder to change the *Australia New Zealand Food Standards Code* to allow stone fruit or other fruits treated with irradiation for phytosanitary purposes to be sold in Australia. Information on these applications can be viewed at the FSANZ web site[1].

5.1.5 Consideration of alternative treatments

Consistent with the principle of equivalence detailed in the *Guidelines for pest risk analysis* (FAO 2004b), 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 which details the proposed treatment and includes data from suitable treatment trials.

5.2 Operational systems for maintenance and verification of phytosanitary status

It is necessary to have a system of operational procedures in place to ensure that the phytosanitary status of stone fruit from California, Idaho, Oregon and Washington is maintained and verified during the process of production and export to Australia. Details of the operational system, or equivalent, will be determined by agreement between Biosecurity Australia and APHIS. The proposed system of operational procedures for the production and export of stone fruit from California, Idaho, Oregon and Washington would include:

- registration of export orchards;
- registration of packinghouses and auditing of procedures;
- phytosanitary measures for quarantine pests;
- packaging and labelling;
- specific conditions for storage and movement of produce;
- pre-export phytosanitary inspection by APHIS;
- phytosanitary certification by APHIS;
- pre-clearance or on-arrival quarantine clearance by AQIS;
- AQIS supervision of irradiation.

5.2.1 Registration of export orchards

All stone fruit for export from California, Idaho, Oregon and Washington must be sourced from commercial orchards registered with APHIS. A list of registered orchards is to be provided to AQIS at the start of each season. APHIS will be required to register each export orchard prior to commencement of exports from that orchard.

The hygiene of export orchards must be maintained by appropriate pest management options that have been approved by APHIS to manage pests and diseases of quarantine concern to Australia. Registered growers must keep records of control measures for auditing purposes. If required, the details of the pest control program will be submitted to Biosecurity Australia/AQIS through APHIS.

The objective of this procedure is to ensure that produce is sourced from orchards producing quality fruit as the risk assessment is based on existing commercial production, harvesting and packing activities and assures orchards from which stone fruit is sourced can be identified. This is to allow trace-back to individual orchards in the event of noncompliance. For example, if live pests are regularly intercepted during inspection, the ability to identify a specific orchard allows investigation and corrective action to be targeted rather than applying actions to all orchards producing fruit for export to Australia.

5.2.2 Registration of packinghouses and auditing of procedures

All packinghouses intending to export stone fruit to Australia will be required to be registered with APHIS for trace-back purposes. The list of registered packinghouses must be kept by APHIS and provided to AQIS prior to exports commencing with updates provided if packinghouses are added or removed from the list.

Packinghouses will be required to identify individual orchards with a unique identifying system and identify fruit from individual orchards by marking cartons or pallets (i.e. one orchard per pallet) with a unique orchard number or identification provided by APHIS.

5.2.3 Packing and labelling

All stone fruit for export must be free from regulated articles, which are defined as any items other than stone fruit. Practically, this may include leaf material, woody plant material, weeds, weed seeds, or any other contaminants, often referred to as 'trash'. No unprocessed packing material of plant origin will be allowed. All wood material used in packaging of stone fruit must comply with the AQIS conditions (e.g. those in "Cargo containers: quarantine aspects and procedures"). All boxes must be labelled with the orchard registration number. Palletised product is to be identified by attaching a uniquely numbered pallet card to each pallet or part pallet to enable trace back to registered orchards.

The objectives of this procedure are to ensure that:

- Stone fruit exported to Australia is not contaminated by quarantine pests or regulated articles.
- 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.

5.2.4 Specific conditions for 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, packinghouse to cool storage/depot, to inspection point, to export point). Product for export to Australia that has been inspected and certified by APHIS must be maintained in secure conditions that will prevent mixing with fruit for domestic consumption or 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. The objective of this procedure is to ensure that the phytosanitary status of the product is maintained during storage and movement.

5.2.5 Phytosanitary inspection and certification by APHIS

APHIS will be required to issue a phytosanitary certificate for each consignment after completion of the pre-export phytosanitary inspection consistent with International Standards for Phytosanitary Measures No. 7 Export Certification Systems (FAO, 1997). The objective of this procedure is to provide formal documentation to AQIS verifying that the relevant measures have been undertaken offshore.

The inspection undertaken by APHIS will be required 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 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 pest for which area freedom, pest free places of production, pest free production sites or areas of low pest prevalence will result in the loss of the relevant pest status. Records of the interceptions made during these inspections (live quarantine pests, dead quarantine pests from pest free areas, pest free places of production, pest free production sites or areas of low pest prevalence, 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 or areas of low pest prevalence 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.

5.2.6 Pre-clearance or on-arrival phytosanitary inspection by AQIS

Inspection lots will be inspected using the standard AQIS inspection protocol. AQIS inspectors are trained to detect all life stages of arthropod pests, including eggs. Inspections are conducted in accordance with AQIS work procedures, which include optical enhancement where necessary. The sample size for inspection of stone fruit is given below.

Consignment size (Units*)	Sample size (Units)
1-1000 units	450 units or 100 per cent of the consignment (which ever is smaller)
1001 units or more	600 units
Unit = one 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 or areas of low pest prevalence, 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 or areas of low pest prevalence will also result in the loss of the relevant pest status. A pre-clearance work plan will be developed, if required, by AQIS and APHIS.

For pre-clearance inspections, AQIS will confirm that a Notice of Intent (NOI) to export is completed and relates to the product presented for inspection, undertake inspection of the inspection lot, and authorise the NOI. AQIS will undertake a documentation compliance examination for consignment verification purposes at the port of entry in Australia prior to release from quarantine. For on-arrival inspections, no land bridging of goods will be permitted until goods have cleared quarantine. If no live quarantine pests, or dead pests from pest free areas, pest free places of production, pest free production sites or areas of low pest prevalence, or other regulated articles are detected in the inspection lot, the consignment will be released from quarantine.

The objective of this procedure is to verify that the required measures have been undertaken.

5.3 Actions for non-complying lots

Where inspection lots are found to be non-compliant with requirements, remedial action must be taken as outlined at the beginning of this section. 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.

5.4 Audit of protocol

Prior to the first season of trade, a representative from Biosecurity Australia and 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.

5.5 Uncategorised pests

If an organism is detected on stone fruit, either in the United States 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. The detection of any pests of quarantine concern not already identified in the analysis may result in remedial action and/or suspension of trade while a review is conducted to ensure that existing measures continue to provide the appropriate level of phytosanitary protection for Australia.

5.6 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 in California, Idaho, Oregon and/or Washington 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. For example, plum pox virus has not been detected in any of the exporting states in the US and ongoing nationwide surveys are being conducted. Should plum pox virus be detected in any of the exporting states, APHIS must immediately advise Biosecurity Australia and AQIS of the changed pest status. Similarly, area freedom from a range of fruit flies in the genera *Anastrepha*, *Bactrocera* and *Ceratitis* was recognised in the pest categorisation tables. Should any fruit flies of these genera be detected in the exporting states, or any other exotic fruit flies that attack stone fruit be detected, APHIS must advise Biosecurity Australia and AQIS of the change in pest status.

6 Conclusion

The findings of this draft IRA report are based on a comprehensive analysis of relevant scientific literature and existing import requirements for stone fruit from New Zealand and cherries from the US.

Biosecurity Australia considers that the risk management measures proposed in the draft IRA report will provide an appropriate level of protection against the pests identified in this risk assessment. Various risk management measures may be suitable to manage the risk associated with stone fruit from California, Idaho, Oregon and Washington and Biosecurity Australia will consider any other measures suggested by stakeholders that provide an equivalent level of phytosanitary protection.

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 2002c) A (APHIS 2006b)	Yes (Halliday 1998) (Poole 2006)	No
Brevipalpus phoenicis (Geijskes, 1939) [Acari: Tenuipalpidae]	False spider mite	N, Pe, Pl (APHIS 2002c)	Yes (Halliday 1998) (Poole 2006)	No
Bryobia rubrioculus (Scheuten, 1857) [Acari: Tetranychidae]	Brown mite	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	Yes (Halliday 1998) (Poole 2006)	No
Diptacus gigantorhynchus (Nalepa, 1892) [Acari: Eriophyidae]	Big-beaked plum mite	N, Pe, Pl (Rice *et al.* 1976)	Yes. Single record, Vic. (APPD 2006)	Yes[2]
Eriophyes insidiosus (Keifer & Wilson, 1955) [Acari: Eriophyidae]	Peach bud mite	Pe (Oldfield 1970)	No records	Yes
Oligonychus mangiferus (Rahman & Sapra, 1940) [Acari: Tetranychidae]	Mango spider mite	N, Pe, Pl (APHIS 2002c)	Yes (Halliday 1998)	No
Panonychus ulmi (Koch, 1836) [Acari: Tetranychidae]	European red mite	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	Yes (Halliday 1998)	No

[2] 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 ?
Panonychus citri (McGregor, 1916) [Acari: Tetranychidae]	Citrus red mite	(CABI 2007) lists peach as a minor host, but no reference to this pest on any stone fruit in the US was found.	Yes (Halliday 1998) Absent from WA (DAWA 2003)	No
Tarsonemus smithi Ewing, 1939 [Acari: Tarsonemidae]	Tarsonemid mite	N, Pe, Pl (APHIS 2002c)	No records	Yes
Tetranychus mcdanieli McGregor, 1931 [Acari: Tetranychidae]	McDaniel spider mite	Pl (Anthon and Smith 1975) A (APHIS 2006b)	No (DAWA 2003)	Yes
Tetranychus neocaledonicus (Andre, 1933) *[Acari: Tetranychidae]*	Vegetable spider mite	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	Yes (Halliday 1998) (Poole 2006)	No
Tetranychus pacificus (McGregor, 1919) [Acari: Tetranychidae]	Pacific spider mite	N, Pe, Pl (APHIS 2002c)	No (DAWA 2003)	Yes
Tetranychus turkestani Ugarov & Nikolski, 1937 [Acari: Tetranychidae]	Strawberry spider mite	N, Pe, Pl (APHIS 2002c)	No (DAWA 2003)	Yes
Tetranychus urticae Koch, 1836 [Acari: Tetranychidae]	Two spotted spider mite	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	Yes (Halliday 1998) (Poole 2006)	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 (CABI 2007; LaGasa *et al.* 2001).	No (Calder 1996)	Yes
Ambrosiodmus rubricollis (Eichhoff, 1875) [Coleoptera: Scolytidae]	Bark beetle	N, Pe, Pl (APHIS 2002c)	Yes. Introduced to Australia (Wood and Bright 1992). Distribution uncertain.	Yes
Ambrosiodmus tachygraphus (Zimmermann, 1868) [Coleoptera: Scolytidae]	Bark beetle	N, Pe, Pl (APHIS 2002c)	No (Wood and Bright 1992)	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

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 ?
Carpophilus freemani Dobson, 1856 [Coleoptera: Nitidulidae]	Nitidulid beetle	Pe (CABI 2007) N, Pe (Guo 1999)	No records	Yes
Carpophilus hemipterus (Linnaeus, 1758) [Coleptera: Nitidulidae]	Dried fruit beetle	Pl (CABI 2007) N, Pe (Guo 1999)	Yes. NSW, Vic, Tas, WA, NT (APPD 2006)	No
Carpophilus humeralis (Fabricius, 1798) [Coleoptera: Nitidulidae]	Pineapple beetle	Pe (CABI 2007)	Yes. NSW, NT, WA (APPD 2006)	No
Carpophilus mutilatus Erichson, 1843 [Coleoptera: Nitidulidae]	Flower beetle	Pe (CABI 2007)	Yes. NSW, Qld, WA (APPD 2006)	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 (Bellamy 2002)	Yes
Chrysobothris mali Horn, 1886 [Coleoptera: Buprestidae]	Pacific flatheaded borer	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	No records (Bellamy 2002)	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
Conotrachelus nenuphar (Herbst, 1797) [Coleoptera: Curculionidae]	Apple curculio; plum curculio	N, Pe, Pl (APHIS 2002c)	No records (DAWA 2003)	Yes
Cotinis mutabilis (Gory & Percheron, 1833) [Coleoptera: Scarabaeidae]	Peach beetle	N, Pe, Pl (APHIS 2002c)	No records (Cassis *et al.* 1992)	Yes
Cotinis nitida (Linnaeus, 1764) [Coleoptera: Scarabaeidae]	Green June beetle	N, Pe, Pl (APHIS 2002c)	No records (Cassis *et al.* 1992)	Yes
Dyslobus nigrescens (Pierce, 1913) [Coleoptera: Curculionidae]	Weevil	Pe (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 ?**
Elaphidionoides villosus (Fabricius, 1792) Synonym: *Anelaphus villosus* Fabricius [Coleoptera: Cerambycidae]	Twig pruner	N, Pe, Pl (APHIS 2002c)	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.* 2006i) A (APHIS 2006b)	No records	Yes
Monarthrum fasciatum (Say, 1826) [Coleoptera: Scolytidae]	Peach bark beetle	N, Pe, Pl (APHIS 2002c)	No records (Wood and Bright 1992)	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
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]	Cribate weevil; Apple curculio	Pe (Beers *et al.* 2003) A (APHIS 2006b)	Yes. NSW, Qld., SA, Vic. (APPD 2006) WA (Poole 2006)	No
Otiorhynchus ligneus (Olivier, 1807) [Coleptera: 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

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 ?
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: *Asynonymsonychus cervinus* (Boheman, 1840) *Naupactus cervinus* (Boheman, 1840) [Coleoptera: Curculionidae]	Fuller's rose weevil	N, Pe, Pl (APHIS 2002c)	Yes (APPD 2006) WA (Poole 2006) WA, SA, NSW, Vic., Tas., Qld. (CSIRO 2005)	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 2002c)	No (Wood and Bright 1992)	Yes
Pleocoma crinita Linsley, 1938 [Coleoptera: Scarabaeidae]	Rain beetle	Pl (Wenatchee 2005)	No (Cassis *et al.* 1992)	Yes
Pleocoma minor Linsley, 1938 [Coleoptera: Scarabaeidae]	Rain beetle	Pl (Wenatchee 2005)	No (Cassis *et al.* 1992)	Yes
Pleocoma oregonensis Leech,1933 [Coleoptera: Scarabaeidae]	Rain beetle	Pl (Wenatchee 2005)	No (Cassis *et al.* 1992)	Yes
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 2002c)	No (Cassis *et al.* 1992) No (DAWA 2003)	Yes
Pyrrhalta cavicollis (LeConte, 1856) [Coleoptera: Chrysomelidae]	Cherry leaf beetle	N, Pe, Pl (APHIS 2002c)	No (Reid 2006)	Yes
Sciopithes obscurus Horn, 1876 [Coleoptera: Curculionidae]	Obscure root weevil	N, 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 ?**
Scolytus rugulosus (Müller, 1818) [Coleoptera: Curculionidae]	Shot-hole borer	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	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
Synonymseta albida LeConte, 1857 [Coleoptera: Chrysomelidae]	Fruit tree leaf beetle; Western fruit beetle; Syneta leaf beetle	Pl (Berry 1998)	No (Reid 2006)	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 2002c)	No (Wood and Bright 1992)	Yes
Xyleborus saxesenii (Ratzeburg, 1837) [Coleoptera: Scolytidae]	Ambrosia beetle	N, Pe, Pl (APHIS 2002c)	Yes. NSW, Tas., WA (APPD 2006) WA (Poole 2006)	No
Xylosandrus crassiusculus (Motschulsky, 1866) Synonym: *Xyleborus crassiusculus* (Motschulsky, 1866) [Coleoptera: Scolytidae]	Ambrosia beetle; Asian ambrosia beetle; Granulate ambrosia beetle	N, Pe, Pl (APHIS 2002c)	No (Wood and Bright 1992)	Yes
DERMAPTERA				
Forficula auricularia Linnaeus, 1758 [Dermaptera: Forficulida]	European Earwig	A (APHIS 2006b) N (Curtis *et al.* 1992)	Yes. NSW (Bower 1993) WA (Rees *et al.* 2001)	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 ?**
DIPTERA (Flies)				
Anastrepha ludens (Loew, 1873) [Diptera: Tephritidae]	Mexican fruit fly	Peach is an occasional host (EPPO/CABI 1997b) Occasional outbreaks in California (Weems Jr *et al.* 2004)	No (White and Elson-Harris 1992)	No[3]
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[3]
Anastrepha suspensa (Loew, 1862) [Diptera: Tephritidae]	Caribbean fruit fly	Occasional transient in California and Texas (APHIS 2002c)	No records	No[3]
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[3]
Bactrocera cucurbitae (Coquillett, 1899) [Diptera: Tephritidae]	Melon fruit fly	Peach is considered an occasional host (Weems Jr and Heppner 2004) Recorded from California, but eradicated (EPPO/CABI 1997d)	No (White and Elson-Harris 1992)	No[3]
Bactrocera dorsalis (Hendel, 1912) [Diptera: Tephritidae]	Oriental fruit fly	Pe, Pl (EPPO/CABI 1997e). Outbreaks in California are eradicated.	No (White and Elson-Harris 1992)	No[3]
Bactrocera zonata (Saunders, 1842) Synonym: *Dacus zonatus* (Saunders, 1842) [Diptera: Tephritidae]	Peach fruit fly	Pe (APHIS 2006a). Outbreak in California in 2006. Since declared as eradicated.	No (White and Elson-Harris 1992)	No[3]
Ceratitis capitata (Wiedemann, 1824) [Diptera: Tephritidae]	Mediterranean fruit fly	N, Pe, Pl (APHIS 2002c) Established in Hawaii, and is considered a transient species in California and Florida. Infestations are subject to eradication efforts.	Yes. WA (Poole 2006) Occasional outbreaks in other states are eradicated.	No[3]
Phytomyza persicae Frick,1954 [Diptera: Agromyzidae]	Peach leafminer	N, Pe, Pl (APHIS 2002c)	No (Spencer 1977)	Yes

[3] 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 (Apricot, Nectarine, Peach, Plum)**	**Presence in Australia**	**Consider Further ?**
Rhagoletis completa Cresson, 1929 Synonym: *Rhagoletis suavis* (Loew) [Diptera: Tephritidae]	Walnut husk fly; Walnut husk maggot	N, Pe, Pl (APHIS 2002c) (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 1997l). 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.* 2007) Hosts incude peach and plum (Yee and Goughnour 2006)	No (White and Elson-Harris 1992)	Yes
HEMIPTERA (Aphids, leafhoppers, mealybugs, psyllids, scales, true bugs, whitflies)				
Acanthocephala femorata (Fabricius, 1775) [Hemiptera: Coreidae]	Leaf footed bug	N, Pe, Pl (APHIS 2002c)	No (Cassis and Gross 2002)	Yes
Acrosternum hilare (Say, 1831) [Hemiptera: Pentatomidae]	Green stink bug	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	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. Qld. (APPD 2006), but under quarantine control. Not in WA (DAWA 2003) and no records for other states.	No
Aonidiella citrina (Coquillett, 1891) [Hemiptera: Diaspididae]	Yellow scale	N, Pe, Pl (CABI 2007)	Yes. NSW, VIC (APPD 2006) WA (Poole 2006)	No
Aphis spiraecola Patch, 1914 [Hemiptera: Aphididae]	Spiraea aphid; Green citrus aphid	Pe (CABI 2007)	Yes. SA (Hollis and Eastop 2005); NSW, Qld., Tas, Vic. (APPD 2006) WA (Poole 2006)	No
Aspidiotus nerii Bouché, 1833 [Hemiptera: Diaspididae]	Oleander Scale; Aucuba scale	Pe (CABI 2007)	Yes. WA (Poole 2006) NSW, NT, SA, Tas., Vic., WA (APPD 2006)	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 ?
Aulacaspis rosae (Bouché, 1833) [Hemiptera: Diaspididae]	Rose scale	N, Pe, Pl (APHIS 2002c)	Yes. NSW, Tas. (APPD 2006) WA (Poole 2006)	No
Brachycaudus helichrysi (Kaltenbach, 1843) Synonym: *Anuraphis helichrysi* Kaltenbach, 1843 [Hemiptera: Aphididae]	Leafcurl plum aphid	N, Pe, Pl (APHIS 2002c)	Yes. SA (Hollis and Eastop 2005); NSW, Qld., Tas., Vic. (APPD 2006) WA (Poole 2006)	No
Brachycaudus persicae (Passerini, 1860) Synonym: *Anuraphis persicae* (Passerini, 1860) [Hemiptera: Aphididae]	Black peach aphid	N, Pe, Pl (APHIS 2002c)	Yes. NSW, Tas., Vic. (APPD 2006) WA (Poole 2006)	No
Brachycaudus schwartzi (Börner, 1931) Synonym: *Anuraphis schwartzi* (Börner, 1931) [Hemiptera: Aphididae]	Aphid, almond aphid	N, Pe, Pl (APHIS 2002c)	No (Hollis and Eastop 2005)	Yes
Ceresa alta Walker, 1851 Synonym: *Ceresa bubalus* (Fabricius, 1794) [Hemiptera: Membracidae]	Buffalo treehopper	N, Pe, Pl (CABI 2007)	No (Fletcher and Lariviere 2005a)	Yes
Ceroplastes cerifera (Fabricus, 1778) [Hemiptera: Coccidae]	Indian white wax scale	Pe (CABI 2007)	Yes. NSW, Qld. (APPD 2006) WA (Poole 2006)	No
Ceroplastes floridensis Comstock, 1881 [Hemiptera: Coccidae]	Florida wax scale	N, Pe, Pl (APHIS 2002c)	Yes. NSW, Qld., (APPD 2006) Not in WA (DAWA 2003)	Yes (WA)[4]
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

[4] (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 ?
Clavaspis disclusa Ferris, 1938 [Hemiptera: Diaspididae]	Armoured scale	N, Pe, Pl (APHIS 2002c)	No (Ben-Dov *et al.* 2006)	Yes
Closterotomus norvegicus (Gmelin, 1788) Synonym: *Calocoris norvegicus* (Gmelin, 1788) [Hemiptera: Miridae]	Potato bug	Pe (Pickel *et al.* 2006g)	Yes. Tas. (APPD 2006).	Yes (WA) [1]
Coccus hesperidum Linnaeus, 1758 [Hemiptera: Coccidae]	Soft brown scale	N, Pe, Pl (CABI 2007)	Yes. ACT, NSW, NT, Qld., SA, Tas, Vic, WA (APPD 2006) WA (Poole 2006)	No
Colladonus clitellarius (Say, 1831) [Hemiptera: Cicadellidae]	Saddled leafhopper	N, Pe, Pl (APHIS 2002c)	No (Fletcher and Lariviere 2005b)	Yes
Colladonus geminatus (Van Duzee, 1890) [Hemiptera: Cicadellidae]	Leafhopper	Pe (DAWA 2006) (Welch and Kondratieff 1993)	No (Fletcher and Lariviere 2005b)	Yes
Colladonus montanus (Van Duzee, 1892) [Hemiptera: Cicadellidae]	Mountain leafhopper	Pe, Pl (CABI 2007)	No (Fletcher and Lariviere 2005b)	Yes
Cuerna costalis (Fabricius, 1803) [Hemiptera: Cicadellidae]	Leafhopper	N, Pe, Pl (APHIS 2002c)	No (Fletcher and Lariviere 2006b)	Yes
Dialeurodes citri (Ashmead, 1885) [Hemiptera: Aleyrodidae]	Citrus whitefly	N, Pe, Pl (CABI 2007)	No (Martin and Gillespie 2001)	Yes
Diaspidiotus ancylus (Putnam, 1878) Synonym: *Abgrallaspis howardi* (Cockerell, 1895) [Hemiptera: Diaspididae]	Putnam scale; Howard scale; Maple bark louse	N, Pe, Pl (CABI 2007)	Yes. Qld., NSW (APPD 2006) No records for WA.	Yes (WA)
Diaspidiotus forbesi (Johnson, 1896) Synonym: *Quadraspidiotus forbesi* (Johnson, 1896) [Hemiptera: Diaspididae]	Forbes scale	N, Pe, Pl (APHIS 2002c)	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 ?
Diaspidiotus juglansregiae (Comstock, 1881) Synonym*: Quadraspidiotus juglansregiae* (Comstock, 1881) [Hemiptera: Diaspididae]	Walnut scale	N, Pe, Pl (APHIS 2002c)	No (Ben-Dov *et al.* 2006)	Yes
Diaspidiotus ostreaeformis (Curtis, 1843) [Hemiptera: Diaspididae]	Oystershell scale; Pear oyster scale; European fruit scale	N, Pe, Pl (CABI 2007) Listed in Idaho, Oregon and Washington (Nakahara 1982)	Yes. NSW, SA, Tas., Vic. (APPD 2006) No records for WA.	Yes (WA)
Disapidiotus perniciosus (Comstock, 1881) Synonym*: Quadraspidiotus perniciosus* (Comstock, 1881) [Hemiptera: Diaspididae]	San Jose scale; Californian scale; Chinese scale	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	Yes. NSW, Qld., Tas., Vic. (APPD 2006) WA (Poole 2006)	No
Epidiaspis leperii (Signoret, 1869) [Hemiptera: Diaspididae]	Italian pear scale	N, Pe, Pl (APHIS 2002c)	No (Ben-Dov *et al.* 2006)	Yes
Eriosoma lanigerum (Hausmann, 1802) [Hemiptera: Aphididae]	Woolly aphid	Pl (CABI 2007)	Yes. NSW, Qld., Tas., WA (APPD 2006) WA (Poole 2006)	No
Eulecanium cerasorum (Cockerell, 1900f) [Hemiptera: Coccidae]	Calico scale	N, Pe, Pl (Dreistadt *et al.* 2007)	No (Ben-Dov *et al.* 2006)	Yes
Eulecanium kunoense (Kuwana, 1907) [Hemiptera: Coccidae]	Kuno scale	N, Pe, Pl (Dreistadt *et al.* 2007)	No (Ben-Dov *et al.* 2006)	Yes
Euschistus conspersus Uhler, 1897 [Hemiptera: Pentatomidae]	Stink bug	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	No (DAWA 2003)	Yes
Euschistus servus (Say, 1832) [Hemiptera: Pentatomidae]	Brown stink bug	N, Pe, Pl (APHIS 2002c)	No (Cassis and Gross 2002)	Yes
Euschistus tristigmus (Say, 1831) [Hemiptera: Pentatomidae]	Dusky stink bug	N, Pe, Pl (APHIS 2002c)	No (Cassis and Gross 2002)	Yes
Euschistus variolarius (Palisot de Beauvois, 1817) [Hemiptera: Pentatomidae]	One spotted stink bug	N, Pe, Pl (APHIS 2002c)	No (Cassis and Gross 2002)	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 ?**
Fieberiella florii (Stål, 1864) [Hemiptera: Cicadellidae]	Leafhopper	N, Pe, Pl (APHIS 2002c)	No (Fletcher and Lariviere 2006d)	Yes
Graphocephala versuta (Say, 1830) [Hemiptera: Cicadellidae]	Leafhopper	N, Pe, Pl (APHIS 2002c)	No (Fletcher and Lariviere 2006c)	Yes
Homalodisca vitripennis (Germar, 1821) Synonym: *Homalodisca coagulata* (Say, 1832) [Hemiptera: Cicadellidae]	Glassy-winged sharpshooter	N, Pe, Pl (APHIS 2002c)	No (Fletcher and Lariviere 2006b) No (DAWA 2003)	Yes
Homalodisca insolita (Walker, 1858) [Hemiptera: Cicadellidae]	Leafhopper	N, Pe, Pl (APHIS 2002c)	No (Fletcher and Lariviere 2006b)	Yes
Hyalopterus pruni (Geoffroy, 1762) [Hemiptera: Aphididae]	Mealy plum aphid	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	Yes. Qld., Tas., Vic. (APPD 2006) No records for WA,	Yes (WA)
Icerya purchasi Maskell, 1878 [Hemiptera: Margarodidae]	Cottony cushion scale	N, Pe, Pl (APHIS 2002c)	Yes. NSW, NT, Qld., Tas., WA (APPD 2006) WA (Poole 2006)	No
Lepidosaphes ulmi (Linnaues, 1758) [Hemiptera: Diaspididae]	Oystershell scale; Mussell scale	N, Pe, Pl (APHIS 2002c)	Yes. NSW, Tas., WA (APPD 2006) WA (Poole 2006)	No
Lygus elisus van Duzee, 1914 [Hemiptera: Miridae]	Pale legume bug; Lucerne plant bug	N, Pe, Pl (APHIS 2002c)	No (Cassis and Gross 2002)	Yes
Lygus hesperus Knight, 1917 [Hemiptera: Miridae]	Western tarnished plant bug	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	No (Cassis and Gross 2002)	Yes
Lygus lineolaris (Palisot de Beauvois, 1818) [Hemiptera: Miridae]	Tarnished plant bug	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	No (Cassis and Gross 2002)	Yes
Maconellicoccus hirsutus (Green, 1908) [Hemiptera: Pseudococcidae]	Pink hibiscus mealybug	Pl (CABI 2007)– localised in California (recent introduction)	Yes. NSW, NT, Qld., Vic. (APPD 2006) WA (Poole 2006)	No
Magicicada septendecim (Linnaeus, 1758) [Hemiptera: Cicadidae]	Periodic cicada	N, Pe, Pl (APHIS 2002c)	No (Moulds and Cowan 2004)	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 ?**
Melanaspis obscura (Comstock, 1881a) [Hemiptera: Diaspididae]	Obscure scale	N, Pe, Pl (APHIS 2002c)	Yes. NSW (APPD 2006) No records for WA,	Yes (WA)
Mercetaspis halli (Green, 1923) [Hemiptera: Diaspididae] Synonym: *Nilotaspis halli* (Green, 1923)	Hall scale	N, Pe, Pl (APHIS 2002c) 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 2002c)	No (Ben-Dov *et al.* 2006)	Yes
Metcalfa pruinosa (Say, 1830) [Hemiptera: Flatidae]	Plant hopper	N, Pe, Pl (APHIS 2002c)	No (Fletcher and Lariviere 1988)	Yes
Myzus persicae (Sulzer, 1776) [Hemiptera: Aphididae]	Green peach aphid	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	Yes. NSW, NT, Qld., Vic., Tas. (APPD 2006) WA (Poole 2006)	No
Neopinnaspis harperi McKenzie, 1949 [Hemiptera: Diaspididae]	Armoured scale	N, Pe, Pl (APHIS 2002c)	No (Ben-Dov *et al.* 2006)	Yes
Neopulvinaria innumberabilis innumerabilis (Rathvon, 1854) [Hemiptera: Coccidae] Synonym: *Pulvinaria innumberabilis* (Rathvon, 1854)	Cottony maple scale	N, Pe, Pl (APHIS 2002c)	No (Ben-Dov *et al.* 2006)	Yes
Nezara viridula (Linnaeus, 1758) [Hemiptera: Pentatomidae]	Southern green stink bug	N, Pe, Pl (APHIS 2002c)	Yes. NSW, NT, Qld., Tas., Vic. (APPD 2006) WA (Poole 2006)	No
Norvellina seminudus (Say, 1830) [Hemiptera: Cicadellidae]	Leafhopper	N, Pe, Pl (APHIS 2002c)	No (Fletcher and Lariviere 2006d)	Yes
Oncometopia orbona (Fabricius, 1798) [Hemiptera: Cicadellidae]	Leafhopper	N, Pe, Pl (APHIS 2002c)	No (Fletcher and Lariviere 2006b)	Yes
Parabemisia myricae (Kuwana, 1927) [Hemiptera: Aleyrodidae]	Bayberry whitefly	Pe, Pl (CABI 2007)	No (Martin and Gillespie 2001)	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 ?
Paraphlepsius irroratus (Say, 1830) [Hemiptera: Cicadellidae]	Brown speckled leafhopper; Irrorate spittlebug	N, Pe, Pl (APHIS 2002c)	No (Fletcher and Lariviere 2005b)	Yes
Parlatoria oleae (Colvée, 1880) [Hemiptera: Diaspididae]	Olive parlatoria scale	N, Pe, Pl (APHIS 2002c)	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 2002c)	No (Ben-Dov *et al.* 2006)	Yes
Parthenolecanium corni (Bouché, 1844) [Hemiptera: Coccidae]	Plum scale; European fruit lecanium	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	Yes. Tas (APPD 2006) No records for WA,	Yes (WA)
Parthenolecanium persicae (Fabricius, 1776) [Hemiptera: Coccidae]	European peach scale	N, Pe, Pl (APHIS 2002c)	Yes. NSW, Qld., SA, Tas., Vic (APPD 2006) WA (Poole 2006)	No
Parthenolecanium pruinosum Coquillett, 1891 [Hemiptera: Coccidae]	Frosted scale	(Gill 1988)	Yes. NSW, Tas. (APPD 2006) WA (Poole 2006)	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 2002c) 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. *P. madeirensis* is known from California, but is not considered a prunus pest (Ben-Dov *et al.* 2006).	No (Ben-Dov *et al.* 2006)	Yes
Philaenus spumarius (Linnaeus,1758) [Hemiptera: Cercopidae]	Meadow froghopper; Meadow spittle bug	N, Pe, Pl (CABI 2007)	No (Fletcher and Lariviere 2006a)	Yes
Phorodon humuli (Schrank, 1801) [Hemiptera: Aphididae]	Hop aphid	Pl (Hollingsworth 2007)	No (Hollis and Eastop 2005)	Yes
Pseudaonidia duplex (Cockerell, 1896) [Hemiptera: Diaspididae]	Camphor scale	N, Pe, Pl (APHIS 2002c)	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 ?**
Pseudaulacaspis pentagona (Targioni Tozzetti, 1886) [Hemiptera: Diaspididae]	Peach white scale	N, Pe, Pl (APHIS 2002c) Recorded from California but eradicated (Gill 1997; Nakahara 1982). Listed as present in Oregon (Nakahara 1982)	Yes. NSW, Qld. (APPD 2006) Not in WA (DAWA 2003)	Yes (WA)
Pseudococcus calceolariae (Maskell, 1879) [Hemiptera: Pseudococcidae]	Citrophilus mealybug	N, Pe, Pl (APHIS 2002c)	Yes. NSW, SA, Tas., Vic., (APPD 2006) Not in WA (DAWA 2003)	Yes (WA)
Pseudococcus comstocki (Kuwana, 1902) [Hemiptera: Pseudococcidae]	Comstock mealybug	N, Pe, Pl (APHIS 2002c)	No (DAWA 2003)	Yes
Pseudococcus maritimus (Ehrhorn, 1900) [Hemiptera: Pseudococcidae]	Grape mealybug	A, Pl (Smith *et al.* 2006) A (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 2002c)	Yes. SA, Tas. (APPD 2006) WA (Poole 2006)	No
Rhizoecus falcifer Künckel d' Herculais, 1878 [Hemiptera: Pseudococcidae]	Ground mealybug	N, Pe, Pl (APHIS 2002c)	Yes. NSW, Qld. (APPD 2006) Not in WA (DAWA 2003)	Yes (WA)
Saissetia oleae (Olivier, 1791) [Hemiptera: Coccidae]	Black scale	N, Pe, Pl (CABI 2007) (APHIS 2002c)	Yes. NSW, NT, Qld., Tas. (APPD 2006) WA (Poole 2006)	No
Scaphytopius acutus (Say, 1830) [Hemiptera: Cicadellidae]	Leafhopper	N, Pe, Pl (APHIS 2002c)	No (Fletcher and Lariviere 2005c)	Yes
Sphaerolecanium prunastri (Boyer de Fonscolombe, 1834) [Hemiptera: Coccidae]	Globose scale	N, Pe, Pl (APHIS 2002c)	No (Ben-Dov *et al.* 2006)	Yes
Thyanta custator (Fabricius, 1803) [Hemiptera: Pentatomidae]	Stink bug	N, Pe, Pl (APHIS 2002c)	No (Cassis and Gross 2002)	Yes
Thyanta pallidovirens (Stål, 1859) [Hemiptera: Pentatomidae]	Redshouldered stink bug	N Pe, (Bentley *et al.* 2006n; Pickel *et al.* 2006f)	No (Cassis and Gross 2002)	Yes
Trialeurodes packardi (Morrill, 1903) [Hemiptera: Aleyrodidae]	Strawberry white fly	N, Pe, Pl (APHIS 2002c)	No (Martin and Gillespie 2001)	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 ?**
Trialeurodes vaporariorum (Westwood, 1855) [Hemiptera: Aleyrodidae]	Greenhouse white fly	N, Pe, Pl (APHIS 2002c)	Yes. NSW, NT, Qld., Tas. (APPD 2006) WA (Poole 2006)	No
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 (DAWA 2003)	No (Nielsen *et al.* 1996)	Yes
Acrobasis tricolorella Grote, 1878 [Lepidoptera: Pyralidae]	Mineola moth; Destructive prune worm	Pl (Epstein *et al.* 2002) (Shull and Wakeland 1941)	No (Nielsen *et al.* 1996)	Yes
Agrotis ipsilon (Hufnagel, 1766) [Lepidoptera: Notodontidae]	Black cutworm moth	Pe, Pl (CABI 2007)	Yes. NSW, NT, SA, Tas. (APPD 2006) WA (Poole 2006)	No
Alsophila pometaria (Harris, 1841) [Lepidoptera: Geometridae]	Fall cankerworm	Pl (Pickel *et al.* 2006h)	No (DAWA 2003)	Yes
Amphipyra pyramidoides Guenée, 1852 [Lepidoptera: Noctuidae]	Noctuid	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	No (DAWA 2003)	Yes
Amyelois transitella (Walker, 1863) [Lepidoptera: Pyralidae]	Navel orange worm	N, Pe, Pl (APHIS 2002c)	No (DAWA 2003)	Yes
Anarsia lineatella Zeller, 1839 [Lepidoptera: Gelechiidae]	Peach twig borer moth	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	No (Nielsen *et al.* 1996)	Yes
Antheraea polyphemus (Cramer, 1776) [Lepidoptera: Saturniidae]	Polyphemus moth; Silk moth	Pe, Pl (Cooperative Agriculture Pest Survey Program 2003; Oehlke 2006; Opler *et al.* 2006)	No (Nielsen *et al.* 1996)	Yes
Archips argyrospilus (Walker, 1863) [Lepidoptera: Tortricidae]	Fruit-tree leafroller	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	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 2006b)	No (Nielsen *et al.* 1996) No (DAWA 2003)	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.* 2006i) A (APHIS 2006b)	No (Nielsen *et al.* 1996) No (DAWA 2003)	Yes
Bondia comonana Kearfott, 1907 [Lepidoptera: Carposinidae]	Prune limb borer	N (Bentley *et al.* 2006m) Pe (Pickel *et al.* 2006a)	No (Nielsen *et al.* 1996)	Yes
Choreutis pariana (Clerck, 1759) [Lepidoptera: Choreutidae]	Apple leaf skeletoniser	Pe, Pl (CABI 2007)	No (Nielsen *et al.* 1996)	Yes
Choristoneura rosaceana (Harris, 1841) [Lepidoptera: Tortricidae]	Oblique banded leafroller	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	No (Nielsen *et al.* 1996) No (DAWA 2003)	Yes
Coleophora sacramenta Heinrich, 1914 [Lepidoptera Coleophoridae]	California pistol case bearer	N, Pe, Pl (APHIS 2002c)	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 2002c)	Yes. NSW, NT, Qld., SA, Tas. (APPD 2006) Eradicated from WA (Poole 2006)	Yes (WA)
Datana ministra (Drury, 1773) [Lepidoptera: Notodontidae]	Yellow necked caterpillar	N, Pe, Pl (APHIS 2002c)	No (Nielsen *et al.* 1996)	Yes
Egira curialis (Grote, 1873) Synonym: *Xylomyges curialis* (Grote, 1873) [Lepidoptera: Noctuidae]	Citrus cutworm	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	No (Nielsen *et al.* 1996)	Yes
Enarmonia formosana (Scopoli, 1763) [Lepidoptera: Tortricidae]	Cherry bark tortrix	Pe, Pl (Washington State University 2001)	No (Nielsen *et al.* 1996)	Yes
Euproctis chrysorrhoea (Linnaeus, 1758) [Lepidoptera: Lymantriidae]	Brown tail moth	N, Pe, Pl (CABI 2007)	No (Nielsen *et al.* 1996) No (DAWA 2003)	Yes
Euzophera semifuneralis (Walker, 1863) [Lepidoptera: Pyralidae]	American plum borer	N, Pe, Pl (APHIS 2002c)	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 2002c) A (APHIS 2006b)	Yes. NSW, Qld., SA, Tas., Vic. (APPD 2006) Not in WA (Poole 2006)	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 (DAWA 2003)	Yes
Grapholita prunivora (Walsh, 1868) Synonym: *Cydia prunivora* (Walsh, 1868) [Lepidoptera: Tortricidae]	Lesser apple fruitworm; Plum moth	N, Pe, Pl (APHIS 2002c)	No (Nielsen *et al.* 1996) No (DAWA 2003)	Yes
Hyphantria cunea (Drury, 1773) [Lepidoptera: Arctiidae]	Fall webworm; American white moth	N, Pe, Pl (APHIS 2002c)	No (Nielsen *et al.* 1996) No (DAWA 2003)	Yes
Lithophane antennata (Walker, 1858) [Lepidoptera: Noctuidae]	Green fruit worm	N, Pe, Pl (APHIS 2002c)	No (Nielsen *et al.* 1996)	Yes
Malacosoma americanum (Fabricius, 1793) [Lepidoptera: Lasiocampidae]	Eastern tent caterpillar	N, Pe, Pl (APHIS 2002c)	No (Nielsen *et al.* 1996)	Yes
Malacosoma californicum (Packard, 1864) [Lepidoptera: Lasiocampidae] ssp. *pluviale* Dyar	Western tent caterpillar	Pl (Collman 1996)	No (Nielsen *et al.* 1996)	Yes
Malacosoma disstria Hübner, 1820 [Lepidoptera: Lasiocampidae]	Forest tent caterpillar	N, Pe, Pl (APHIS 2002c)	No (Nielsen *et al.* 1996)	Yes
Operophtera brumata (Linnaeus, 1758) [Lepidoptera: Geometridae]	Winter moth	N, Pe, Pl (CABI 2007)	No (Nielsen *et al.* 1996) No (DAWA 2003)	Yes
Orgyia antiqua (Linnaeus, 1758) [Lepidoptera: Lymantriidae]	Rusty tussock moth; European tussock moth	Possibly damages plums (Trenchev and Pavlov 1982) Present in Western Canada and US (Hughes 1976)	No (Nielsen *et al.* 1996)	Yes
Orgyia vetusta (Boisduval, 1852) [Lepidoptera: Lymantriidae]	Western tussock moth	Pl (Bentley and Day 2006e) A (APHIS 2006b)	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 ?
Orthosia hibisci (Guenée, 1852) [Lepidoptera: Noctuidae]	Speckled green fruit worm	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	No (Nielsen *et al.* 1996)	Yes
Ostrinia nubilalis (Hübner, 1796) [Lepidoptera: Pyralidae]	European corn borer	N, Pe, Pl (APHIS 2002c)	No (Nielsen *et al.* 1996) No (DAWA 2003)	Yes
Paleacrita vernata (Peck, 1795) [Lepidoptera: Geometridae]	Spring cankerworm	Pl (Pickel *et al.* 2006h)	No (Nielsen *et al.* 1996)	Yes
Pandemis pyrusana Kearfott, 1907 [Lepidoptera: Tortricidae]	Apple pandemis; pandemis leafroller	Pe (Washington State University 2005) Pl (Hollingsworth 2007) A (APHIS 2006b)	No (Nielsen *et al.* 1996)	Yes
Papilio eurymedon Lucas, 1852 [Lepidoptera: Papilionidae]	Pale swallowtail	Pl (CABI 2007) (Opler *et al.* 2006)	No (Braby 2000)	Yes
Papilio rutulus Lucas, 1852 [Lepidoptera: Papilionidae]	Western tiger swallowtail	Associated with *Prunus* spp. in California and the Pacific Northwest (Dowell *et al.* 1990)	No (Braby 2000)	Yes
Peridroma saucia (Hübner, 1808) [Lepidoptera: Notodontidae]	Variegated cutworm moth; Finnish dart	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, 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	N, Pe, Pl (CABI 2007)	No (Nielsen *et al.* 1996) No (DAWA 2003)	Yes
Plodia interpunctella (Hübner, 1813) [Lepidoptera: Pyralidae]	Indian meal moth	N, Pe, Pl (CABI 2007)	Yes. ACT, NSW, NT, Qld., Tas., WA (APPD 2006) WA (Poole 2006)	No
Spodoptera frugiperda (J.E. Smith, 1797) [Lepidoptera: Noctuiidae]	Fall armyworm	Pe (CABI 2007)	No (Nielsen *et al.* 1996) No (DAWA 2003)	Yes
Schizura concinna (J.E. Smith, 1797) [Lepidoptera: Notodontidae]	Red humped caterpillar moth	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	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 ?**
Sphinx drupiferarum (J.E. Smith, 1797) [Lepidoptera: Sphingidae]	Wild cherry sphinx	N, Pe, Pl (APHIS 2002c)	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 (DAWA 2003)	Yes
Synonymsanthedon exitiosa (Say, 1823) [Lepidoptera: Aegeriidae]	Peach tree borer moth	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	No (Nielsen *et al.* 1996)	Yes
Synonymsanthedon pictipes (Grote & Robinson, 1868) [Lepidoptera: Aegeriidae]	Lesser peach tree borer moth	N, Pe, Pl (APHIS 2002c)	No (Nielsen *et al.* 1996)	Yes
Xestia c-nigrum (Linnaeus, 1758) [Lepidoptera: Notodontidae]	Spotted cutworm	Pe (CABI 2007) A (APHIS 2006b)	No (Nielsen *et al.* 1996) No (DAWA 2003)	Yes
Zeuzera pyrina (Linnaeus, 1761) [Lepidoptera: Cossidae]	Leopard moth	N, Pe, Pl (APHIS 2002c)	No (Nielsen *et al.* 1996)	Yes
ORTHOPTERA (crickets, grasshoppers, katydids)				
Melanoplus femurrubrum (DeGeer, 1773) [Orthoptera: Acrididae]	Redlegged grasshopper	N, Pe, Pl (APHIS 2002c)	No (Rentz 2006)	Yes
Microcentrum retinerve (Burmeister, 1838) [Orthoptera: Tettigioniidae]	Angular winged katydid	N (Bentley and Day 2006b) Pe (Pickel *et al.* 2006c) Pl (Bentley *et al.* 2006d)	No (Rentz 2006)	Yes
Scudderia furcata Brunner von Wattenwyl, 1878 [Orthoptera: Tettigioniidae]	Forktailed bush katydid	N (Bentley and Day 2006b) Pe (Pickel *et al.* 2006c) Pl (Bentley *et al.* 2006d)	No (Rentz 2006)	Yes
THYSANOPTERA (thrips)				
Frankliniella bispinosa (Morgan, 1913) [Thysanoptera: Thripidae]	Thrips	N, Pe, Pl (APHIS 2002c)	No (DAWA 2003)	Yes
Frankliniella fusca (Hinds, 1902) [Thysanoptera: Thripidae]	Tobacco thrips	N, Pe, Pl (APHIS 2002c)	No (DAWA 2003)	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 ?
Frankliniella minuta (Moulton, 1907) [Thysanoptera: Thripidae]	Minute flower thrips	Pe (Hoddle *et al.* 2004) (Texas A&M University 2006)	No (DAWA 2003)	Yes
Frankliniella occidentalis (Pergande, 1895) [Thysanoptera: Thripidae]	Western flower thrips	N, Pe, Pl (APHIS 2002c)	Yes. ACT, NSW, Qld., Tas., Vic., WA (APPD 2006) WA (Poole 2006) Absent from NT. Under official control in Tas.	Yes
Frankliniella tritici (Fitch, 1855) [Thysanoptera: Thripidae]	Flower thrips	N, Pe, Pl (APHIS 2002c)	No (DAWA 2003)	Yes
Frankliniella intonsa (Trybom, 1895) [Thysanoptera: Thripidae]	Taiwan flower thrips	Pe (CABI 2007)	No (DAWA 2003)	Yes
Heliothrips haemorrhoidalis (Bouché, 1833) [Thysanoptera: Thripidae]	Greenhouse thrips	Pe, Pl (CABI 2007)	Yes. NSW, NT, Qld., SA., Tas., Vic., WA (APPD 2006) WA (Poole 2006)	No
Taeniothrips inconsequens (Uzel, 1895) [Thysanoptera: Thripidae]	Pear thrips	Pe, Pl (CABI 2007)	No (Mound 2005a)	Yes
Thrips hawaiiensis (Morgan, 1913) [Thysanoptera: Thripidae]	Hawaiian flower thrips	N, Pe, Pl (APHIS 2002c)	Yes (Mound and Gillespie 1997) WA (Poole 2006)	No
NEMATODES				
Aphelenchoides fragariae (Ritzema – Bos, 1892) Christie 1932 [Tylenchida: Aphelenchodidae]	Bud & leaf nematode; Strawberry crimp nematode	Pe (CABI 2007)	Yes. NSW, Qld, SA, Tas., Vic., WA (McLeod *et al.* 1994) NSW, Vic. (APDD 2006)	No
Criconema mutabile (Taylor, 1936) [Tylenchida: Criconematidae]	Ring nematode	A in California (Nyczepir 1991)	Yes. NSW, Qld, SA, WA (McLeod *et al.* 1994)	No
Criconemella curvata (Raski, 1952) [Tylenchida: Criconematidae]	Ring nematode	Pe (Merrifield 2000)(MD, NJ, PA) (Jaffee *et al.* 1987)(PA)	Yes. NSW, Qld, WA (McLeod *et al.* 1994) Qld (Blair *et al.* 1999)	No
Criconemella ornata (Raski, 1958) [Tylenchida: Criconematidae]	Ring nematode	Pe (Jaffee *et al.* 1987)(GA, SC)	Yes. NSW, NT, Qld, WA (McLeod *et al.* 1994)	No
Criconemella similis (Cobb, 1918) [Tylenchida: Criconematidae]	Ring nematode	Pe (Merrifield 2000)(MD & NJ)	Yes. NSW, Qld, SA, Vic., WA (McLeod *et al.* 1994)	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 ?
Criconemella xenoplax (Raski, 1952) [Tylenchida: Criconematidae]	Ring nematode	Pe California (Jaffee *et al.* 1987) Considered a pest of peach in temperate agriculture (Nyczepir and Halbrendt 1993) Pl Considered a pest of plum in temperate agriculture (Nyczepir and Halbrendt 1993) A (APHIS 2006b)	Yes. NSW, Qld, SA, Vic., WA (McLeod *et al.* 1994) Vic. (APDD 2006)	No
Helicotylenchus pseudorobustus (Steiner, 1914) [Tylenchida: Hoplolaimidae]	Spiral nematode	Pe (CABI 2007)	Yes. NSW, SA, Tas., Vic. (APDD 2006) Vic., WA (McLeod *et al.* 1994)	No
Longidorus elongatus (de Man, 1876) [Dorylaimida: Longidoridae]	Nematode	Pe (Merrifield 2000) (CABI 2007)(OR)	No. References to genus level only. NSW, Qld, SA Longidorus spp. (McLeod *et al.* 1994) NSW, Vic. Longidorus spp. (APDD 2006)	Yes
Meloidogyne arenaria (Neal, 1889) [Tylenchida: Meloidogynidae]	Peanut root-knot nematode	N (Westerdahl *et al.* 2006) Pe (CABI 2007). Considered a pest of peach in temperate agriculture (Nyczepir and Halbrendt 1993) Present in California (McKenry 1991) A (APHIS 2006b)	Yes. NSW, Qld, Tas., Vic. (APDD 2006) NSW, Qld, SA, Tas., Vic., WA (McLeod *et al.* 1994)	No
Meloidogyne hapla Chitwood, 1949 [Tylenchida: Meloidogynidae]	Nematode	N (Westerdahl *et al.* 2006) Pe (Merrifield 2000). Considered a pest of peach in temperate agriculture (Nyczepir and Halbrendt 1993). Present in California (McKenry 1991) A (APHIS 2006b)	Yes. NSW, Qld, SA, Tas, Vic., WA (McLeod *et al.* 1994) NSW, SA, Tas., Vic. (APDD 2006)	No
Meloidogyne incognita (Kofoid & White, 1919) [Tylenchida: Meloidogynidae]	Root-knot nematode	N (CABI 2007) Present in California (McKenry 1991) Pe Pl (CABI 2007; Nyczepir and Halbrendt 1993). A (APHIS 2006b)	Yes. ACT, NSW, Qld, SA, Vic. (APDD 2006) NSW, NT, Qld, SA, Tas., Vic., WA (McLeod *et al.* 1994) Qld (Blair *et al.* 1999)	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 ?**
Meloidogyne javanica (Treub, 1885) [Tylenchida: Meloidogynidae]	Sugarcane eelworm; Root-knot nematode	N Pe Pl (CABI 2007). (McKenry 1991) A (APHIS 2006b)	Yes. All states (McLeod *et al.* 1994) NSW, NT, Qld, SA, Tas., Vic., WA (APDD 2006) Qld (Blair *et al.* 1999)	No
Paratylenchus hamatus Thorne & Allen, 1950 [Tylenchida: Tylenchulidae]	Pin nematode	A, Pe (Duncan and Stapleton 1994) Pl (McKenry 1989) Abundant species in California (Nyczepir and Halbrendt 1993)	Yes. Qld, SA (McLeod *et al.* 1994)	Yes (WA)
Paratylenchus neoamblycephalus Geraert, 1965 [Tylenchida: Tylenchulidae]	Pin nematode	Pl (Braun and Lownsbery 1975) Abundant species in California (Nyczepir and Halbrendt 1993)	Yes. WA (McLeod *et al.* 1994) SA (Fisher 1967)	No
Pratylenchus brachyurus (Godfrey, 1929) [Tylenchida: Pratylenchidae]	Meadow nematode	Pe (CABI 2007)	Yes. NSW, NT, Qld, WA (McLeod *et al.* 1994) NSW, Qld (APDD 2006)	No
Pratylenchus coffeae (Zimmermann, 1898) [Tylenchida: Pratylenchidae]	Banana root nematode	Pe (CABI 2007)	Yes. NSW, Qld, SA, Vic, WA (McLeod *et al.* 1994) NSW, Tas., Vic. (APDD 2006)	No
Pratylenchus crenatus (Loof, 1960) [Tylenchida: Pratylenchidae]	Nematode	Pe (Merrifield 2000)	Yes. NSW, SA, Tas., Vic. (APDD 2006) NSW, Tas., Vic., WA (McLeod *et al.* 1994)	No
Pratylenchus hexincisus Taylor & Jenkins, 1957 [Tylenchida: Pratylenchidae]	Nematode	Pe (Duncan *et al.* 1992)	Yes. NSW (APDD 2006) NSW (McLeod *et al.* 1994)	Yes (WA)
Pratylenchus neglectus (Rensch, 1924) [Tylenchida: Pratylenchidae]	Root lesion nematode	Pe, Pl (Merrifield 2000)	Yes. NSW, SA, Tas., Vic., WA (APDD 2006) NSW, Qld, SA, Tas., Vic., WA (McLeod *et al.* 1994)	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 ?
Pratylenchus penetrans (Cobb 1917) [Tylenchida: Pratylenchidae]	Cobb's root-lesion nematode	Pe Pl (CABI 2007; Merrifield 2000; Merrifield 2000)	Yes. NSW, Qld, SA, Tas., Vic., WA (McLeod *et al.* 1994) NSW, SA, Tas., Vic., WA (APDD 2006)	No
Pratylenchus thornei Sher & Allen, 1953 [Tylenchida: Pratylenchidae]	Nematode	N, Pe, Pl (CABI 2007; Merrifield 2000)	Yes. NSW, Qld, SA, Tas., Vic. (APDD 2006) NSW, Qld, SA, Vic. (McLeod *et al.* 1994) WA (DAWA 2006)	No
Pratylenchus vulnus Allen & Jensen, 1951 [Tylenchida: Pratylenchidae]	Meadow nematode	N (Westerdahl *et al.* 2006) Pe (CABI 2007) Pl (McKenry *et al.* 1995) A (APHIS 2006b; Nyczepir 1991)	Yes. NSW, Qld, SA, Vic., WA (APDD 2006) NSW, Qld, SA, Vic, WA (McLeod *et al.* 1994)	No
Scutellonema brachyurum (Steiner, 1938) [Tylenchida: Hoplolaimidae]	British spiral nematode	Pe (CABI 2007)	Yes. NSW, NT, Qld, SA, Vic., WA (McLeod *et al.* 1994)	No
Tylenchorhynchus claytoni Steiner, 1937 [Tylenchida: Belonolaimidae]	Stunt nematode	Pe (CABI 2007)	Yes. Qld (McLeod *et al.* 1994) Qld (Blair *et al.* 1999)	Yes (WA)
Tylenchulus semipenetrans Cobb, 1913 [Tylenchida: Tylenchulidae]	Citrus root nematode	Pl (McKenry *et al.* 1995)	Yes. NSW, NT, Qld, SA, Vic., WA (McLeod *et al.* 1994) NSW, SA, Vic., (APDD 2006)	No
Xiphinema americanum Cobb, 1913 [Dorylaimida: Longidoridae]	American dagger nematode	N (Westerdahl *et al.* 2006) Pe, Pl (CABI 2007) (Merrifield 2000) A (APHIS 2006b)	Yes. NSW, NT, Qld, SA, Vic., WA (McLeod *et al.* 1994) NSW, SA, Vic. (APDD 2006) Qld (Blair *et al.* 1999)	No
Xiphinema diversicaudatum (Micoletzky, 1927) [Dorylaimida: Longidoridae]	Dagger nematode	Pe, Pl (CABI 2007)	Yes. Vic. (McLeod *et al.* 1994)1963 record Qld, Vic. (CABI 2007)– invalid record & eradicated respectively)	Yes (WA)
Xiphinema index Thorne & Allen, 1950 [Dorylaimida: Longidoridae]	Dagger nematode	Pl (CABI 2007; Merrifield 2000)	Yes. Vic. (APDD 2006)	Yes (WA)

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 ?
Xiphinema rivesi Dalmosso, 1969 [Dorylaimida: Longidoridae]	Dagger nematode	Pe, Pl (CABI 2007)	No records	Yes
GASTROPODA				
Helix aspersa Muller,1774 [Hellicidae]	Brown garden snail	N, Pe, Pl (APHIS 2002c)	Yes. Qld, NSW, Vic, Tas, SA, WA (CSIRO 2005) NT (APPD 2006)	No
BACTERIA				
Agrobacterium tumefaciens (Smith & Townsend, 1907) Conn, 1942 [Rhizobiales: Rhizobiaceae]	Crown gall	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	Yes. NSW, SA, Tas., Vic. (APDD 2006) Qld (Simmonds 1966) WA (Shivas 1989)	No
Erwinia amylovora (Burrill 1882) Winslow, Broadhurst, Buchanan, Krumwiede, Rogers and Smith, 1920 [Enterobacteriales: Enterobacteriaceae]	Fireblight of apple	There are two reports of natural infection of *Prunus* species. (Mohan); (Mohan and Thomson 1996)	No. *Erwina 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
Pseudomonas syringae pv. *syringae* van Hall, 1902 [Pseudomonadales: Pseudomonadaceae]	Bacterial canker; Gummosis; Blossom blast; Dieback; Spur blight; Twig blight	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	Yes. NSW, Qld, SA, Tas., Vic., WA (APDD 2006) NT (Bradbury 1986)	No
Xylella fastidiosa (Wells, Raju, Hung, Weisburg, Mandelco-Pauland, Brenner, 1987) [Xanthomonadales: Xanthomonadaceae]	Phoney peach disease;	Present in California (CABI 2007)	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 ?
FUNGI				
Alternaria alternata (Fr.:Fr.) Keissl. [Anamorphic Pleosporaceae]	Alternaria spot; Alternaria fruit rot; Cork spot; Leaf spot; Storage rot	Pl Present in California on fruit and twigs (Farr *et al.* 1989) Pe (APHIS 2002c)	Yes. All states and territories (APDD 2006)	No
Apiosporina morbosa (Schwein.:Fr.) Arx [Dothideales: Venturaceae]	Black knot	Present in all states (CABI 2007)	Possibly. *Fusicladium* sp. NSW, Vic. (APDD 2006) *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	N, Pe, Pl (APHIS 2002c) (Farr *et al.* 1989) A (APHIS 2006b)	No evidence that *A. mellea* is established in Australia (May and Wood 1997).	Yes
Armillaria gallica Marxmüller & Romagni [Agaricales: Armillariaceae]	Armillaria root rot	(Baumgartner and Rizzo 2001)	No records	Yes
Armillaria nabsnona Volk & Burdsall [Agaricales: Armillariaceae]	Armillaria root rot	(Baumgartner and Rizzo 2001)	No records	Yes
Armillaria ostoyae (Romagn.) Herink [Agaricales: Armillariaceae]	Armillaria root rot	(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	N, Pe, Pl (APHIS 2002c) (Farr *et al.* 1989)	Yes. ACT, NSW, NT, Qld, SA, Vic., WA (APDD 2006)	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 ?
Aureobasidium pullulans (de Bary) G. Arnaud [Anamorphic Dothioraceae]		N, Pe, Pl (Hong and Michailides 2000)	Yes. All states and territories (APDD 2006)	No
Blumeriella jaapii (Rehm) Arx Anamorph: *Phloeosporella padi* (Lib.) Arx [Helotiales: Dermateaceae]	Cherry leaf spot	A (Farr *et al.* 1989) Other hosts are susceptible, but area freedom has been previously assessed for cherry imports.	No. Previously present. Eradicated (Cook and Dubé 1989)	Yes
Botrytis cinerea Pers.:Fr. Teleomorph: *Botryotinia fuckeliana* (de Bary) Whetzel [Heliotiales: Sclerotiniaceae]	Grey mould	N, Pe, Pl (APHIS 2002c) (Farr *et al.* 1989) A (APHIS 2006b)	Yes. ACT, NSW, Qld, SA, Tas., Vic., WA (APDD 2006)	No
Candida albicans (C.P. Robin) Berkhout [Anamorphic Saccharomycetales]	Sour rot	Pe, Pl (APHIS 2002c) Pe (Farr *et al.* 1989)	Yes. A widespread yeast, commonly isolated from humans.	No
Ceratocystis fimbriata Ellis & Halst. Anamorph: *Chalara* sp. [Ophiostomatales: Ceratocystidaceae]	Canker; Mallet wound fungus	Pe, Pl (APHIS 2002c) (Farr *et al.* 1989) A (APHIS 2006b)	Yes. NSW, Qld, SA, Vic. (APDD 2006) *Chalara* sp. ACT, NSW, Qld, SA, Tas., Vic. (APDD 2006) WA (Shivas 1989)	No
Ceriporia spissa (Schwein.) Rajchenberg [Polyporales: Hapalopilaceae]		Pe (Farr *et al.* 2007)	Yes. Tas. (APDD 2006). No records for WA,	Yes (WA)
Chondrostereum purpureum (Pers.:Fr.) Pouzar [Meruliales: Meruliaceae]	Silver leaf; Leaf rot; Heart rot	Pe, Pl (APHIS 2002c) (Farr *et al.* 1989) A, Pe, Pl (Farr *et al.* 2007)	Yes. NSW, Qld, SA, Tas., Vic. WA (APDD 2006)	No
Cladosporium herbarum (Pers.:Fr.) Link [Anamorphic Mycosphellaceae]	Cladosporium rot	Pe (Farr *et al.* 2007) Pl (Farr *et al.* 1989)	Yes. NSW, Qld, SA, Tas., Vic., WA (APDD 2006)	No
Colletotrichum acutatum J.H. Simmonds [Anamorphic Glomerellaceae]	Anthracnose	N, Pe CA (Ogawa *et al.* 1995)	Yes. NSW, Qld, SA, Vic., WA (APDD 2006)	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 ?
Colletotrichum gloeosporioides (Penz.) Penz. & Sacc. In Penz. Teleomorph: *Glomerella cingulata* (Stoneman) Spauld. & H. Schrenk [Phyllachorales: Glomerellaceae]	Anthracnose	N (Ogawa *et al.* 1995) Pe (Ogawa *et al.* 1995) Pl	Yes. All states and territories (APDD 2006) *Glomerella cingulata* NSW, NT, Qld, Vic., WA (APDD 2006)	No
Dendrophoma sp. [Anamorphic Xylariales]		Pe (Farr *et al.* 1989)	Yes. SA, Vic. (APDD 2006)	Yes (WA)
Diplocarpon mespili (Sorauer) Sutton Anamorph: *Entomosporium macalatum* Lév. [Heliotales: Dermateaceae]	Leaf blight	Pe, Pl (APHIS 2002c; Farr *et al.* 1989; Farr *et al.* 1989)	Yes. Qld (APDD 2006) *Entomosporium mespili* ACT, NSW, Tas., Vic. (APDD 2006) SA (Cook and Dubé 1989) WA (Shivas 1989)	No
Eutypa lata (Pers.:Fr.) Tul. & C. Tul. [Xylariales: Diatrypaceae]	Eutypa dieback	A, Pl (Farr *et al.* 2007) (APHIS 2006b) (APHIS 2006b)	Yes. NSW, Qld, SA, Vic. WA (APDD 2006)	No
Fascospora gilva (Schwein.:Fr.) T. Wagner & M. Fisch. [Hymenochaetales: Hymenochaetaceae]	White rot	Pe (Farr *et al.* 2007)	Yes. NSW, NT, Qld, Vic. (APDD 2006) SA (Cook and Dubé 1989) WA (DAWA 2006)	No
Fomes fomentarius (L.:Fr.) J. Kickx [Polyporales: Polyporaceae]	Trunk rot	Pl (Campbell *et al.* 1989; Farr *et al.* 1989; Farr *et al.* 2007)	Yes. Vic. (APDD 2006) No records for WA.	Yes (WA)
Fomitiporia robusta (P. Karst.) Fiasson & Niemelä [Hymenochaetales: Hymenochaetaceae]		Pl (Farr *et al.* 2007)	Yes. NSW, NT, Qld, Vic. (APDD 2006) SA (Cook and Dubé 1989) No records for WA.	Yes (WA)
Fomitopsis cajanderi (P. Karst.) Kotlaba & Pouzar [Polyporales: Fomitopsidaceae]	Brown cubical rot	Pe, Pl (Farr *et al.* 1989) A, Pe, Pl (Farr *et al.* 2007)	No records	Yes
Fomitopsis pinicola (Sw.:Fr.) P. Karst. [Polyporales: Fomitopsidaceae]	Brown cubical rot	Pe (Farr *et al.* 1989; Farr *et al.* 2007) Pl (Farr *et al.* 1989; Farr *et al.* 2007)	Yes. Vic. (APDD 2006) 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 ?**
Fomitopsis rosea (Albertini & Schwein.:Fr.) P. Karst. [Polyporales: Fomitopsidaceae]	Brown pocket rot	Pe (Campbell *et al.* 1989; Farr *et al.* 1989; Farr *et al.* 2007)	No records	Yes
Fusarium avenaceum (Fr.:Fr.) Sacc. Teleomorph: *Gibberella avenacea* R.J. Cooke [Hypocreales: Nectriaceae]	Fruit rot	Pe (APHIS 2002c) (Campbell *et al.* 1989; Farr *et al.* 1989; Farr *et al.* 2007) Pl (APHIS 2002c)	Yes. NSW, NT, Qld., SA, Tas., Vic., WA (APDD 2006)	No
Fusarium graminearum Schwabe Teleomorph:*Gibberella zeae* (Schwein.) Petch [Hypocreales: Nectriaceae]	Root rot	Pe, Pl (APHIS 2002c) Pe (Farr *et al.* 1989)	Yes. NSW, NT, Qld, SA, Vic., WA (APDD 2006)	No
Fusarium lateritium Nees:Fr. Teleomorph:*Gibberella baccata* (Wallr.) Sacc. [Hypocreales: Nectriaceae]	Bud rot; Twig rot	Pe, Pl (APHIS 2002c) Pe (Farr *et al.* 1989)	Yes. NSW, Qld, SA, Tas., Vic., WA (APDD 2006)	No
Fusarium oxysporum Schlechtend.:Fr. [Anamorphic Nectriaceae]	Fruit rot; Basal stem rot	Pe, Pl (APHIS 2002c) Pe (Campbell *et al.* 1989; Farr *et al.* 1989; Farr *et al.* 2007)	Yes. All states and territories (APDD 2006)	No
Fusarium solani (Mart.) Sacc. Teleomorph: *Nectria haematococca* Berk. & Broome [Hypocreales: Nectriaceae]	Fruit rot	Pe, Pl (APHIS 2002c) Pe (Campbell *et al.* 1989; Farr *et al.* 1989; Farr *et al.* 2007)	Yes. NSW, Qld, SA, Tas., Vic., WA (APDD 2006)	No
Fusicladium carpophilum (Thuem.) Oudem. Teleomorph: *Venturia carpophila* E.E. Fisher [Dothideales: Venturiaceae]	Scab; Scab & freckle; Black spot	N, Pe, Pl (APHIS 2002c) (Farr *et al.* 1989)	Yes. ACT, NSW, Qld, SA, Tas., Vic. (APDD 2006) WA (Shivas 1989) *Venturia carpophila* Qld, Vic. (APDD 2006)	No
Fusicoccum arbuti D.F. Farr & M. Elliot [Anamorphic Botryosphaeriaceae]	Canker	Pe, Pl (APHIS 2002c) Pe (Farr *et al.* 1989)	Yes. WA (APDD 2006), but distribution in Australia may be limited.	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 applanatum (Pers.) Pat. [Polyporalea: Ganodermataceae]	White rot	Pe (Farr *et al.* 1989) (Farr *et al.* 2007) Pl (Farr *et al.* 2007)	Records of *G. applanatum* in Australia are misidentifications (Smith and Sivasithamparam 2003).	Yes
Ganoderma brownii (Murrill) R.L. Gilbertson [Polyporales: Ganodermataceae]		Pe (Farr *et al.* 2007)	No records	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) Pe (Michailides *et al.* 2004)	Yes. NSW, NT, Qld, Tas., Vic., WA (APDD 2006) SA (Cook and Dubé 1989)	No
Gilbertella persicaria (E.D. Eddy) Hesseltine [Mucorales: Choanephoraceae]	Fruit rot	Pe, Pl (APHIS 2002c) Pe (Campbell *et al.* 1989; Farr *et al.* 1989; Farr *et al.* 2007) A (APHIS 2006b)	No records	Yes
Gloeophyllum sepiarium (Wulfen:Fr.) P. Karst. [Polyporales: Gloeophyllaceae]	Brown rot	Pe (Farr *et al.* 1989; Farr *et al.* 2007) Pl (Farr *et al.* 1989; Farr *et al.* 2007)	No records	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)	No records	Yes
Lambertella pruni Whetzel, Zeller, & Dumont in Dumont [Helotiales: Rutstroemiaceae]	Fruit rot	Pe, Pl (APHIS 2002c) Pl (Farr *et al.* 1989) A (APHIS 2006b)	No records	Yes
Leucostoma persoonii Höhn Anamorph: *Cytospora leucostoma* Sacc. [Diaporthales: Valsaceae]	Peach canker; Cytospora canker	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	Yes. NSW, Qld, SA (APDD 2006) *Leucostoma persoonii* Vic. (APDD 2006) No records for WA,	Yes (WA)
Maireina marginata (McAlpine) W.B. Cooke [Agaricales: Tricholomataceae]	Twig blight	Pe (Campbell *et al.* 1989; Farr *et al.* 1989; Farr *et al.* 2007)	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 ?**
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 2002c) N, Pl (Farr *et al.* 1989) A, M, Pe, Pl (Farr *et al.* 2007)	Yes. ACT, NSW, Qld, Tas., Vic. (APDD 2006) SA (Cook and Dubé 1989) Present in WA (APPD 2006)	No
Monilinia fructigena Honey in Whetzel Ananmorph: *Monilia fructigena* Pers.:Fr. [Heliotales: Sclerotiniaceae]	Brown rot;	Old reports of this pathogen exist (Farr *et al.* 2007), 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 2002c) (Farr *et al.* 1989) A, N, Pe, Pl (Farr *et al.* 2007)	Yes. ACT, NSW, Qld, SA, Tas., Vic. (APDD 2006) Present in WA	No
Mucor circinelloides Tiegh. [Mucorales: Mucoraceae]		Pe (Farr *et al.* 2007) Located in soil and other organic substrates, does not have any *Prunus* species as a host (APHIS 2002c)	Yes. Qld, Vic. (APDD 2006)	No
Mucor piriformis A. Fisch. [Mucorales: Mucoraceae]	Fruit rot	Pe, Pl (APHIS 2002c) Pe (Farr *et al.* 1989) A, Pe, Pl (Farr *et al.* 2007)	Yes. Qld, Vic. (APDD 2006)	No
Mucor racemosus Fresen. [Mucorales: Mucoraceae]	Storage rot	A, N, Pl (Farr *et al.* 2007)	Yes. ACT, NSW, Vic. (APDD 2006)	No
Nectria cinnabarina (Tode:Fr.) Fr. Anamorph: *Tubercularia vulgaris* Tode:Fr. [Hypocreales: Nectriaceae]	Twig blight; Dieback; Coral spot fungus	Pe (Farr *et al.* 1989) A, Pe (Farr *et al.* 2007)	Yes. NSW, Qld, Tas., Vic. (APDD 2006) No records for WA,	Yes (WA)

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 ?**
Ophiostoma californicum (DeVay, R.W. Davidson & W.J. Moller) Georg Hausner, J. Reid & Klassen [Ophiostomatales: Ophiostounaceae]		Pl (Farr *et al.* 2007)	No records	Yes
Passalora circumcissa (Sacc.) U. Braun Teleomorph: *Mycosphaerella cerasella* Aderhold [Mycosphaerellales: Mycosphaerellaceae]	Cercospore leaf spot; Shot hole; Leaf spot	Pe, Pl (APHIS 2002c)	Yes. NSW, Qld, SA, Vic. (APDD 2006) *Mycosphaerella cerasella* Qld (APDD 2006) No records for WA,	Yes (WA)
Penicillium expansum Link [Anamorphic Trichocomaceae]	Penicillium fruit rot; Blue mould; Soft rot; Storage rot	A, Pl (Farr *et al.* 2007) Pl (Farr *et al.* 1989)	Yes. NSW, Qld, Vic. (APDD 2006) SA (Cook and Dubé 1989) Tas.(Sampson and Walker 1982) WA (Shivas 1989)	No
Phanerochaete arizonica Burdsall & R.L. Gilbertson [Meruliales: Phanerachaetaceae]	White rot	Pe (Campbell *et al.* 1989; Farr *et al.* 1989; Farr *et al.* 2007)	No records	Yes
Phoma pomorum Thuem. [Anamorphic Leptosphaeriaceae]	Scurfy bark; Leaf spot; Phoma fruit spot; Shot-hole spot	Pl (Farr *et al.* 1989) A, Pl (Farr *et al.* 2007)	Yes. NSW, Qld, SA, Vic., WA (APDD 2006) Tas. (Sampson and Walker 1982)	No
Plicaturopsis crispa (Pers.:Fr.) D. Reid [Polyporales: Atheliaceae]		Pl (Campbell *et al.* 1989; Farr *et al.* 1989; Farr *et al.* 2007)	Yes. Qld., Vic. (May and Wood 1997).	No
Podosphaera clandestina (Wallr.:Fr.) Lév. Anamorph: *Oidium crataegi* Grognot. [Erysiphales: Erysiphaceae]	Hawthorne powdery mildew	Pe, Pl (APHIS 2002c) Pe, Pl (Farr *et al.* 1989) N (Farr *et al.* 1989) A (APHIS 2006b)	Yes. Recorded in Australia, but only from *Cretagus* spp. (APDD 2006). North American strain not present in Australia.	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 ?
Podosphaera leucotricha (Ellis & Everh.) E.S. Anamorph: *Oidium mespili* Cooke [Erysiphales: Erysiphaceae]	Apple powdery mildew	Pe, Pl (APHIS 2002c) Pe (Farr *et al.* 1989)	Yes. NSW, Qld, SA, Tas., Vic., WA (APDD 2006)	No
Podosphaera pannosa (Wallr.) de Bary Anamorph: *Oidium leucoconium* Desmaz. [Erysiphales: Erysiphaceae]	Rose powdery mildew	N, Pe, Pl (APHIS 2002c) N, Pe (Farr *et al.* 1989) A (APHIS 2006b)	Yes. All states and territories (APDD 2006)	No
Podosphaera tridactyla (Wallr.) de Bary Anamorph: *Oidium passerinii* G. Bertol. [Erysiphales: Erysiphaceae]	Plum powdery mildew	A, N, Pe, Pl (Farr *et al.* 2007)	Yes. ACT, NSW, SA, Tas., Vic. (APDD 2006) 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 2002c) (Farr *et al.* 1989)	Yes. ACT, NSW, Qld, SA, Tas., Vic., WA (APDD 2006) *Thanatephorus cucumeris* NSW, NT, Qld, SA, Tas., Vic., WA (APDD 2006)	No
Rhizopus stolonifer (Ehrenb.:Fr.) Vuill. [Mucorales: Mucoraceae]	Rhizopus rot; Post-harvest decay of fruit; Soft rot; Coryneum blight	Pe, Pl (APHIS 2002c; Farr *et al.* 1989; Farr *et al.* 1989) A, Pe, Pl (Farr *et al.* 2007)	Yes. NSW, NT, Qld, Vic. (APDD 2006) SA (Cook and Dubé 1989) Tas. (Sampson and Walker 1982) WA (DAWA 2006)	No
Rhodosticta quercina J.C. Carter [Anamorphic Phyllacharaceae]	President plum canker	Pe, Pl (APHIS 2002c) Pe (Farr *et al.* 1989)	No records	Yes
Schizophyllum commune Fr.:Fr. [Agaricales: Schizophyllaceae]	Wood rot; Wound rot	Pe, Pl (APHIS 2002c) (Farr *et al.* 1989) A (APHIS 2006b)	Yes. NSW, NT, Qld, SA, Vic., WA (APDD 2006) Tas. (Sampson and Walker 1982)	No
Schizothyrium pomi (Mont. & Fr.) Arx Anamorph: *Zygophiala jamaicensis* E. Mason [Dothideales: Schizothyriaceae]	Fly speck on fruits & twigs	Pe (Campbell *et al.* 1989; Farr *et al.* 1989; Farr *et al.* 2007)	Yes. NSW, WA (APDD 2006) Qld (Simmonds 1966)	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 ?
Sclerotinia sclerotiorum (Lib.) de Bary [Helotiales: Sclerotiniaceae]	Blossom blight; Green fruit rot	Pe, Pl (APHIS 2002c) Pe (Farr *et al.* 1989) A (APHIS 2006b)	Yes. ACT, NSW, Qld, SA, Tas. (APDD 2006) 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 *et al.* 2007)	Yes. SA (May *et al.* 2003).	No
Stereum hirsutum (Willd.:Fr.) S.F.Gray [Stereales: Steraceae]	White rot	Pe, Pl (Campbell *et al.* 1989; Farr *et al.* 1989; Farr *et al.* 2007)	Yes. NSW, Qld, SA, Vic., WA (APDD 2006)	No
Stigmina carpophila (Lév.) M.B. Ellis [Anamorphic Pothidiaceae]	Shot hole disease; Stone fruit gumspot; Shot-hole disease	N, Pe, Pl (APHIS 2002c) (Farr *et al.* 1989) A, P, Pl (APHIS 2006b; Farr *et al.* 2007)	Yes. ACT, NSW, Qld, SA, Tas., Vic. (APDD 2006) WA (Shivas 1989)	No
Taphrina deformans (Berk.) Tul. [Taphrinales: Taphrinaceae]	Peach leaf curl	N, Pe, Pl (APHIS 2002c) Pl FL (Farr *et al.* 1989) N, Pe (Farr *et al.* 1989) Occurs every year in the Pacific Northwest and CA (Ogawa *et al.* 1995)	Yes. ACT, NSW, Qld, SA, Tas., Vic. (APDD 2006) WA (Shivas 1989)	No
Taphrina pruni Tula. [Taphrinales: Taphrinaceae]	Leaf blister; Plum pockets; Bladder plum	Pe, Pl (APHIS 2002c) Pl (Farr *et al.* 1989)	Yes. NSW (APDD 2006) Vic. (Washington and Nancarrow 1983) No records for WA,	Yes (WA)
Taphrina pruni-subcordatae (Zeller) Mix [Taphrinales: Taphrinaceae]	Witches' broom	Pl (Farr *et al.* 1989; Farr *et al.* 2007) (Farr *et al.* 1989)	No records	Yes
Trametes hirsuta (Wulfen:Fr.) Lloyd [Polyiporales: Polyiporaceae]	White rot	Pe, Pl (Farr *et al.* 1989)	Yes. Widespread in Australia (May *et al.* 2003).	No
Trametes versicolor (L.:Fr.) Lloyd [Poliporales: Polyiporaceae]	White rot; Heart rot	Pe, Pl (APHIS 2002c) A, Pe, Pl (Farr *et al.* 2007)	Yes. ACT, NSW, Qld, Tas., Vic., WA (APDD 2006)	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	A, N, Pe, Pl (Farr *et al.* 2007)	Yes. The Australian plant pest database only record this pathogen to species level, but it has been recorded from apricot, peach and plum.This form species may already 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 2002c) Pe (Farr *et al.* 1989) A (APHIS 2006b)	Yes. ACT, NSW, Qld, SA, Tas., Vic., WA (APDD 2006)	No
Tranzschelia pruni-spinosae (Pers.:Pers.) Dietel [Uredinales: Uropyxidiaceae]	Telial host of leaf rust (Heteroecious)	N, Pe, Pl (APHIS 2002c) (Farr *et al.* 1989)	Yes. SA, Vic. (APDD 2006) Tas. (Sampson and Walker 1982) WA (Shivas 1989)	No
Trichothecium roseum (Pers.:Fr.) Link [Anamorphic Bionectriaceae]	Pink fruit rot; Pink mould fruit rot	N, Pe (APHIS 2002c) Pe (Farr *et al.* 1989)	Yes. ACT, NSW, Qld, Vic., WA (APDD 2006) SA (Cook and Dubé 1989) WA (Shivas 1989)	No
Tyromyces galactinus (Berk.) J. Lowe [Polyiporales: Polyiporaceae]		Pl (Campbell *et al.* 1989; Farr *et al.* 1989; Farr *et al.* 2007)	No records	Yes
Valsaria insitiva (Tode) Ces. & De Not. Anamorph: *Cytospora cincta* Sacc. [Diaporthales: Valsaceae]	Perennial canker of peach; Canker; Dieback	Pe (Farr *et al.* 1989) (Farr *et al.* 2007) Pl ID (Farr *et al.* 1989) (Farr *et al.* 2007) A (APHIS 2006b)	Yes. NSW, NT (APDD 2006) *Leucostoma cincta* NSW, Vic. (APDD 2006) No records for WA,	Yes (WA)
Verticillium albo-atrum Reinke & Berthier [Anamorphic Phyllachorales]	Verticillium wilt	Pe, Pl (Farr *et al.* 1989) A, Pe, Pl (Farr *et al.* 2007)	Yes. SA, Tas., Vic. (APDD 2006) WA (DAWA 2006)	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 ?
Verticillium dahliae Kleb. [Anamorphic Phyllachorales]	Verticillium wilt	N, Pe, Pl (APHIS 2002c) (Farr *et al.* 1989) A, N, Pe, Pl (Farr *et al.* 2007)	Yes. ACT, NSW, Qld, SA, Tas., Vic., WA (APDD 2006)	No
PHYTOPLASMAS				
Candidatus Phytoplasma pruni	X-disease	N, Pe, Pl (APHIS 2002c) Pe (CDFA 2006) A (APHIS 2006b)	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 2002c) (Farr *et al.* 1989) A (APHIS 2006b)	Yes. ACT, NSW, SA, Tas., Vic., WA (APDD 2006)	No
Phytophthora cambivora (Petri) Buisman [Peronosporales: Pythiaceae]	Crown & root rot	N, Pe, Pl (APHIS 2002c) (Farr *et al.* 1989) A (APHIS 2006b)	Yes. NSW, SA, Vic., WA (APDD 2006)	No
Phytophthora citrophthora (R.E. Sm. & E.H. Sm.) Leonian [Peronosporales: Pythiaceae]	Crown & trunk canker	Pe, Pl (APHIS 2002c) Pe (Farr *et al.* 1989) A (APHIS 2006b)	Yes. NSW, SA, Vic., WA (APDD 2006) Qld (Simmonds 1966) Tas. (Sampson and Walker 1982)	No
Phytophthora cryptogea Pethybr. & Lafferty [Peronosporales: Pythiaceae]	Crown & root rot	Pe, Pl (APHIS 2002c) Pe (Farr *et al.* 1989) A (APHIS 2006b)	Yes. ACT, NSW, SA, Tas., Vic., WA (APDD 2006)	No
Phytophthora megasperma Drechs. [Peronosporales: Pythiaceae]	Crown & root rot	Pe, Pl (APHIS 2002c) (Farr *et al.* 1989)	Yes. ACT, NSW, Qld, SA, Tas., Vic. (APDD 2006) WA (Shivas 1989)	No
Phytophthora syringae (Kleb.) Kleb. [Peronosporales: Pythiaceae]	Canker; Brown rot; Crown & root rot	Pe, Pl (APHIS 2002c) Pe (Farr *et al.* 1989) A (APHIS 2006b)	Yes. NSW (APDD 2006) SA (Cook and Dubé 1989) Vic. (Washington and Nancarrow 1983) 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 ?
Pythium ultimum Trow [Peronosporales: Pythiaceae]	Damping-off	Pe (Campbell *et al.* 1989; Farr *et al.* 1989; Farr *et al.* 2007)	Yes. ACT, NSW, SA, Tas., Vic. (APDD 2006) Qld (Simmonds 1966) No records for WA,	Yes (WA)
VIROIDS				
Peach latent mosaic viroid	Peach blotch Peach calico	N, Pe, Pl (APHIS 2002c) N, Pe (CDFA 2006) Pl (APHIS 2002c)	Yes. SA First report of this viroid in an Australian orchard (Di Serio *et al.* 1999) NSW (APDD 2006) No records for WA,	Yes (WA)
VIRUSES				
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. NSW, Qld, Tas., Vic. (APDD 2006) SA (Cook and Dubé 1989) WA (Büchen-Osmond *et al.* 1988)	No
Apple mosaic ila rvirus 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. NSW, Qld, SA, Tas., Vic., WA (APDD 2006)	No
Apple stem pitting capillovirus ICTV 79.0.P.DE.02	ASP Apple stem pitting; Cherry twisted leaf; Apricot ring spot	Pe (CDFA 2006) Pl (APHIS 2002c) A (APHIS 2006b)	Yes. Qld, NSW, SA, Tas., Vic., WA (APDD 2006)	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 ?**
Apricot ring pox Synonyms: Apricot pit pox		Pe, Pl (APHIS 2002c) A (APHIS 2006b) 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 virus has been considered separately.	Yes. NSW (APDD 2006) Vic. (Washington and Nancarrow 1983)	Yes (WA)
Asteroid spot virus Synonym: Peach asteroid spot agent		N, Pe, Pl (APHIS 2002c) N, Pe (CDFA 2006)	No records	Yes
Cherry mottle leaf trichovirus ICTV 76.0.1.T.DE.1 Synonym: Prunus virus 1		Pe, Pl (APHIS 2002c) Pe (CDFA 2006) Apricot and peach are considered susceptible (Brunt *et al.* 1996).	Yes. NSW (APDD 2006) No records for WA,	Yes (WA)
Cherry rasp leaf nepovirus ICTV 18.0.3.T.003 Synonym: Flat apple virus	Cherry rasp leaf	Pe, Pl (APHIS 2002c) Pe (CDFA 2006)	Yes. NSW, Tas. (APDD 2006) NSW, Vic., WA (Büchen-Osmond *et al.* 1988) Vic. (Washington and Nancarrow 1983)	No
Peach mosaic closterovirus	Peach mosaic	N, Pe, Pl (APHIS 2002c) A (APHIS 2006b)	No records	Yes
Peach mule's ear Synonym: Almond bud failure		Pe, Pl (APHIS 2002c)	No records	Yes
Peach stubby twig virus		N, Pe, Pl (APHIS 2002c)	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, Pl (APHIS 2002c) Pe (CDFA 2006)	No records	Yes
Plum pox potyvirus ICTV 57.0.1.0.054 *Prunus* virus 7 Sarka virus 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 ilavirus ICTV 10.0.2.04.01 Synonyms: Peach stunt virus Cherry chlorotic ringspot virus Sour cherry yellows virus	Prune dwarf	N, Pe, Pl (APHIS 2002c) (CDFA 2006)	Yes. NSW (APDD 2006) NSW, SA, Vic., WA (Büchen-Osmond *et al.* 1988) SA (Cook and Dubé 1989)	No
Prunus diamond canker virus		Pe, Pl (APHIS 2002c)	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 ?
Prunus necrotic ringspot ilarvirus 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 2002c) (CDFA 2006) A (APHIS 2006b)	Yes. NSW, Qld, Tas., SA, Vic., WA (Büchen-Osmond *et al.* 1988) NSW, Tas., Vic. (APDD 2006) SA (Cook and Dubé 1989)	No
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 2002c) A (APHIS 2006b)	Yes. SA (Cook and Dubé 1989)	Yes

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 and Day 2006a). There are no reports that this mite causes damage to the fruit or is found on the fruit.	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 it's hosts (Gispert *et al.* 1997). Normally limited to adventitious buds on the trunk or lower branches (EPPO/CABI 1997i). Recorded only from flowering peaches in a few areas of the San Joaquin Valley (Oldfield 1970).	No
Tarsonemus smithi Ewing, 1939 [Acari: Tarsonemidae]	Tarsonmeid 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 stonefruit from New Zealand (PDI 2003).	Yes
Tetranychus mcdanieli McGregor, 1931 [Acari: Tetranychidae]	McDaniel spider mite	Yes. Tetranychid mites are principally leaf feeders, wth most species in this family preferring the underside of leaves as a habitat. These mites are mobile and some species are recorded in and around the stems and calyx of fruit. There have been numerous interceptions of this genus on fruit from New Zealand (PDI 2003).	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
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

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
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 1997c). 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.* 2006b).	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.* 2006b).	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
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 2007) and this is supported by the European Plant Protection (EPPO/CABI 1997f) 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

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
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 attack overripe fruit such as peaches and may also feed on leaves (Brown and Hudson 1999). Not associated with mature, harvested fruit.	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 2005). 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. Pycnidia form on woody tissue. Spores will be washed away during packhouse procedures. Those contaminating the fruit surface are short-lived and will die within 6 hours (Biggs 1997).	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.* 2006i).	No
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

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
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) [Coleptera: Curculionidae]	Weevil	No. *Otiorhynchus ligneus* larvae are recorded as polyphagous root feeders (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 2006).	No
Otiorhynchus singularis (Linnaeus, 1767) [Coleoptera: Curculionidae]	Claycolored weevil	No. Eggs are deposited in soil, where larvae gnaw at roots (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. Adults can be longed lived, but do not feed. Females are flightless and lay eggs in their pupation burrow under the soil surface (Wenatchee 2005).	No
Pleocoma minor Linsley, 1938 [Coleoptera: Scarabaeidae]	Rain beetle	No. *Pleocoma* larvae feed on the roots of forest and orchard trees. Adults can be longed lived, but do not feed. Females are flightless and lay eggs in their pupation burrow under the soil surface (Wenatchee 2005).	No
Pleocoma oregonensis Leech,1933 [Coleoptera: Scarabaeidae]	Rain beetle	No. *Pleocoma* larvae feed on the roots of forest and orchard trees. Adults can be longed lived, but do not feed. Females are flightless and lay eggs in their pupation burrow under the soil surface (Wenatchee 2005).	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). Adults feed on leaves and larvae feed on roots (Ontario Ministry of Agriculture and Food 2004).	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 1997j; Gyeltshen and Hodges 2005).	No
Pyrrhalta cavicollis (LeConte, 1856) [Coleoptera: Chrysomelidae]	Cherry leaf beetle	No. Chryosomelid beetles are leaf feeders. This species is reported to feed on young leaves (APHIS 2002c).	No

Scientific Name	**Common Name(s)**	**Is the pest likely to be associated with mature, fresh harvested fruit?**	**Consider Further ?**
Sciopithes obscurus Horn, 1876 [Coleoptera: Curculionidae]	Obscure root weevil	No. Larvae feed on roots while adults feed on leaves causing notching. 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. Larvae live and develop in galleries under the bark on branches and tree trunks while adults feed on leaves and buds (Dreistadt *et al.* 2004). Not associated with the fruit.	No
Sitona californicus (Fahraeus, 1840) [Coleoptera: Curculionidae]	Weevil	No. Larval stage feeds below ground (Rudgers 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
Synonymseta 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. Adults feed on buds, blossoms and leaves and also chew on the stems of fruit resulting in fruit drop. Adults may feed on developing fruit, causing scarring or deformation, but are not reported on mature fruit (Berry 1998).	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. Ambroisa 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 15–20 cm in diameter or larger (Wood 1982).	No
Xylosandrus crassiusculus (Motschulsky, 1866) Synonym: *Xyleborus crassiusculus* (Motschulsky, 1866) [Coleoptera: Scolytidae]	Ambrosia beetle	No. Ambroisa 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. It also attacks the root collar of newly transplanted seedlings (Wood 1982).	No
DIPTERA (Flies)			
Phytomyza persicae Frick,1954 [Diptera: Agromyzidae]	Peach leafminer	No. Agromyzid flies lay eggs in leaves and the developing larvae mine thorugh the leaf. Pupation occurs in the leaf (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 (CABI/EPPO, 1997).	Yes

Scientific Name	**Common Name(s)**	**Is the pest likely to be associated with mature, fresh harvested fruit?**	**Consider Further ?**
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, whitflies)			
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 2005), 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 2005). 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
Brachycaudus schwartzi (Börner, 1931) Synonym: *Anuraphis schwartzi* (Börner, 1931) [Hemiptera: Aphididae]	Aphid, almond aphid	No. Linked to transmission of *plum pox poytvirus* 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
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; Stimmel 1998; Stimmel 1998).	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. *Clavaspis herculeana* and *C. ulmi* are reported as potential pests associated with the trunks of trees (Miller and Davidson 2005).	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.* 2006g).	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.* 2006b). 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)
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 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.* 2007). 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.* 2006a) 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
Graphocephala versuta (Say, 1830) [Hemiptera: Cicadellidae]	Leafhopper	No. Economically important as a potential vector. Feeds on twigs of peach (University of Georgia 2002), not fruit.	No
Homalodisca vitripennis (Germar, 1821) Synonym: *Homalodisca coagulata* (Say, 1832) [Hemiptera: Cicadellidae]	Glassy-winged sharpshooter	No. Economically important as a potential vector. Feeds on twigs of peach (University of Georgia 2002), not fruit.	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Homalodisca insolita (Walker, 1858) [Hemiptera: Cicadellidae]	Leafhopper	No. Economically important as a potential vector. Feeds on twigs of peach (University of Georgia 2002), not fruit.	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
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.* 2006g).	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.* 2006g).	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 inside the branches causing dieback or pruning (Hoover 2003).	No
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 limb dieback (Miller and Davidson 2005).	No
Mesolecanium nigrofasciatum (Pergande, 1898) [Hemiptera: Coccidae]	Terrapin scale	No. Nymphs and adults are found on leaves, branches and twigs (Ben-Dov and Hodgson 1997). Crawlers settle on the underside of leaves and return to twigs and branches as adults for egg laying.	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 innumberabilis innumerabilis (Rathvon, 1854) [Hemiptera: Coccidae] Synonym*: Pulvinaria innumberabilis* (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 2002c). No other information found.	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Oncometopia orbona (Fabricius, 1798) [Hemiptera: Cicadellidae]	Leafhopper	No. Economically important as a potential virus vector. Feeds on twigs of peach (University of Georgia 2002), not fruit.	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 2002c), not fruit.	No
Parlatoria oleae (Colvée, 1880) [Hemiptera: Diaspididae]	Olive parlatoria scale	Yes. The most significant injury caused by this scale is on the fruit (Verma and Dinabandhoo 2005).	Yes (WA)
Parlatoria theae Cockerell, 1896 [Hemiptera: Diaspididae]	Tea parlatoria scale	No. An important pest of ornamental plants, where it is found on all aerial parts of the plant, especially twigs (Watson 2006). No evidence that this pest is associated with the fruit.	No
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. It settles mostly on the underside of leaves, especially along the veins during spring, moving back to the twigs in autumn; immature female scales overwinter on the bark of twigs and limbs (Henderson 2001).	No
Philaenus spumarius (Linnaeus,1758) [Hemiptera: Cercopidae]	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 polyvirus* biotype M (Manachini *et al.* 2004). Damages leaves and reduces tree vitality (Olsen 2006), but not associated with the fruit.	No
Pseudaonidia duplex (Cockerell, 1896) [Hemiptera: Diaspididae]	Camphor scale	No. Crawlers settle on twigs (CABI 2007).	No
Pseudaulacaspis pentagona (Targioni Tozzetti, 1886) [Hemiptera: Diaspididae]	Peach white scale	Yes. Leaves and fruit are not generally infested, but fruit infestions can occur and result in discolouration of the fruit (Watson 2006).	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 (PDI 2003).	Yes (WA)
Pseudococcus comstocki (Kuwana, 1902) [Hemiptera: Pseudococcidae]	Comstock mealybug	Yes. Feeds on the phloem in leaves (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 (PDI 2003).	Yes

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
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
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 2002c).	No
Sphaerolecanium prunastri (Boyer de Fonscolombe, 1834) [Hemiptera: Coccidae]	Globose scale	No. Crawlers settle on twigs, green twigs, large branches or the trunk, but not leaves (Ben-Dov and Hodgson 1997).	No
Thyanta custator (Fabricius, 1803) [Hemiptera: Pentatomidae]	Stink bug	No. Feeds on fruit, leaves and stems (APHIS 2002c). 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. Principally a pest on strawberries where it feeds on leaf tissue (Bentley *et al.* 2006n).	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 nectarines (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 rarely found on stone fruit and not to feed on fruit (Oregon State University 2005; 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 2007b). Sour cherry and plums are preferred hosts in the eastern US (Epstein *et al.* 2002), 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 Pacfic 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.* 2006h). 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 2002c). 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 2002c).	No
Anarsia lineatella Zeller, 1839 [Lepidoptera: Gelechiidae]	Peach twig borer moth	Yes. May feed directly on fruit (Pickel *et al.* 2006e).	Yes
Antheraea polyphemus (Cramer, 1776) [Lepidoptera: Saturniidae]	Polyphemus moth; Silk moth	No. May be occasional pest in peach or plum orchards. Larvae feed on leaves (Struttman 2005), not fruit.	No
Archips argyrospilus (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 withering, 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 larve can cause skin damage to mature fruits (Dickler 1991).	Yes
Archips rosana (Linnaeus, 1758) [Lepidoptera: Tortricidae]	European leafroller	Yes. Similar biology to *Archips argyrospilus*. A frequent pest of tree 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.* 2006a). 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 2002c), 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.* 2006a).	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. 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.* 2006a).	No
Grapholita molesta (Busck, 1916) [Lepidoptera: Tortricidae]	Oriental fruit moth	Yes. Serious internal pest of stone fruit (Weires and Riedl 1991). Peach is a major host and other stone fruit are also infested.	Yes (WA)
Grapholita packardi Zeller, 1875 Synonym: *Cydia prunivora* (Zeller, 1875) [Lepidoptera: Tortricidae]	Cherry fruitworm	Yes. Recorded from the fruits of peach and plum (Weires and Riedl 1991).	Yes

Scientific Name	**Common Name(s)**	**Is the pest likely to be associated with mature, fresh harvested fruit?**	**Consider Further ?**
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 peaches and plums (Weires and Riedl 1991).	Yes
Hyphantria cunea (Drury, 1773) [Lepidoptera: Arctiidae]	Fall webworm; American white moth	No. Eggs are laid on leaves and larvae may cause defoliation of trees. Native to the US where it is mainly found on wild trees (CABI 2007).	No
Lithophane antennata (Walker, 1858) [Lepidoptera: Noctuidae]	Green fruit worm	No. Reported to feed on the fruit (APHIS 2002c). This species overwinters as adults and lays eggs in the spring, with fruit feeding restricted to the later instars. Larvae drop to the soil in the first weeks of summer to pupate and would therefore not be associated with fruit during harvest (Rings 1973).	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 1997h).	No
Malacosoma californicum (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 1997h). 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 crevies 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. Coccoons 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 (CABI 2007).	No
Orthosia hibisci (Guenée, 1852) [Lepidoptera: Noctuidae]	Speckled green fruit worm	No. Reported to feed on fruit (APHIS 2002c). 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 2002c). Not associated with fruit.	No

Scientific Name	**Common Name(s)**	**Is the pest likely to be associated with mature, fresh harvested fruit?**	**Consider Further ?**
Paleacrita vernata (Peck, 1795) [Lepidoptera: Geometridae]	Spring cankerworm	No. Larvae are primarily leaf feeders, but occasionally feed on young fruit (Pickel *et al.* 2006h). Not associated with mature fruit.	No
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 (Washington State University 2005).	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.* 2006).	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.* 2006).	No
Peridroma saucia (Hübner, 1808) [Lepidoptera: Notodontidae]	Variegated cutworm moth; Finnish dart	No. While this pest is suggested as a pest of peaches 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, 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 2002c).	Yes
Spodoptera frugiperda (J.E. 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
Schizura concinna (J.E. Smith, 1797) [Lepidoptera: Notodontidae]	Red humped caterpillar moth	No. Feeds on leaves and may cause skeletonisation (Coates and Van Steenwyk 2006d).	No
Sphinx drupiferarum (J.E. 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. Feeds mainly on leaves, but may also feed on fruit. Principally a pest of pear and apple, where buds are attacked causing economic losses (Dickler 1991). No direct evidence for damage to stone fruit.	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Synonymsanthedon exitiosa (Say, 1823) [Lepidoptera: Aegeriidae]	Peach tree borer moth	No. Native to the US. All *Prunus* spp. are considered to be hosts. The peachtree borer prefers healthy plants. Eggs are laid on the trunk around the soil line and larvae bore into the trunk, large roots and stems. Oozing gum is a typical sign of infestation (Strickland 2002).	No
Synonymsanthedon 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. Oozing gum 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 2002c). 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: Tettigioniidae]	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.* 2006d). 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: Tettigioniidae]	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.* 2006d). 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

Scientific Name	**Common Name(s)**	**Is the pest likely to be associated with mature, fresh harvested fruit?**	**Consider Further ?**
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
Frankliniella occidentalis (Pergande, 1895) [Thysanoptera: Thripidae]	Western flower thrips	Yes. Feeding causes scarring on fruit (EPPO/CABI 1997g).	Yes
Frankliniella tritici (Fitch, 1855) [Thysanoptera: Thripidae]	Flower thrips	Yes. Feeding causes scarring on fruit (EPPO/CABI 1997g).	Yes
Taeniothrips inconsequens (Uzel, 1895) [Thysanoptera: Thripidae]	Pear thrips	Yes. Feeding causes scarring on fruit (Lewis 1997).	Yes
NEMATODES			
Longidorus elongatus (de Man, 1876) [Dorylaimida: Longidoridae]	Nematode	No. *Longidorus elongatus* is a root ectoparasite. All stages of life cycle occur in the soil (CABI 2007).	No
Paratylenchus hamatus Thorne & Allen, 1950 [Tylenchida: Tylenchulidae]	Pin nematode	No. Ectoparasite associated with roots. Found in soil. Not associated with fruit or leaves (UC Davis). Found in the soil to a depth of 120 cm (McKenry 1989).	No
Pratylenchus hexincisus Taylor & Jenkins, 1957 [Tylenchida: Pratylenchidae]	Nematode	No. Found in the soil and tree roots (Duncan *et al.* 1992).	No
Tylenchorhynchus claytoni Steiner, 1937 [Tylenchida: Belonolaimidae]	Stunt nematode	No. *Tylenchorhynchus claytoni* is a ectoparasite on roots and inhabits rhizospheres (CABI 2007).	No
Xiphinema diversicaudatum (Micoletzky, 1927) [Dorylaimida: Longidoridae]	Dagger nematode	No. *Xiphinema* spp. are migratory ectoparasites of roots (CABI 2007). They are not associated with fruit.	No
Xiphinema index Thorne & Allen, 1950 [Dorylaimida: Longidoridae]	Dagger nematode	No. *Xiphinema* spp. are migratory ectoparasites of roots (CABI 2007). They are not associated with fruit.	No
Xiphinema rivesi Dalmosso, 1969 [Dorylaimida: Longidoridae]	Dagger nematode	No. *Xiphinema* spp. are migratory ectoparasites of roots (CABI 2007). They are not associated with fruit.	No
BACTERIA			

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Erwinia amylovora (Burrill 1882) Winslow, Broadhurst, Buchanan, Krumwiede, Rogers and Smith, 1920 [Enterobacteriales: Enterobacteriaceae]	Fireblight 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 and Thomson 1996) (Mohan)	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 (Ogawa *et al.* 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 (Ogawa *et al.* 1995).	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 (Ogawa *et al.* 1995).	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 (Ogawa *et al.* 1995).	No
Armillaria nabsnona Volk & Burdsall [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(Ogawa *et al.* 1995).	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 (Ogawa *et al.* 1995).	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 (Ogawa *et al.* 1995).	No
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. Therfore, fruit infection is rare (Ogawa *et al.* 1995). It is unlikley, but not impossible, that this fungus would be present on mature fruit shipped to Australia.	Yes
Ceriporia spissa (Schwein.) Rajchenberg [Polyporales: Hapalopilaceae]		No. Not common on US stonefruits. Generally, hosts are hardwoods (Farr *et al.* 1989).	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Dendrophoma sp. [Anamorphic Xylariales]		No. Found on peaches in Oregon. Known to mainly infect limbs of hardwoods (Farr *et al.* 1989). 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 *et al.* 1989).	No
Fomitiporia robusta (P. Karst.) Fiasson & Niemelä [Hymenochaetales: Hymenochaetaceae]		No. Causes wood decay of stone fruit trees. Pathogen enters trees primarily through wounds that expose secondary xylem of sapwood or heartwood (Ogawa *et al.* 1995).	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 (Ogawa *et al.* 1995).	No
Fomitopsis pinicola (Sw.:Fr.) P. Karst. [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 (Ogawa *et al.* 1995).	No
Fomitopsis rosea (Albertini & Schwein.:Fr.) P. Karst. [Polyporales: Fomitopsidaceae]	Brown pocket rot	No. Causes wood decay of stone fruit trees. Pathogen enters trees primarily through wounds that expose secondary xylem of sapwood or heartwood (Ogawa *et al.* 1995).	No
Fusicoccum arbuti D.F. Farr & M. Elliot [Anamorphic Botryosphaeriaceae]	Canker	No. Canker found in California in apricots, almonds and peaches (Farr *et al.* 1989). Pathogen that attacks wounds and is unlikely to be associated with mature, fresh harvested fruit.	No
Ganoderma applanatum (Pers.) Pat. [Polyporalea: 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 (Ogawa *et al.* 1995).	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 (Ogawa *et al.* 1995).	No
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 *et al.* 1995). Affects injured fruit that would be culled at harvest.	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. Found in the bird cherry in Pennsylvania and Washington, the common plum in Oregon and Northwestern states, peaches in Oregon and South Carolina, and *Prunus* sp in Oregon, Idaho and Washington (Farr *et al.* 1989). A wood rot fungi that is not associated with the fruit.	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
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). A post-harvest rot that affects damaged fruit. As damaged fruit would be culled during harvest and processing, these would not be exported.	No
Kloeckera apiculata (Reess) Janke [Saccharomycetales: Saccharomycetaceae]	Post-harvest disease; Sour rot	No. Found on nectarine and peach fruit in California (Michailides *et al.* 2004). A post-harvest rot that affects damaged fruit. As damaged fruit would be culled during harvest and processing, these would not be exported.	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 *et al.* 1989). A post-harvest rot that affects damaged fruit. As damaged fruit would be culled during harvest and processing, these would not be 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 (Ogawa *et al.* 1995). In *Prunus* sp. in Pacific Northwest states, though only on wood of infected hosts (Ogawa *et al.* 1995).	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 *et al.* 1989).	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. Hosts are apricots in Calfornia, Indiana and Washington, bird cherry in Washington, Caroline cherry-laurel in Florida, sour cherry in Arkansas, common plum in Arkansas, bitter cherry in Idaho, Montana and Washington, English cherry-laurel in Florida, European bird-cherry in Arkansas, bird cherry in North Carolina, Tennessee and Washington, peach in Alabama and Washington, rum cherry in Florida, chokecherry in Idaho, Montana and Washington black chokecherry in North Dakota, and *Prunus* sp. in Arkansas and Idaho (Farr *et al.* 1989). A wound parasite on various hosts (Dingley), but 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* (Farr *et al.* 1989).	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
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 (Ogawa *et al.* 1995). Shallow circular spots may also form on the fruit (Little 1987).	Yes (WA)[1]
Phanerochaete arizonica Burdsall & R.L. Gilbertson [Meruliales: Phanerachaetaceae]	White rot	No. Found on hardwoods. Found in California on peach (Farr *et al.* 1989). Causes wood rots.	No
Podosphaera clandestina (Wallr.:Fr.) Lév. Anamorph: *Oidium crataegi* Grognot. [Erysiphales: Erysiphaceae]	Hawthorn powdery mildew	Yes. Apricot, cherry, nectarine and plum are susceptible to hawthorn powdery mildew (Ogawa *et al.* 1995). Fruit infections result in large economic losses (Ogawa *et al.* 1995).	Yes (WA)
Podosphaera tridactyla (Wallr.) de Bary Anamorph: *Oidium passerinii* G. Bertol. [Erysiphales: Erysiphaceae]	Plum powdery mildew	Yes. Apricot, cherry, nectarine and plum are susceptible to plum powdery mildew. Fruit infections result in large economic losses (Ogawa *et al.* 1995). Fruit and leaves can both be infected (Ogawa *et al.* 1995).	Yes (WA)
Rhodosticta quercina J.C. Carter [Anamorphic Phyllacharaceae]	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.) (Ogawa *et al.* 1995). Affects the inner bark tissues.	No
Taphrina pruni Tula. [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 (Ogawa *et al.* 1995).	Yes (WA)
Taphrina pruni-subcordatae (Zeller) Mix [Taphrinales: Taphrinaceae]	Witches' broom	No. Reported by (Farr *et al.* 1989) 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. Unlilkely to be associated with imported domestic plum fruit.	No
Trametes hirsuta (Wulfen:Fr.) Lloyd [Polyiporales: Polyiporaceae]	White rot	No. Causes wood decay of stone fruit trees. Pathogen enters trees primarily through wounds that expose secondary xylem of sapwood or heartwood (Ogawa *et al.* 1995).	No
Tyromyces galactinus (Berk.) J. Lowe [Polyiporales: Polyiporaceae]		No. On hardwoods, found in common plum in Oregon and *Prunus* sp. in New York and Oregon (Ogawa *et al.* 1995). Causes wood rots and is not likely to be associated with mature, fresh harvested fruit.	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
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 (Ogawa *et al.* 1995).	No
PHYTOPLASMAS			
Candidatus Phytoplasma pruni	X-disease	No. Phytoplasmas are not known to be transmitted through seed (Welliver 1999). Spread is by phloem feeding vectors and by budding and grafting (Ogawa *et al.* 1995).	No
Candidatus Phytoplasma ulmi	Peach yellows	No. The plum leafhopper (*Macropsis trimaculata* (Fitch)) transmits peach yellows. Fruits produced on diseased limbs develop prematurely (Ogawa *et al.* 1995). Phytoplasmas are not known to be transmitted through seed (Welliver 1999). Spread is by phloem feeding vectors and by budding and grafting (Ogawa *et al.* 1995).	No
STRAMINOPILA			
Phytophthora syringae (Kleb.) Kleb. [Peronosporales: Pythiaceae]	Canker; Brown rot; Crown & root rot	No. Soilborne 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 (Ogawa *et al.* 1995). Not directly associated with the fruit.	No
Pythium ultimum Trow [Peronosporales: Pythiaceae]	Damping-off	No. Found in the roots of peach in California (Farr *et al.* 1989).	No
VIROID			
Peach latent mosaic viroid	Peach blotch Peach calico	No. Transmitted by budding and grafting. Peach is a host. Natural symptoms include chlorotic leaf areas (Ogawa *et al.* 1995).	No
VIRUSES			
Apricot ring pox Syn: Apricot pit pox		Yes. An undetermined, graft transmissible agent causes this disease, but no vector has been indentified. Symptoms appear in fruit, but the number of fruit affected each year can vary greatly (Ogawa *et al.* 1995).	Yes (WA)
Asteroid spot virus Syn: Peach Asteroid Spot Agent		No. Causes deformed fruit, leaf spots and discolouration (Ogawa *et al.* 1995). Considered a minor pathogen that is tranmissible by budding and grafting. Seed transmission is not known. Fruit is not considered a pathway for spread.	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 (Ogawa *et al.* 1995). No records to suggest tranmission through seed or fruit.	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
Peach blotch virus		No. Transmitted by budding and grafting. Peach is a host. Natural symptoms include chlorotic leaf areas (Ogawa *et al.* 1995).	No
Peach calico virus		No. Transmitted by budding and grafting. Hosts include peach and nectarine. Natural symptoms include chlorotic to white spots in leaves, shoots and fruit (Ogawa *et al.* 1995). Fruit is not considered a pathway for spread.	No
Peach mosaic closterovirus	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 (Ogawa *et al.* 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 (Ogawa *et al.* 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 (Ogawa *et al.* 1995). No evidence of seed transmission.	No
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-transmissable agent. Peach is a natural host of the pathogen (Ogawa *et al.* 1995). Not found to be seed transmissible (Ogawa *et al.* 1995).	No
Plum pox potyvirus ICTV 57.0.1.0.054 *Prunus* virus 7 Sarka virus 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 (Ogawa *et al.* 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 (Ogawa *et al.* 1995).	No

Scientific Name	Common Name(s)	Is the pest likely to be associated with mature, fresh harvested fruit?	Consider Further ?
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 seedborne in several weed hosts (Ogawa *et al.* 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 in environments similar to Australia (Nucifora and Vacante 2004).	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 mcdanieli McGregor, 1931 [Acari: Tetranychidae]	McDaniel spider mite	Yes. Wide host range and distributed across North America in environments similar to Australia (Roy *et al.* 2005).	Yes. Feed and lay eggs on buds and fruit. An economically important pest (Roy *et al.* 2005).	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 similiarities to Australia (CABI 2007).	Yes. Damage caused by high populations feeding on leaves can adversely affect tree vitality and fruit size (CABI 2007).	Yes
Tetranychus turkestani Ugarov & Nikolski, 1937 [Acari: Tetranychidae]	Strawberry spider mite	Yes. Wide host range and distributed globally in a variety of environemtns similar to Australia. (Bailly *et al.* 2004).	Yes. An economically important pest (Bailly *et al.* 2004).	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; Norrbom 2004).	Yes. Eggs laid in fruit, maggots feed on fruit leading to unmarketable fruit (CABI 2007; Norrbom 2004).	Yes
Rhagoletis pomonella (Walsh, 1867) [Diptera: Tephritidae]	Apple maggot	Yes. Wide host range and distributed in a variety of environments across North America with similiarities to Australia (CABI 2007; Norrbom 2004).	Yes. Eggs laid in fruit, maggots feed on fruit leading to unmarketable fruit (CABI 2007; Norrbom 2004).	Yes

Scientific Name	Common Name(s)	Potential for Establishment and Spread	Potential for Consequences	Consider Further ?
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.* 2006l; Ferguson *et al.* 1997; Schroeder *et al.* 1998).	Yes. Adults feed on fruit and seed and can lead to severe economic losses (Bentley *et al.* 2006l; 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).	Yes. Forbes scale feeds on plant juices. This causes loss of vigor, deformation of infested plant parts, loss of leaves, and even death of the plant (Guillebeau *et al.* 2006).	Yes
Diaspidiotus juglansregiae (Comstock, 1881) Synonym*:* *Quadraspidiotus juglansregiae* (Comstock, 1881) [Hemiptera: Diaspididae]	Walnut scale	Yes. Present in California (Dreistadt *et al.* 2007), which has similar climatic conditions to many areas of Australia.	Yes. Feeds on plant juices. This causes loss of vigor, deformation of infested plant parts, loss of leaves, and even death of the plant (Bentley *et al.* 2005a).	Yes
Diaspidiotus ostreaeformis (Curtis, 1843) [Hemiptera: Diaspididae]	Oystershell scale; Pear oyster scale	Yes. Wide host range and distibuted globally, found in Tas., Vic. and NSW suggest potential for spread into WA (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. In cases of heavy infestation the branches of the trees can die (CABI 2007; Morgan and Angle 1968).	Yes (WA)
Lygus elisus van Duzee, 1914 [Hemiptera: Miridae]	Pale legume bug; Lucerne plant bug	Yes. Wide host range many generations per year (Bentley *et al.* 2006l; Mueller *et al.* 2005; Mueller *et al.* 2005).	Yes. Eggs laid in fruit and adults feed on fruit which can lead to severe economic losses (Bentley *et al.* 2006l).	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 simililar to those found in Australia, suggests potential for establishment and spread (Bentley *et al.* 2006l; Mueller *et al.* 2005).	Yes Eggs laid in fruit and adults feed on fruit which can lead to severe economic losses (Bentley *et al.* 2006l).	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 dstributed in a variety of environments across central and Northern America with similiarities 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 lead to premature fruit drop and reduced marketability. (Bostanian *et al.* 2005; CABI 2007; University of Missouri 2000).	Yes
Parlatoria oleae (Colvée, 1880) [Hemiptera: Diaspididae]	Olive parlatoria scale	Yes. Presence in Qld. and NSW suggest potential for spread and establishment in Australia (CABI 2007; CSIRO 2005).	Yes. All parts of the host plant, except the roots, are attacked. Fruit feeding can reduce marketability and may lead to premature fruit drop (CABI 2007; University of Missouri 2000).	Yes (WA)
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)
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 mold which discolours the plant and reduces photsysnthesis (CABI 2007).	Yes (WA)
Pseudococcus comstocki (Kuwana, 1902) [Hemiptera: Pseudococcidae]	Comstock mealybug	Yes. Distributed globally in a variety of environments similiar to Australia, suggests potential for establishment and spread (CABI 2007; Grafton-Cardwell *et al.* 2004).	Yes. Feeds on fruit leaves and stems. Mealybugs produce honeydew that serves as the substrate for the development of sooty mould which prevents photsysnthesis in addition to making the plant ugly (CABI 2007; Grafton-Cardwell *et al.* 2004).	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

Scientific Name	**Common Name(s)**	**Potential for Establishment and Spread**	**Potential for Consequences**	**Consider Further ?**
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; Pickel *et al.* 2006e) (CABI 2007; Gencsoylu *et al.* 2006; Gencsoylu *et al.* 2006).	Yes. Feeds on fruit reducing marketability. (CABI 2007; Gencsoylu *et al.* 2006; Pickel *et al.* 2006e).	Yes
Archips argyrospilus (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.* 2006b; Bentley *et al.* 2006c; Deland *et al.* 1993).	Yes. Larvae feed on leaves, buds and fruit. Fruit damage reduces marketability. (Bentley *et al.* 2006b; Bentley *et al.* 2006c; Hollingsworth 2007).	Yes
Archips podana (Scopoli, 1763) [Lepidoptera: Tortricidae]	Great brown twist moth	Yes. Wide host range and distrubted 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.* 2006i; CABI 2007; Coates and Van Steenwyk 2006b; 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.* 2006i; CABI 2007; Coates and Van Steenwyk 2006b; Walker and Welter 2004).	Yes
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.* 2006e; Bentley *et al.* 2006f; CABI 2007; Coates and Van Steenwyk 2006a; Wilkinson *et al.* 2004).	Yes. The fruit are scarred and distorted by early feeding reducing marketablility. Fruit contamination during harvesting can lead to further economic losses. Major pest of apple (Bentley *et al.* 2006e; Bentley *et al.* 2006f; CABI 2007; Coates and Van Steenwyk 2006a; Wilkinson *et al.* 2004).	Yes
Cydia latiferreana (Walsingham, 1879) [Lepidoptera: Tortricidae]	Filbertworm	Yes. Distrubted across North America with similar environments to Australia, suggests potential for establishment and spread (Dohanian 1940).	Yes. Larvae bore into fruit, chief pest of filberts (Dohanian 1940; Olsen 2002).	Yes

Scientific Name	Common Name(s)	Potential for Establishment and Spread	Potential for Consequences	Consider Further ?
Cydia pomonella (Linnaeus, 1758) [Lepidoptera: Tortricidae]	Codling moth	Yes. Established in NSW Qld., Vic., and Tas. suggests potential for establishment and spread in WA (CABI 2007; Caprile *et al.* 2006b).	Yes. Larvae damage developing shoots and fruit. Severe damage can occur causing a reduction in marketability. Serious pest of apple, pear and walnut (CABI 2007; Caprile *et al.* 2006b; 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.* 2006j; CABI 2007; Gencsoylu *et al.* 2006).	Yes. Larvae eat and bore into fruit reducing marketabitiy. Major pest of peach (Barcenas *et al.* 2005; Bentley *et al.* 2006j; CABI 2007; 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 similiar 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 simiiliar to Australia, suggests potential for establishment and spread (Barcenas *et al.* 2005; CABI 2007).	Yes. Larvae eat fruit and excrement build in fruit reducing marketablity (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.* 2006a; Jones *et al.* 2005).	Yes. Eat holes in fruit and leaves causing reduction in fruit marketablity. Key pest of apple (Caprile *et al.* 2006a; Jones *et al.* 2005).	Yes
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.* 2006g; Bentley *et al.* 2006h; CABI 2007; Zhou *et al.* 2000).	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.* 2006g; Bentley *et al.* 2006g; Bentley *et al.* 2006h; CABI 2007; CABI 2007; Zhou *et al.* 2000; Zhou *et al.* 2000).	Yes

Scientific Name	Common Name(s)	Potential for Establishment and Spread	Potential for Consequences	Consider Further ?
THYSANOPTERA (thrips)				
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 sutiable environments exist in Australia for this thrips to establish (CABI 2007; Davidson *et al.* 2006; Jones 2005; Stavisky *et al.* 2002) (Bentley *et al.* 2006p).	Yes. Major pest and can be responsible for epidemics of tomato spotted wilt. Feeds on leaves and flowers (Bentley *et al.* 2006p; CABI 2007; Davidson *et al.* 2006; Jones 2005; Stavisky *et al.* 2002).	Yes
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 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; Rieske and Raffa 2003).	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. Suitable vectors and hosts exist in Australia (Adlerz *et al.* 1989; Li *et al.* 2003).	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 (Adlerz *et al.* 1989).	Yes
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 likley 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 ocassionally fruit resulting in economic losses and increased production costs (Ogawa *et al.* 1995).	Yes

Scientific Name	Common Name(s)	Potential for Establishment and Spread	Potential for Consequences	Consider Further ?
Passalora circumcissa (Sacc.) U. Braun Teleomorph: *Mycosphaerella cerasella* Aderhold [Mycosphaerellales: Mycosphaerellaceae]	Cercospora leaf spot; Shot hole; Leaf spot	Yes. Hosts are limited to *Prunus* species, but suitable hosts are present in Australia (Farr *et al.* 2007).	Yes. Infection can cause defoliation and subsequent loss of plant health (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 (Adaskaveg *et al.* 2006).	Yes. Most serious pre-harvest disease of cherry in Washington State (Grove and Boal 1991). Infection common on foliage though can be economically devesting if occurs on fruit (Grove 1998).	Yes (WA)
Podosphaera tridactyla (Wallr.) de Bary Anamorph: *Oidium passerinii* G. Bertol. [Erysiphales: Erysiphaceae]	Plum 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 (Grove 1997).	Yes (WA)
Taphrina pruni Tula. [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. Rain and damp conditions 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		Yes. Distributed in areas across the USA in similar environments to Australia and affected severy *Prunus* species (CABI 2007).	Yes. Infects fruit, causing deformation and premature drop which can result in unmarketable fruit (CABI 2007).	Yes (WA)
Plum pox potyvirus ICTV 57.0.1.0.054 *Prunus* virus 7 Sarka virus 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. (Gildow *et al.* 2004).	Yes. Infects fruit, severally reducing financial yield available (EPPO/CABI 2004).	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’s) 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[5], 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.

[5] 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 2004a).
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 2004a).
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 2004a).
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO 2004a).
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 2004a).
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 2004a).
Establishment	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO 2004a).
Establishment potential	Likelihood of the establishment of a pest.
Fresh	Living; not dried, deep-frozen or otherwise conserved (FAO 2004a).
Fruits and vegetables	A commodity class for fresh parts of plants intended for consumption or processing and not for planting (FAO 2004a).
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 2004a).
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 2004a).
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 2004a).
Intended use	Declared purpose for which plants, plant products, or other regulated articles

	are imported, produced, or used (FAO 2004a).
Interception (of a pest)	The detection of a pest during inspection or testing of an imported consignment (FAO 2004a).
International Plant Protection Convention	As deposited with FAO in Rome in 1951 and subsequently amended (FAO 2004a).
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 2004a).
Introduction	The entry of a pest resulting in its establishment (FAO 2004a).
Lot	A number of units of a single commodity, identifiable by its homogeneity of composition, origin etc., forming part of a consignment (FAO 2004a).
National Plant Protection Organisation (NPPO)	Official service established by a government to discharge the functions specified by the IPPC (FAO 2004a). (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 2004a).
Pathway	Any means that allows the entry or spread of a pest (FAO 2004a).
Pest	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2004a).
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 2004a).
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 2004a).
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 2004a).
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 2004a).
Pest risk management (for quarantine pests)	Evaluation and selection of options to reduce the risk of introduction and spread of a pest (FAO 2004a).
Phytosanitary Certificate	Certificate patterned after the model certificates of the IPPC (FAO 2004a).
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 2004a).
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 2004a).
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 2004a).

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 2004a).
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 2004a).
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 2004a).
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 2004a).
Unrestricted risk	'Unrestricted' risk estimates apply in the absence of risk management measures.

Appendix D. References

Ackerman K (2007) 'Questions regarding US stone fruit'. Email to: Darryl Barbour 26 October 2007.

Adaskaveg JE, Gubler WD, Coates WW, and Stapleton JJ (2006) 'UC IPM: UC Management Guidelines for Powdery Mildew on Apricot'. Webpage: http://ipm.ucdavis.edu/PMG/r5100711.html, Accessed: 15/10/2007.

Adem HH (2003) 'Walnuts - Australian Walnut Industry Association'. Webpage: http://www.walnut.net.au/public/walnut_production_Adem.htm, Accessed: 14 February 2008.

Adlerz WC, Bistline FW, Russo LW, Hopkins DL (1989) Rate and spread of citrus blight reduced when sharpshooter leafhoppers (Homoptera: Cicadellidae) are controlled. *Journal of Economic Entomology* **82,** 1733-1737.

Agnello A (1996) 'Scaffolds Fruit Journal, April 29, 1996'. Webpage: http://www.nysaes.cornell.edu/ent/scaffolds/1996/scaffolds_0429.html, Accessed: 15/10/2007.

Agnello A, Chouinard G, Firlej A, Turechek W, Vanoosthuyse F, and Vincent C (2006) 'Tree Fruit Field Guide to Insect, Mite, and Disease Pests and Natural Enemies of Eastern North America'. Webpage: http://neipmc.org/resources/fruit/Treefruit_Promo2.pdf, Accessed: 15/10/2007.

Ahmad TR (1988) Predicting emergence and flight activity of peach twig borer (Lepidoptera: Gelechiidae) by heat unit accumulation. *Insect Science and its Application* **9,** 197-200.

Ahmad TR, Khadhum AA (1986) Influence of pheromone trap design and placement on capture of peach twig borer, *Anarsia lineatella* (Zeller) (Lepidoptera: Gelechiidae). *Insect Science and its Application* **7,** 637-640.

AliNiazee MT (1983a) Influence of environmental factors on daily flight activity of the filbertworm, *Melissopus latiferreanus* (Lepidoptera, Olethreutidae). *Ecological Entomology* **8,** 241-248.

AliNiazee MT (1983b) Monitoring the filbertworm, *Melissopus latiferreanus* (Lepidoptera: Olethreutidae), with sex attractant traps: effect of trap design and placement on moth catches. *Environmental Entomology* **12,** 141-146.

AliNiazee MT (1983c) Pest status of filbert (hazelnut) insects: a 10-year study. *Canadian Entomologist* **115,** 1155-1162 .

AliNiazee MT (1998) Ecology and management of hazelnut pests. *Annual Review of Entomology* **43,** 395-419.

AliNiazee MT, Stafford EM (1972) Notes on the biology, ecology, and damage of *Platynota stultana* on grapes. *Journal of Economic Entomology* **65,** 1042-1044.

Almeida RP, Blua MJ, Lopes JRS, Purcell AH (2005) Vector transmission of *Xylella fastidiosa*: applying fundamental knowledge to generate disease management strategies. *Annals of the Entomological Society of America* **98,** 775-786.

Almeida RPP, Purcell AH (2003) Biological traits of *Xylella fastidiosa* strains from grapes and almonds. *Applied and Environmental Microbiology* **69,** 7447-7452.

Alston DG and Reding ME (2003) 'Western Tentiform Leafminer'. Webpage: http://extension.usu.edu/files/factsheets/leafmine.pdf, Accessed: 15/10/2007.

Aluja M, Lozada N, Pińero J, Birke A, Hernández-Oritz V, Díaz-Fleischer F (2001) Basic behaviour of *Rhagoletis turpiniae* (Diptera: Tephritidae) with comparative notes on the sexual behavior of *Rhagoletis pomonella* and *Rhagoletis zoqui*. *Annals of the Entomological Society of America* **94,** 268-274.

Anderson JB, Ullrich RC (1979) Biological species of *Armillaria* in North America. *Mycologia* **71,** 402-414.

Anthon EW, Smith LO (1975) Integrated control of mites on prunes in central Washington. *Journal of Economic Entomology* **68,** 655-656.

Antonelli AL (2003) 'Thrips'. Webpage: http://www.puyallup.wsu.edu/plantclinic/resources/pdf/pls36thrips.pdf, Accessed: 15/10/2007.

APDD (2006) 'Australian Plant Disease Database'. Webpage: http://www.planthealthaustralia.com.au/appd/contributors/APDD.asp, Accessed: 15/10/2007.

APHIS (2002a) 'Code of Federal Regulations - January, 2002 -7 CFR PART 301 - Domestic quarantine notices subpart - Plum Pox'. Webpage: http://ceris.purdue.edu/napis/pests/ppox/freg/cfrppox.html#top, Accessed: 15/10/2007.

APHIS (2002b) Diseases on *Prunus domestica* (Plum), *Prunus persica* (Peach) and *Prunus persica* var. nucipersica (Nectarine) from the United States and California. Letter to Biosecurity Australia, 29 May 2002.

APHIS (2002c) Pests of US Peaches, Nectarines and Plums. Letter to Biosecurity Australia. 29 May 2002.,

APHIS (2006a) Information on quarantine for peach fruit fly (*Bactrocera zonata*) in California. Letter to Biosecurity Australia, 22 May 2006.

APHIS (2006b) Pests associated with Pacific North West and California apricot. Letter to Biosecurity Australia, 22 September 2006.

APHIS (2007) Additional information on the distribution of pests of stone fruit. Letter to Biosecurity Australia, 16 May 2007.

APPD (2006) 'Australian Plant Pest Database'. Webpage: http://www.planthealthaustralia.com.au/APPD/legal.asp, Accessed: 2006.

Atkins Jr EL, Frost Jr MH, Deal AS, Reynolds HT (1957) The omnivorous leaf roller, *Platynota stultana* Wlshm., on cotton in southern California: damage and control. *Journal of Economic Entomology* **50,** 59-64.

Australian Bureau of Statistics (2006) 'Selected Agriculture Commodities'. Webpage: http://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/714A4A59F6271B65CA25732300126C08/$File/71120_2005-06.pdf, Accessed: 15/10/2007.

Azam G (2002) 'Farmnote No. 25/2002, Management of spider mites (Tetranychidae) in vegetable crops in Carnarvon'. Webpage: http://wwwtest.agric.wa.gov.au/pls/portal30/docs/FOLDER/IKMP/HORT/VEG/PW/FN025_2002_01.PDF, Accessed: 14/07/2007.

Bailly X, Migeon A, Navajas M (2004) Analysis of microsatellite variation in the spider mite pest *Tetranychus turkestani* (Acari: Tetranychidae) reveals population genetic structure and raises questions about related ecological factors. *Biological Journal of the Linnean Society* **82,** 69-78.

Baker EW, Tuttle DM (1994) A guide to the spider mites (Tetranychidae) of the United States. Indira Publishing House, Michigan.

Baker JR (2002) 'NCSU: ENT/ort-72 Western Flower Thrips'. Webpage: http://www.ces.ncsu.edu/depts/ent/notes/O&T/flowers/ort072e/ort072e.htm, Accessed: 15/10/2007.

Bancroft JS (2005) Dispersal and abundance of *Lygus hesperus* in field crops. *Environmental Entomology* **34,** 1517-1523.

Barcenas NM, Unruh TR, Neven LG (2005) DNA diagnostics to identify internal feeders (Lepidoptera: Tortricidae) of pome fruits of quarantine importance. *Journal of Economic Entomology* **98,** 299-306.

Barlow VM, Godfrey LD, Norris RF (1999) Population dynamics of *Lygus hesperus* (Heteroptera: Miridae) on selected weeds in comparison with alfalfa. *Journal of Economic Entomology* **92,** 846-852.

Barnes JK (2004) 'Univeristy of Arkansas: Arthopod Museum Notes - A southeastern grass leafhopper.'. Webpage: http://www.uark.edu/depts/entomolo/museum/cuerna.html, Accessed: 11 July 2006.

Barnes MM (1991) Codling moth occurrence, host race formation, and damage. In 'Tortricid Pests: Their Biology, Natural Enemies and Control' (Eds LPS van der Geest and HH Evenhuis). Elsevier Science Publishers, Amsterdam, Oxford, New York and Tokyo pp. 313-328.

Barrett BA (2005) 'Twig Girdler and Twig Pruner'. Webpage: http://muextension.missouri.edu/explore/agguides/pests/g07276.htm, Accessed: 15/10/2007.

Baumgartner K, Rizzo DM (2001) Distribution of *Armillaria* species in Caluifornia. *Mycologia* **93,** 821-830.

Beardsley JW, Su TH, McEwen FL, Gerling D (1982) Field investigations on the interrelationships of the big-headed ant, the grey pineapple mealybug, and pineapple mealybug wilt disease in Hawaii. *Proceedings of the Hawaiian Entomological Society* **26,** 51-67.

Beardsley JWJ, Gonzalez RH (1975) The biology and ecology of armored scales [Diaspididae]. *Annual Review of Entomology* **20,** 47-73.

Beers EH, Klaus MW, Gebhard A, Cockfield S, Zack R, O'Brien C.W. (2003) Weevils attacking fruit trees in Washington. In 'Proceedings of the 77th Annual Western Orchard Pest and Disease Management Conference.' Washington State University, Pullman.

Bélanger A, Bostanian NJ, Rivard I (1985) Apple maggot (Diptera: Trypetidae) control with insecticides and their residues in and on apples. *Journal of Economic Entomology* **78,** 463-466.

Bellamy CL (2002) Coleoptera: Buprestoidea. In 'Zoological Catalogue of Australia' (Ed. WWK Houston). CSIRO Publishing, Melbourne pp. xii, 491.

Ben-Dov Y (1994) A Systematic Catalogue of the Mealybugs of the World (Insecta: Homoptera: Coccoidea: Pseudococcidae and Putoidae) with Data on Geographical Distribution, Host Plants, Biology and Economic Importance. Intercept Limited, Andover.

Ben-Dov Y, Hodgson CJ (1997) Soft Scale Insects: Their Biology, Natural Enemies and Control. Elsevier Science Publishers, Amsterdam.

Ben-Dov Y, Miller DR, and Gibson GAP (2006) 'ScaleNet: A database of the Scale insects of the World'. Webpage: http://www.sel.barc.usda.gov/scalenet/scalenet.htm, Accessed: 15/10/2007.

Bentley WJ, Coates WW, Hasey JK, Pickel C, Van Steenwyk RA, and Grant JA (2005a) 'UC IPM: UC Management Guidelines for Walnut Scale on Walnut'. Webpage: http://ipm.ucdavis.edu/PMG/r881300311.html, Accessed: 15/10/2007.

Bentley WJ, Coates WW, Hasey JK, Pickel C, Van Steenwyk RA, and Grant JA (2005b) 'UC IPM: UC Management Guidelines for Walnut Husk Fly on Walnut'. Webpage: http://ipm.ucdavis.edu/PMG/r881301211.html, Accessed: 15/10/2007.

Bentley WJ and Day KR (2006a) 'UC IPM: UC Management Guidelines for Eriophyid Mites on Plum'. Webpage: http://www.ipm.ucdavis.edu/PMG/r611301711.html, Accessed: 15/10/2007.

Bentley WJ and Day KR (2006b) 'UC IPM: UC Management Guidelines for Katydids on Nectarine'. Webpage: http://www.ipm.ucdavis.edu/PMG/r540301311.html, Accessed: 15/10/2007.

Bentley WJ and Day KR (2006c) 'UC IPM: UC Management Guidelines for Mealy Plum Aphid on Plum'. Webpage: http://www.ipm.ucdavis.edu/PMG/r611301711.html, Accessed: 15/10/2007.

Bentley WJ and Day KR (2006d) 'UC IPM: UC Management Guidelines for Peach Twig Borer on Nectarine'. Webpage: http://ipm.ucdavis.edu/PMG/r540300611.html, Accessed: 15/10/2007.

Bentley WJ and Day KR (2006e) 'UC IPM: UC Management Guidelines for Western Tussock Moth on Plum'. Webpage: http://www.ipm.ucdavis.edu/PMG/r611301211.html, Accessed: 15/10/2007.

Bentley WJ, Day KR, and Rice RE (2006a) 'UC IPM: UC Management Guidelines for Citrus Cutworm on Plum'. Webpage: http://ipm.ucdavis.edu/PMG/r611302911.html, Accessed: 15/10/2007.

Bentley WJ, Day KR, and Rice RE (2006b) 'UC IPM: UC Management Guidelines for Fruittree Leafroller on Nectarine'. Webpage: http://ipm.ucdavis.edu/PMG/r540300311.html, Accessed: 15/10/2007.

Bentley WJ, Day KR, and Rice RE (2006c) 'UC IPM: UC Management Guidelines for Fruittree Leafroller on Peach'. Webpage: http://ipm.ucdavis.edu/PMG/r602300311.html, Accessed: 15/10/2007.

Bentley WJ, Day KR, and Rice RE (2006d) 'UC IPM: UC Management Guidelines for Katydids on Plum'. Webpage: http://ipm.ucdavis.edu/PMG/r611303111.html, Accessed: 15/10/2007.

Bentley WJ, Day KR, and Rice RE (2006e) 'UC IPM: UC Management Guidelines for Obliquebanded Leafroller on Nectarine'. Webpage: http://ipm.ucdavis.edu/PMG/r540301111.html, Accessed: 15/10/2007.

Bentley WJ, Day KR, and Rice RE (2006f) 'UC IPM: UC Management Guidelines for Obliquebanded Leafroller on Peach'. Webpage: http://www.ipm.ucdavis.edu/PMG/r602300411.html, Accessed: 15/10/2007.

Bentley WJ, Day KR, and Rice RE (2006g) 'UC IPM: UC Management Guidelines for Omnivorous Leafroller on Nectarine'. Webpage: http://ipm.ucdavis.edu/PMG/r540301011.html, Accessed: 29/10/2007.

Bentley WJ, Day KR, and Rice RE (2006h) 'UC IPM: UC Management Guidelines for Omnivorous Leafroller on Plum'. Webpage: http://ipm.ucdavis.edu/PMG/r611303011.html, Accessed: 29/10/2007.

Bentley WJ, Day KR, and Rice RE (2006i) 'UC IPM: UC Management Guidelines for Orange Tortrix on Plum'. Webpage: http://ipm.ucdavis.edu/PMG/r611300711.html, Accessed: 29/10/2007.

Bentley WJ, Day KR, and Rice RE (2006j) 'UC IPM: UC Management Guidelines for Oriental Fruit Moth on Nectarine'. Webpage: http://ipm.ucdavis.edu/PMG/r540300211.html, Accessed: 15/10/2007.

Bentley WJ, Day KR, and Rice RE (2006k) 'UC IPM: UC Management Guidelines for Peach Twig Borer on Plum'. Webpage: http://ipm.ucdavis.edu/PMG/r611300211.html, Accessed: 29/10/2007.

Bentley WJ, Day KR, and Rice RE (2006l) 'UC IPM: UC Management Guidelines for Plant Bugs on Nectarine'. Webpage: http://ipm.ucdavis.edu/PMG/r540301711.html, Accessed: 29/10/2007.

Bentley WJ, Day KR, and Rice RE (2006m) 'UC IPM: UC Management Guidelines for Prune Limb Borer and American Plum Borer on Nectarine'. Webpage: http://ipm.ucdavis.edu/PMG/r540300911.html, Accessed: 29/10/2007.

Bentley WJ, Day KR, and Rice RE (2006n) 'UC IPM: UC Management Guidelines for Stink Bugs on Nectarine'. Webpage: http://ipm.ucdavis.edu/PMG/r540300111.html, Accessed: 29/10/2007.

Bentley WJ, Day KR, and Rice RE (2006o) 'UC IPM: UC Management Guidelines for Webspinning Spider Mites on Plum'. Webpage: http://ipm.ucdavis.edu/PMG/r611400411.html, Accessed: 15/10/2007.

Bentley WJ, Day KR, and Rice RE (2006p) 'UC IPM: UC Management Guidelines for Western Flower Thrips on Plum'. Webpage: http://ipm.ucdavis.edu/PMG/r611301911.html, Accessed: 29/10/2007.

Bentley WJ, Varela LG, Zalom FG, Smith RJ, Purcell AH, Phillips PA, Haviland DR, Daane KM, and Battany MC (2006q) 'UC IPM: UC Management Guidelines for Mealybugs (Pseudococcus) on Grape'. Webpage: http://ipm.ucdavis.edu/PMG/r302301811.html, Accessed: 22/10/2007.

Benz G (1991) Physiology, Reproduction and Ecology. In 'Tortricid Pests: Their Biology, Natural Enemies and Control' (Eds LPS van der Geest and HH Evenhuis). Elsevier Science Publishers, Amsterdam, Oxford, New York and Tokyo pp. 89-147.

Berry RE (1998) Insects and Mites of Economic Importance in the Pacific Northwest. Oregon State University Bookstore Inc., Corvalis.

Bevan M (2000) The bugs from Brazil. *Nature* **406,** 140-141.

Biggs AR (1997) 'Leucostoma Canker of Stone Fruits, *Leucostoma persoonii* and *L. cincta*'. Webpage: Web Page: http://www.caf.wvu.edu/kearneysville/disease_month/diseasefocussept.html, Accessed: 12/03/2008.

Blackmer JL, Naranjo SE, Williams LH (2004) Tethered and untethered flight by *Lygus hesperus* and *Lygus lineolaris* (Heteroptera: Miridae). *Enviornmental Entomology* **33,** 1389-1400.

Blair BL, Stirling GR, Whittle PJL (1999) Distribution of pest nematodes on sugarcane in south Queensland and relationship to soil texture, cultivar, crop age and region. *Australian Journal of Experimental Agriculture* **39,** 43-49.

Bobb ML (1970) Reduction of cat-facing injury to peaches. *Journal of Economic Entomology* **63,** 1026-1027.

Bodine EW, Kreutzer WA (1942) Ring spot of apricot. *Phytopathology* **32,** 179-181.

Bohart RM (1942) *Platynota stultana* as a pest of field-grown carnations. *Journal of Economic Entomology* **35,** 399-403.

Bolland HR, Guiterrez J, Flechtmann CHW (1998) World Catalogue of the Spider Mite Family (Acari:Tetranychidae). Brill, Boston, Massachusetts.

Boller EF, Prokopy RJ (1976) Bionomics and management of *Rhagoletis*. *Annual Review of Entomology* **21,** 223-246.

Bommireddy PL, Parajulee MN, Porter DO (2004) Influence of constant temperatures on life history of immature *Lygus elisus* (Hemiptera: Miridae). *Environmental Entomology* **33,** 1549-1553.

Booth DC (1999) 'Technical Report: Pear Thrips'. Webpage: http://www.onlinegardener.com/pests/Pear%20thrips.pdf, Accessed: 24/10/2007.

Boriss H and Brunke H (2006) 'Commodity Profile: Peaches and Nectarines'. Webpage: http://aic.ucdavis.edu/profiles/Peach-2006B.pdf, Accessed: 25/10/2007.

Boriss H, Brunke H, and Kreith M (2006a) 'Commodity Profile: Apricots'. Webpage: http://aic.ucdavis.edu/profiles/Apricot-2006.pdf, Accessed: 25/10/2007.

Boriss H, Brunke H, and Kreith M (2006b) 'Commodity Profile: Plums, fresh market'. Webpage: http://aic.ucdavis.edu/profiles/PlumsFresh-2006.pdf, Accessed: 25/10/2007.

Bostanian NJ, Hardman JM, Ventard E, Racette G (2005) The intrinsic toxicity of several neonicotinoids to *Lygus lineolaris* and *Hyaliodes vitripennis*, a phytophagous and a predacious mirid. *Pest Management Science* **61,** 991-996.

Botha J, Davis P, Woods B, and Power G (2000) Codling moth, *Cydia pomenella*, Exotic threat to Western Australia. Factsheet 44/2000, Agriculture Western Australia, Western Australia

Bower CC (1993) Control of European earwig *Forficula auricularia* L. in stone fruit orchards at Young, New South Wales. *General and Applied Entomology* **24,** 11-18.

Boyce AM (1934) Bionomics of the walnut husk fly, *Rhagoletis completa*. *Hilgardia* **8,** 363-579.

Braby MF (2000) Butterflies of Australia: Their Identification, Biology and Distribution. CSIRO Publishing, Collingwood, Melbourne.

Bradbury JF (1986) Guide to Plant Pathogenic Bacteria. CAB International, Wallingford.

Braun AL, Lownsbery BF (1975) The pin nematode *Paratylenchus neoamlycephalus* on Myrobalun plum and other hosts. *Journal of Nematology* **7,** 336-343.

Broadbent AB, Lachance S, Sear MK, Goulet H (2006) Native braconid parasitism of the Tarnished plant bug (Hemiptera: Miridae) in Southern Ontario. *Biocontrol Science and Technology* **16,** 687-698.

Brooks FE (1924) The Cambium Curculio, *Conotrachelus anaglypticus* Say. *Journal of Agricultural Research* **28,** 377-386.

Brown EE (1953) Life cycle of lesser apple worm in northeastern Oregon. *Journal of Economic Entomology* **46,** 163.

Brown SL and Hudson W (1999) 'Green June Beetle - *Cotinis nitida* (Linnaeus)'. Webpage: http://www.gaipm.org/top50/gjb.html, Accessed: 29/10/2007.

Brunner JF, Rice RE (1984) Peach twig borer, *Anarsia lineatella* Zeller (Lepidoptera: Gelechiidae), development in Washington and California. *Environmental Entomology* **13,** 607-610.

Brunt AA, Crabtree K, Dallwitz MJ, Gibbs AJ, Watson L, and Zurcher EJ (1996) 'Viruses of Plants: Descriptions and Lists from the VIDE Database'. Webpage: http://image.fs.uidaho.edu/vide/, Accessed: 29/10/2007.

Büchen-Osmond C, Crabtree K, Gibbs A, McLean G (1988) Viruses of Plants in Australia: Descriptions and Lists from the VIDE Database. The Australian National University Printing Service, Canberra.

CABI (2007) 'Crop Protection Compendium'. Webpage: www.cabi.org/compendia/cpc/, Accessed: 2006.

Calder AA (1996) Genera of Australian Click Beetles (Coleoptera: Elateridae). CSIRO Publishing, Collingwood.

California Tree Fruit Agreement (2007a) 'Cal State PPN: Post Harvest Practices'. Webpage: http://www.eatcaliforniafruit.com/csppn/after-harvest/post-harvest.asp, Accessed: 21/02/2008.

California Tree Fruit Agreement (2007b) 'California peaches, plums and nectarines '. Webpage: http://www.eatcaliforniafruit.com/csppn/index.asp, Accessed: 29/10/2007.

California Tree Fruit Agreement (2007c) 'California Tree Fruit Agreement, International Market Report, September 10, 2007'. Webpage: http://www.eatcaliforniafruit.com/ppn/pdfs/international/IMR/353Newsletter_IX_-_September_10_2007.pdf, Accessed: 24/10/2007.

Campbell JM, Sarazin MJ, Lyons DB (1989) Canadian Beetles (Coleoptera) Injurious to Crops, Ornamentals, Stored Products, and Buildings. Research Branch, Agriculture Canada, Ottawa.

Canadian Food Inspection Agency (2007) '*Grapholita molesta* (Busck) - Oriental Fruit Moth'. Webpage: Web Page: http://www.inspection.gc.ca/english/sci/surv/data/gramole.shtml, Accessed: 11/03/2008.

Caprile JL, Wunderlich LR, Vossen PM, Coates WW, Andris HL, Varela LG, and Bentley WJ (2006a) 'UC IPM: UC Management Guidelines for Apple Pandemis on Apple'. Webpage: http://ipm.ucdavis.edu/PMG/r4300611.html?printpage, Accessed: 29/10/2007.

Caprile JL, Wunderlich LR, Vossen PM, Coates WW, Andris HL, Varela LG, and Bentley WJ (2006b) 'UC IPM: UC Management Guidelines for Codling Moth on Apple'. Webpage: http://ipm.ucdavis.edu/PMG/r4300111.html, Accessed: 15/10/2007.

Caprile JL, Wunderlich LR, Vossen PM, Coates WW, Andris HL, Varela LG, and Bentley WJ (2006c) 'UC IPM: UC Management Guidelines for Apple Maggot on Apple'. Webpage: http://ipm.ucdavis.edu/PMG/r4300511.html, Accessed: 24/10/2007.

Carroll D, Puget B, Higbee B, Quist M, Magallenes O, Smith N, Gjerde A, and Schneider K (2006) 'Pomegranate Pest Management in the San Joaquin Valley'. Webpage: http://www.aaie.net/IPMinfo/PomegranatePestManagement_002.pdf, Accessed: 29/10/2007.

Carter W (1962) Insects in relation to plant disease. John Wiley and Sons, New York, USA.

Carver M, Gross GF, Woodward TE (1991) Hemiptera. In 'Insects of Australia a Textbook for Students and Research Workers' (Ed. CSIRO (Division of Entomology)). Melbourne University Press, Carlton pp. 429-509.

Cassis G, Gross GF (2002) Hemiptera: Heteroptera (Pentatomomorpha). In 'Zoological Catalogue of Australia' (Eds WWK Houston and A Wells). CSIRO Publishing, Collingwood, Melbourne pp. xiv, 737 pp.

Cassis G, Houston WWK, Weir TA, Moore BP (1992) Coleoptera: Scarabaeoidea. In 'Zoological Catalogue of Australia' (Eds DD Walton and WWK Houston). AGPS, Canberra pp. xii, 544 pp.

Castellari PL (1976) Recente infestazione di *Peridroma saucia* Hb. su Peschi cv. Stark Red Gold. *Informatore Fitopatologico* **26,** 21-28.

CDFA (2002) 'California Agricultural Statistical Review'. Webpage: http://www.cdfa.ca.gov/files/pdf/card/ResDir06_Overview.pdf, Accessed: 29/10/2007.

CDFA (2005) 'Guava Fruit Fly', Guava Fruit Fly Pest Profile,CDFA, Pest Detection/Emergency Projects Branch, California.

CDFA (2006) 'Index of Plant Virus, Viroid, and Phytoplasma Diseases in California'. Webpage: http://plant.cdfa.ca.gov/virology/viruslist.htm, Accessed: 05 July 2006.

Chandler SC (1950) Forbes scale as a major pest of peach. *Journal of Economic Entomology* **43,** 398.

Chapman PJ, Lienk SE (1971) Tortricid fauna of apple in New York (Lepidoptera: Tortricidae): including an account of apples' occurrence in the State, especially as a naturalized plant. New York State Agricultural Experiment Station, Cornell University, Geneva, New York State.

Chellemi DO, Marois JJ (1992) Influence of leaf removal, fungicide application and fruit maturity on incidence and severity of grape powdery mildew. *American Journal of Enology and Viticulture* **43,** 53-57.

Childers CC, Achor DS (1995) Thrips feeding and oviposition injuries to economic plants, subsequent damage and host responses to infestation. In 'Parker, B.L.// Lewis, T.// Skinner, M.' (Ed. Towards Understanding Thrips Management). Plenum, London.

Christenson LD, Foote RH (1960) Biology of fruit flies. *Annual Review of Entomology* **5,** 171-192.

Cleveland TC (1985) Toxicity of several insecticides applied topically to tarnished plant bugs. *Journal of Entomological Science* **20,** 95-97.

Clift AD, Tesoriero L (2002) Aspects of vector thrips biology and epidemiology of tospoviruses in Australia. In 'Thrips and Tospoviruses: Proceedings of the 7th International Symposium on Thysanoptera.'

Coates WW and Van Steenwyk RA (2006a) 'UC IPM: UC Management Guidelines for Obliquebanded Leafroller on Apricot'. Webpage: http://ipm.ucdavis.edu/PMG/r5301711.html, Accessed: 29/10/2007.

Coates WW and Van Steenwyk RA (2006b) 'UC IPM: UC Management Guidelines for Orange Tortrix on Apricot'. Webpage: http://ipm.ucdavis.edu/PMG/r5300411.html, Accessed: 29/10/2007.

Coates WW and Van Steenwyk RA (2006c) 'UC IPM: UC Management Guidelines for Peach Twig Borer on Apricot'. Webpage: http://ipm.ucdavis.edu/PMG/r5300111.html, Accessed: 15/10/2007.

Coates WW and Van Steenwyk RA (2006d) 'UC IPM: UC Management Guidelines for Redhumped Caterpillar on Apricot'. Webpage: http://www.ipm.ucdavis.edu/PMG/r5301411.html, Accessed: 29/10/2007.

Cochran LC, Calavan EC (1957) Apricot ring pox virus not transmitted through apricot seeds. *Plant Disease Reporter* **41,** 690.

Collman SJ (1996) 'Gardening in Western Washington: Biology and Control of Tent Caterpillars'. Webpage: http://gardening.wsu.edu/library/inse003/inse003.htm, Accessed: 29/10/2007.

Cook RP, Dubé AJ (1989) Host-Pathogen Index of Plant Diseases in South Australia,South Australian Department of Agriculture, Adelaide.

Cooperative Agriculture Pest Survey Program (2003) 'NAPIS USA ARCHIPS podana Survey Map - tree fruit tortrix'. Webpage: http://ceris.purdue.edu/napis/states/wa/imap/archips-usa.html, Accessed: 24/10/2007.

Cooperative Research Centre for Viticulture (2004) Characteristics of powdery mildew. *Viti-Notes* **1**.

Costa HS, Raetz E, Pinckard TR, Gispert C, Hernandez-Martinez R, Dumenyo CK, Cooksey DA (2004) Plant hosts of *Xylella fastidiosa* in and near California vineyards. *Plant Disease* **88,** 1255-1261.

Coyle DR, Booth DC, Wallace MS (2005) Ambrosia Beetle (Coleoptera: Scolytidae) Species, Flight, and Attack on Living Eastern Cottonwood Trees. *Forest Entomology* **98,** 2049-2057.

Cranham JE, Helle W (1985) Pesticide resistance in Tetranychidae. In 'Spider Mites, Their Biology, Natural Enemies and Control' (Eds W Helle and MW Sabelis). Elsevier Science Publishers, Amsterdam, Oxford, New York and Tokyo pp. 405-422.

Cranshaw WS and Sclar DC (2007) 'Spider Mites'. Webpage: http://www.ext.colostate.edu/pubs/insect/05507.html, Accessed: 17/10/2007.

Croft BA, Hull LA (1991) Tortricid pests of pome and stone fruits, chemical control and resistance to pesticides. In 'Tortricid Pests: Their Biology, Natural Enemies and Control' (Eds LPS van der Geest and HH Evenhuis). Elsevier Science Publishers, Amsterdam, Oxford, New York and Tokyo pp. 473-486.

CSIRO (2005) 'Australian Insect Common Names Online ver 1.53'. Webpage: http://www.ento.csiro.au/aicn/index.htm, Accessed: 6 June 2006.

Curtis CE, Clark JD, Tebbets JS (1991) Incidence of codling moth (Lepidoptera: Tortricidae) in packed nectarines. *Journal of Economic Entomology* **84,** 1686-1690.

Curtis CE, Clark JD, Tebbets JS, Mackey BE (1992) Incidence of arthropods found in packed nectarine fruit in central California. *Southwestern Entomologist* **17,** 29-39.

DAFF (2006) Pest Interception Records from January 2003, Incidence Database,Australian Government Department of Agriculture, Fisheries and Forestry, Canberra.

Davidson JA, Miller DR (1990) Ornamental plants. In 'Armoured Scale Insects: Their Biology, Natural Enemies and Control' (Ed. D Rosen). Elsevier Science Publishers, Amsterdam pp. 603-632.

Davidson MM, Butler RC, Teulon DAJ (2006) Starvation period and age affect the response of female *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) to odor and visual cues. *Journal of Insect Physiology* **52,** 729-736.

Davidson WM (1918) The California pistol case borer, *Coleophora sacramenta*, Heinrich. *Journal of Economic Entomology* **11,** 446-452.

Davis HG, McDonough LM (1981) Sex attractant for the filbertworm, *Melissopus latiferranus* (Walsingham). *Environmental Entomology* **10,** 390-391.

Davis HG, McDonough LM, Richardson G (1983) Sex attractant of the filbertworm moth: tests in pomegranate orchards. *Southwestern Entomologist* **8,** 137-139.

DAWA (2003) Draft Western Australian Quarantine pestlist (invertebrate species). Confidential internal report. Department of Agriculture, Perth.

DAWA (2006) Draft Plant Pathology lists of Pathogen Species. Confidential internal report,Department of Agriculture, Perth.

De Boer R (1985) Reproductive Barriers. In 'Spider Mites, Their Biology, Natural Enemies and Control' (Eds W Helle and MW Sabelis). Elsevier Science Publishers, Amsterdam, Oxford, New York and Tokyo pp. 193-200.

Dean RW, Chapman PJ (1973) Bionomics of the apple maggot in eastern New York. *Search Agriculture, Entomology* **3,** 64.

Deland JP, Gries R, Gries G, Judd GJR, Roitberg BD (1993) Sex pheromone components of the fruit-tree leaf roller, *Archips argyrospilus* (Walker) (Lepidoptera: Tortricidae), in British Columbia. *Journal of Chemical Ecology* **19,** 2855-2864.

Di Serio F, Malfitano M, Flores R, Randles JW (1999) Detection of peach latent mosaic viroid in Australia. *Australasian Plant Pathology* **28,** 80-81.

Dickler E (1991) Other Tortricides on Pome and Stone Fruits: Eurasian Species. In 'Tortricid Pests: Their Biology, Natural Enemies and Control' (Eds LPS van der Geest and HH Evenhuis). Elsevier Science Publishers, Amsterdam, Oxford, New York and Tokyo pp. 435-452.

Dingley JM 'Records of Plant Diseases in New Zealand', Bulletin 192,New Zealand Department of Scientific and Industrial Research, New Zealand.

Dixon WN and Fasulo TR (2006) 'Featured Creatures - Tarnished plant bug'. Webpage: http://creatures.ifas.ufl.edu/trees/tarnished_plant_bug.htm, Accessed: 22/10/2007.

Dohanian SM (1940) *Melissopus latiferreanus* as a pest of filberts in the northwest. *Journal of Economic Entomology* **33,** 852-856.

Dowell RV, Scriber JM, Lederhouse RC (1990) Survival of *Papilio rutulus* Lucas (Lepidoptera: Papilionidae) larvae on 42 potential host plants. *Pan Pacific Entomologist* **66,** 140-146.

Drees BM, Jackman JA, and Merchant ME (1994) 'Wood-boring Insects of Trees and Shrubs'. Webpage: http://insects.tamu.edu/extension/bulletins/b-5086.html, Accessed: 29/10/2007.

Dreistadt SH, Dahlsten DL, and Paine TD (2004) 'UC IPM: Bark Beetles Management Guidelines'. Webpage: http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7421.html, Accessed: 29/10/2007.

Dreistadt SH, Morse JG, Phillips PA, and Rice RE (2007) 'Scale Management Guidelines--UC IPM'. Webpage: http://ipm.ucdavis.edu/PMG/PESTNOTES/pn7408.html, Accessed: 24/10/2007.

Dreistadt SH and Phillips PA (2001) 'Thrips Management Guidelines--UC IPM'. Webpage: http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7429.html, Accessed: 22/10/2007.

Dulić Marković I, Ranković M (1996) An experiment with plum pox virus transmission by apricot and peach seed. In 'Proceedings of the Middle European Meeting '96 on Plum Pox.' Plant Health and Soil Conservation Station of the Ministry of Agriculture, Budapest.

Duncan RA, Stapleton JJ (1994) Mulching young *Prunus* trees with black polyethylene film increases blossoming and yield, reduces need for irrigation, eliminates weeds, and controls pathogenic nematodes. In 'Proceedings for the 24th National Agricultural Plastics Congress.' American Society of Plasticulture, Overland Park, Kansas.

Duncan RA, Stapleton JJ, McKenry MV (1992) Establishment of orchards with black polyethylene film mulching: effect on nematode and fungal pathogens, water conservation, and tree growth. *Journal of Nematology* **24,** 681-687.

Dunley JE, Brunner JF, Doerr MD, Beers EH (2006) Resistance and cross-resistance in populations of the leafrollers, *Choristoneura rosaceana* and *Pandemis pyrusana*, in Washington apples. *Journal of Insect Science* **6,** 1-7.

Duruz WP (1922) The Cherry Fruit Sawfly and its Control. *Monthly Bulletin of the Californian Department of Agriculture* **11,** 393-399.

Dustan GG (1964) Mating behaviour of the oriental fruit moth, *Grapholitha molesta* (Busck) (Lepidoptera: Olethreutidae). *Canadian Entomologist* **96,** 1087-1093.

El-Sayed AM (2008) 'The Pherobase: Database of Insect Pheromones and Semiochemicals'. Webpage: http://www.pherobase.com, Accessed: 14 February 2008.

English LM (2001) 'Codling moth (*Cydia pomonella*) and its control'. Webpage: Web Page: http://www.cahe.nmsu.edu/pubs/_h/h-427.html, Accessed: 11/03/2008.

EPPO (1999) 'Guidelines on Good Plant Protection Practice: Pome Fruits'. Webpage: Web Page: http://archives.eppo.org/EPPOStandards/PP2_GPP/pp2-18-e.doc, Accessed: 11/03/2008.

EPPO (2002) *Frankliniella occidentalis*. *Bulletin OEPP/EPPO Bulletin* **32,** 281-292.

EPPO (2004a) 'EPPO Reporting Service 2004, No. 09'. Webpage: http://www.invasive.org/library/eppo/Rse-0409.pdf, Accessed: 24/10/2007.

EPPO (2004b) Stone fruits. *Bulletin OEPP/EPPO Bulletin* **34,** 427-438.

EPPO/CABI (1989) Distribution maps of plant pests, *Taeniothrips inconsequens* (Uzel). Map No. 504,CAB International, Wallingford.

EPPO/CABI (1997a) Data sheets on quarantine pests *Anarsia lineatella* . In 'Quarantine Pests for Europe' (Eds IM Smith, DG McNamara, PR Scott, and M Holderness). CAB International, Wallingford pp. 34-36.

EPPO/CABI (1997b) Data sheets on quarantine pests *Anastrepha ludens*. In 'Quarantine Pests for Europe' (Eds IM Smith, DG McNamara, PR Scott, and M Holderness). CAB International, Wallingford pp. 42-46.

EPPO/CABI (1997c) Data sheets on quarantine pests *Anthonomus quadrigibbus*. In 'Quarantine Pests for Europe' (Eds IM Smith, DG McNamara, PR Scott, and M Holderness). CAB International, Wallingford pp. 73-77.

EPPO/CABI (1997d) Data sheets on quarantine pests: *Bactrocera curcubitae*. In 'Quarantine Pests for Europe' (Eds IM Smith, DG McNamara, PR Scott, and M Holderness). CAB International, Wallingford pp. 1-6.

EPPO/CABI (1997e) Data sheets on quarantine pests *Bactrocera dorsalis*. In 'Quarantine Pests for Europe' (Eds IM Smith, DG McNamara, PR Scott, and M Holderness). CAB International, Wallingford pp. 96-103.

EPPO/CABI (1997f) Data sheets on quarantine pests *Conotrachelus nenuphar*. In 'Quarantine Pests for Europe' (Eds IM Smith, DG McNamara, PR Scott, and M Holderness). CAB International, Wallingford pp. 176-180.

EPPO/CABI (1997g) Data sheets on quarantine pests *Frankliniella occidentalis*. In 'Quarantine Pests for Europe' (Eds IM Smith, DG McNamara, PR Scott, and M Holderness). CAB International, Wallingford pp. 267-272.

EPPO/CABI (1997h) Data sheets on quarantine pests *Malacosoma americanum*. In 'Quarantine Pests for Europe' (Eds IM Smith, DG McNamara, PR Scott, and M Holderness). CAB International, Wallingford pp. 388-391.

EPPO/CABI (1997i) 'Data sheets on quarantine pests peach mosaic ?closterovirus'. Webpage: http://www.eppo.org/QUARANTINE/virus/Peach_american_mosaic_virus/PCMV00_ds.pdf, Accessed: 23/10/2007.

EPPO/CABI (1997j) Data sheets on quarantine pests *Popillia japonica*. In 'Quarantine Pests for Europe' (Eds IM Smith, DG McNamara, PR Scott, and M Holderness). CAB International, Wallingford pp. 456-460.

EPPO/CABI (1997k) Data sheets on quarantine pests *Rhagoletis completa*. In 'Quarantine Pests for Europe' (Eds IM Smith, DG McNamara, PR Scott, and M Holderness). CAB International, Wallingford pp. 475-479.

EPPO/CABI (1997l) Data sheets on quarantine pests *Rhagoletis fausta*. In 'Quarantine Pests for Europe' (Eds IM Smith, DG McNamara, PR Scott, and M Holderness). CAB International, Wallingford pp. 480-483.

EPPO/CABI (1997m) Data sheets on quarantine pests *Xylella fastidiosa*. In 'Quarantine Pests for Europe' (Eds IM Smith, DG McNamara, PR Scott, and M Holderness). CAB International, Wallingford pp. 1152-1161.

EPPO/CABI (1999) Distribution maps of plant pests, *Frankliniella intonsa* (Trybom). Map No. 597. CAB International, Wallingford.

EPPO/CABI (2004) Diagnostic protocols for regulated pests plum pox potyvirus. *Bulletin OEPP/EPPO Bulletin* **34,** 247-256.

Epstein D, Gut LJ, Jones AL, and Maxson-Stein K (2002) 'A Pocket Guide for IPM Scouting in Stone Fruits'. Webpage: http://ipm.msu.edu/stonefruit.htm, Accessed: 8 February 2005.

Erkiliç LB, Uygun N (1997) Studies on the effects of some pesticides on white peach scale, *Pseudaulacaspis pentagona* (Targ.-Tozz.) (Homoptera: Diaspidae) and its side-effects on two common scale insect predators. *Crop Protection* **16,** 69-72.

Esfaki FM, Cunningham RT (1987) Host plants of fruit flies (Diptera: Tephritidae) of economic importance in Guatemala. *Florida Entomologist* **70,** 116-123.

Essig EO (1914) The Cherry Fruit Sawfly. *Monthly Bulletin of the State Commission for Horticulture* **3,** 31-35.

Eyles AC (1999) Introduced Mirinae of New Zealand (Hemiptera: Miridae). *New Zealand Journal of Zoology* **26,** 353-372.

Fanigliulo A, Comes S, Maiss E, Piazzolla P, Crescenzi A (2003) The complete nucleotide sequence of Plum pox virus isolates from sweet (PPV-SwC) and sour (PPV-SoC) cherry and their taxonomic relationships within the species. *Archives of Virology* **148,** 2137-2153.

FAO (2004a) International Standards for Phytosanitary Measures. Glossary of Phytosanitary Terms, ISPM Publication No. 5. Secretariat of the International Plant Protection Convention, Food and Agriculture Organisation of the United Nations, Rome.

FAO (2004b) International Standards for Phytosanitary Measures. Pest Risk Analysis for Quarantine Pests, Including Analysis of Environmental Risks and Living Modified Organisms, Publication No. 11. Secretariat of the International Plant Protection Convention, Food and Agriculture Organisation of the United Nations,

FAO (2005) Draft ISPM on Requirements for the Establishment and Maintenance of Pest Free Areas for Tephritid Fruit Flies for Country Consultation (May 2005),Secretariat of the International Plant Protection Convention, Food and Agriculture Organisation of the United Nations, Rome.

FAO (2007a) International Standards for Phytosanitary Measures: Framework for pest risk analysis, Publication No. 2. Secretariat of the International Plant Protection Convention, Food and Agriculture Organisation of the United Nations,

FAO (2007b) International Standards for Phytosanitary Measures. Glossary of phytosanitary terms, Publication No. 5. Secretariat of the International Plant Protection Convention, Food and Agriculture Organisation of the United Nations,

Farr DF, Bills GF, Chamuris GP, Rossman AY (1989) Fungi on Plants and Plant Products in the United States. APS Press, St Paul.

Farr DF, Rossman AY, Palm ME, and McCray EB (2007) 'Fungal Databases, Systematic Botany & Mycology Laboratory, ARS, USDA'. Webpage: http://nt.ars-grin.gov/fungaldatabases/, Accessed: 2007.

Faulkner D (2006) '*Cotinis mutabilis*, Green Fruit Beetle, Figeater Beetle'. Webpage: http://www.sdnhm.org/fieldguide/inverts/coti-mut.html, Accessed: 29/10/2007.

Feil H, Purcell AH (2001) Temperature-dependent growth and survival of *Xylella fastidiosa* in vitro and in potted grapevines. *Plant Disease* **85,** 1230-1234.

Ferguson AW, Fitt BDL, Williams IH (1997) Insect injury to linseed in south-east England. *Crop Protection* **16,** 643-652.

Fisher D, Wicks T (2003) Powdery Mildew in Wine Grapes in Western Australia. *Government of Western Australia (Department of Agriculture) Bulletin No. 4575.*

Fisher G and Olsen J (2002) 'The Apple Maggot in Oregon, FS 271'. Webpage: http://extension.oregonstate.edu/catalog/html/fs/fs271/, Accessed: 25/10/2007.

Fisher JM (1967) Effect of temperature and host on Paratylenchus neoamblycephalus and effect of the nematode on the host. *Australian Journal of Agricultural Research* **18,** 921-929.

Flemings Nurseries (2008) 'Landscapers - Developers - Councils'. Webpage: http://www.flemings.com.au/retail/default.asp, Accessed: 18 February 2008.

Fletcher BS (1989) Ecology; movements of Tephritid fruit flies. In 'Fruit Flies: Their Biology, Natural Enemies and Control' (Eds AS Robinson and G Hooper). Elsevier Science Publishers, Amsterdam pp. 209-219.

Fletcher MJ and Lariviere M-C (1988) 'Identification Keys and Checklists for the leafhoppers, planthoppers and their relatives occurring in Australia (Hemiptera: Auchenorrhyncha). Species of Flatidae known to occur in Australia'. Webpage: http://www.agric.nsw.gov.au/Hort/ascu/fulgor/flat0.htm, Accessed: 16/10/2007.

Fletcher MJ and Lariviere M-C (2005a) 'Identification Keys and Checklists for the leafhoppers, planthoppers and their relatives occurring in Australia (Hemiptera: Auchenorrhyncha). Species of Membracidae known to occur in Australia'. Webpage: http://www.agric.nsw.gov.au/Hort/ascu/leafhop/membrac.htm, Accessed: 16/10/2007.

Fletcher MJ and Lariviere M-C (2005b) 'Identification Keys and Checklists for the leafhoppers, planthoppers and their relatives occurring in Australia (Hemiptera: Auchenorrhyncha). Species of Tribe Athysanini (Cicadellidae, Deltocephalinae) known to occur in Australia and New Zealand'. Webpage: http://www.agric.nsw.gov.au/Hort/ascu/leafhop/athysan.htm, Accessed: 16/10/2007.

Fletcher MJ and Lariviere M-C (2005c) 'Identification Keys and Checklists for the leafhoppers, planthoppers and their relatives occurring in Australia (Hemiptera: Auchenorrhyncha). Species of Tribes Scaphoideini and Scaphytopiini (Cicadellidae: Deltocephalinae) known to occur in Australia'. Webpage: http://www.agric.nsw.gov.au/Hort/ascu/leafhop/scaphoid.htm#Scaphytopiini, Accessed: 16/10/2007.

Fletcher MJ and Lariviere M-C (2006a) 'Identification Keys and Checklists for the leafhoppers, planthoppers and their relatives occurring in Australia (Hemiptera: Auchenorrhyncha). Species of Cercopidae known to occur in Australia'. Webpage: http://www.agric.nsw.gov.au/Hort/ascu/cercopid/cercop.htm, Accessed: 16/10/2007.

Fletcher MJ and Lariviere M-C (2006b) 'Identification Keys and Checklists for the leafhoppers, planthoppers and their relatives occurring in Australia (Hemiptera: Auchenorrhyncha). Subfamily Cicadellinae. Tribe Proconiini. The Glassy-winged Sharpshooter *Homalodisca vitripennis* (Germar)'. Webpage: http://www.agric.nsw.gov.au/Hort/ascu/leafhop/gwss.htm, Accessed: 16/10/2007.

Fletcher MJ and Lariviere M-C (2006c) 'Identification Keys and Checklists for the leafhoppers, planthoppers and their relatives occurring in Australia (Hemiptera: Auchenorrhyncha). Species of Cicadellinae known to occur in Australia'. Webpage: http://www.agric.nsw.gov.au/Hort/ascu/leafhop/cicadell.htm, Accessed: 16/10/2007.

Fletcher MJ and Lariviere M-C (2006d) 'Identification Keys and Checklists for the leafhoppers, planthoppers and their relatives occurring in Australia (Hemiptera: Auchenorrhyncha). Superfamilies Fulgoroidea, Cercopoidea and Membracoidea (Cicadelloidea). Checklists of Australian and New Zealand species'. Webpage: http://www.agric.nsw.gov.au/Hort/ascu/leafhop/taxa.htm, Accessed: 15 September 2006.

Foote RH, Blanc FL, Norrbom AL (1993) Handbook of the Fruit Flies (Diptera: Tephritidae) of America North of Mexico. Comstock Publishing Associates, Ithaca and London.

Foreign Agricultural Service (2005) 'Stone Fruit Situation and Outlook for Selected Countries'. Webpage: http://www.fas.usda.gov/htp/Hort_Circular/2005/08-05/_08-03-05_%20Stone%20Fruit%20Situation%20and%20Outlook.pdf, Accessed: 25/10/2007.

Frances, R. (20 May 2006) Another exotic fruit fly found in Fresno County, Madera Tribune, Madera, California, 20 May 2006.

Garrison RW (2001) 'New agricultural pest for Southern California: Giant Whitefly (*Aleurodicus dugesii*)'. Webpage: http://acwm.co.la.ca.us/pdf/Giantw.pdf, Accessed: 29/10/2007.

Gencsoylu I, Aksit T, Ozer G, Cacamer A, Baspinar N (2006) Population dynamics and damages on shoots and fruits caused by *Grapholita molesta* Busck (Lep.: Tortricidae), *Anarsia lineatella* Zell (Lep.: Gelechiidae) and *Ceratitis capitata* (Wied.) (Dip.: Tephritidae) in some peach varieties. *Asian Journal of Plant Sciences* **5,** 487-491.

Gentry CR, Beroza M, Blythe JL, Bierl BA (1974) Efficacy trials with the pheromone of the oriental fruit moth and data on the lesser appleworm. *Journal of Economic Entomology* **67,** 607-609.

George JA, Davidson TR (1959) Notes on the life-history and rearing of *Colladonus clitellarius* (Say) (Homoptera: Cicadellidae). *Canadian Entomologist* **91,** 376-379.

Gildow F, Damsteegt V, Stone A, Schneider W, Luster D, Levy L (2004) Plum pox in North America: Identification of aphid vectors and a potential role for fruit in virus spread. *Phytopathology* **94,** 868-874.

Gill RJ (1988) The Scale Insects of California Part 1: The Soft Scales (Homoptera: Coccoidea: Coccidae). California Department of Food and Agriculture, Sacramento.

Gill RJ (1997) The Scale Insects of California. Part 3. The Armored Scales (Homoptera: Coccoidea: Coccidae). California Department of Food and Agriculture, Sacramento.

Gispert C, Oldfield GN, Perring TM, Creamer R (1998) Biology of the transmission of peach mosaic virus by *Eriophyes insidiosus* (Acari: Eriophyidae). *Plant Disease* **82,** 1371-1374.

Gispert C, Perring TM, Oldfield GN (1997) Rearing *Eriophyes insidiosus* Keifer and Wilson (Acari: Eriophyoidea), a fastidious bud mite. *International Journal of Acarology* **23,** 227.

Glasa M, Palkovics L, Komínek P, Labonne G, Pittnerová S, Kúdela O, Candresse T, Šubr Z (2004) Geographically and temporally distant natural recombinant isolates of Plum pox virus (PPV) are genetically very similar and form a unique PPV subgroup. *Journal of General Virology* **85,** 2671-2681.

Glasa M, Svanella L, Candresse T (2006) The complete nucleotide sequence of the Plum pox virus El Amar isolate. *Archives of Virology* **151,** 1679-1682.

Gould F (1979) Rapid host range evolution in a population of the phytophagous mite *Tetranychus urticae* Koch. *Evolution* **33,** 791-802.

Government of South Australia (2007) 'Electronic flora of South Australia species fact sheet: Crataegus monogyna *Jacq.*'. Webpage: Web Page: http://www.flora.sa.gov.au/cgi-bin/texhtml.cgi?form=speciesfacts&family=Rosaceae&genus=Crataegus&species=monogyna, Accessed: 11/03/2008.

Grafton-Cardwell EE, Morse JG, O'Connell NV, Phillips PA, Kallsen CE, and Haviland DR (2004) 'UC IPM: UC Management Guidelines for Mealybugs on Citrus'. Webpage: http://ucipm.ucdavis.edu/PMG/r107300511.html, Accessed: 29/10/2007.

Grantham R (2006) 'Oklahoma State University - Information on Insects and Plant Diseases'. Webpage: http://www.ento.okstate.edu/ddd/insects/fscale.htm, Accessed: 29/10/2007.

Grimes EW, Cone WW (1985) Life history, sex attraction, mating, and natural enemies of the grape mealybug, *Pseudococcus maritimus* (Homoptera: Pseudococcidae). *Annals of the Entomological Society of America* **78,** 554-558.

Grove G (1997) New directions in controlling cherry powdery mildew. *The Goodfruit Grower* **48,** 27-32.

Grove GG (1995) Powdery Mildew. In 'Compendium of Stone Fruit Diseases' (Eds JM Ogawa, EI Zehr, GW Bird, DF Ritchie, K Uiru, and JK Uyemoto). The American Phytopathological Society, St. Paul, Minnesota pp. 12-14.

Grove GG (1998) Meteorological factors affecting airborne conidia concentrations and the latent period of *Podosphaera clandestina* on sweet cherry. *Plant Disease* **82,** 741-746.

Grove GG, Boal RJ (1991) Overwinter survival of *Podosphaera clandestina* in Eastern Washington. *Phytopathology* **81,** 385-391.

Guillebeau P, Hinkle N, Roberts P (2006) Summary of losses from insect damage and costs of control in Georgia, 2004.,University of Georgia, Athens.

Gullan PJ (2000) Identification of the immature instars of mealybugs (Hemiptera: Pseudococcidae) found on citrus in Australia. *Australian Journal of Entomology* **39,** 160-166.

Guo L (1999) Survival of *Mucor pyriformis* in soil of apple orchards in California. *Plant Disease* **83,** 189-193.

Gyeltshen J and Hodges A (2005) 'University of Florida: Featured Creatures - *Popillia japonica*'. Webpage: http://creatures.ifas.ufl.edu/orn/beetles/japanese_beetle.htm, Accessed: 29/10/2007.

Halliday RB (1998) Mites of Australia: A Checklist and Bibliography. CSIRO Publishing, Collingwood.

Hallman GJ (2004a) Ionizing **irradiation** quarantine treatment against oriental fruit moth (Lepidoptera: Tortricidae) in ambient and hypoxic atmospheres. *Journal of economic entomology* **97,** 827-927.

Hallman GJ (2004b) Irradiation disinfestation of apple maggot (Diptera: Tephritidae) in hypoxic and low-temperature storage. *Journal of Economic Entomology* **97,** 1245-1248.

Harper JM, Standiford RB, and LeBlanc JW (2000) 'Integrated Hardwood Range Management Program - Filbert Pests in Live Oak'. Webpage: http://danr.ucop.edu/ihrmp/oak19.htm, Accessed: 24/10/2007.

Hazelnut Nursery Propagators (2006) 'The Planting, Growing and Cultivation of Hazelnut Trees in Australia'. Webpage: http://www.hazelnuts.com.au/, Accessed: 14 February 2008.

Helle W, Pijnacker LP (1985) Parthenogenesis, chromosomes and sex. In 'Spider Mites, Their Biology, Natural Enemies and Control' (Eds W Helle and MW Sabelis). Elsevier Science Publishers, Amsterdam, Oxford, New York and Tokyo pp. 129-139.

Hely PC, Pasfield G, Gellatley JC (1982) Insect Pests of Fruit and Vegetables in NSW. Inkata Press, Melbourne and Sydney.

Henderson RC (2001) 'Habitats of New Zealand Soft Scale Insects'. Webpage: http://www.landcareresearch.co.nz/research/biosystematics/invertebrates/softscales/, Accessed: 25/10/2007.

Hendson M, Purcell AH, Smart C, Guilhabert C, Kirkpatrick B (2001) Genetic diversity for Pierce's disease strains and other pathotyppes of *Xylella fastidiosa*. *Applied and Environmental Microbiology* **67,** 895-903.

Henry Doubleday Research Association (2007) 'Powdery Mildew - Factsheet DC15'. Webpage: http://www.gardenorganic.org.uk/factsheets/dc15.php, Accessed: 23/10/2007.

Hernandez-Martinez R, de la Cerda KA, Costa HS, Cooksey DA, Wong FP (2007) Phylogenetic relationships of *Xylella fastidiosa* strains isolated from landscape ornamentals in Southern California. *Phytopathology* **97,** 857-864.

Hill BL, Purcell AH (1995) Acquisition and retention of *Xylella fastidiosa* by an efficient vector, *Graphocephala atropunctata*. *Phytopathology* **85,** 209-212.

Hoddle MS, Mound LA, Nakahara S (2004) Thysanoptera recorded from California, USA: A Checklist. *Florida Entomologist* **87,** 317-323.

Hoerner JL, List GM (1952) Controlling Cherry Fruitworm in Colorado. *Journal of Economic Entomology* **45,** 800-805.

Hollingsworth CS (2007) 'Pacific Northwest Insect Management Handbook Online'. Webpage: http://pnwpest.org/pnw/insects, Accessed: 29/10/2007.

Hollis D and Eastop VF (2005) 'Australian Faunal Directory. Hemiptera Aphidoidea. Aphids, Greenflies'. Webpage: http://www.environment.gov.au/cgi-bin/abrs/fauna/details.pl?pstrVol=APHIDOIDEA;pstrTaxa=1;pstrChecklistMode=1, Accessed: 16/10/2007.

Hong CX, Michailides TJ (2000) Mycoflora of stone fruit mummies in California orchards. *Plant Disease* 417-422.

Hoover GA (2002a) 'Pear Thrips in Pennsylvania - Penn State Entomology Department Fact Sheet'. Webpage: http://www.ento.psu.edu/extension/factsheets/pear_thrips.htm, Accessed: 24/10/2007.

Hoover GA (2002b) 'Yellownecked caterpillar *Datana ministra* (Drury)'. Webpage: http://www.ento.psu.edu/extension/factsheets/yelloweckcat.htm, Accessed: 29/10/2007.

Hoover GA (2003) 'Penn State University - Entomological Notes, Periodical Cicada'. Webpage: http://www.ento.psu.edu/extension/factsheets/pdfs/periodicalCicada.pdf, Accessed: 29/10/2007.

Hopkins DL (1989) *Xylella fastidiosa*: Xylem-limited bacterial pathogen of plants. *Annual Review of Phytopathology* **27,** 271-290.

Hopkins DL, Purcell AH (2002) *Xylella fastidiosa* : cause of Pierce's disease of grapevine and other emergent diseases. *Plant Disease* **86,** 1056-1066.

Horticulture Australia Limited (2003) 'Australian Apples'. Webpage: Web Page: http://www.apal.org.au/assets/content/3122/Aust-Apple-Information-Chart.pdf, Accessed: 06/03/08.

HortResearch (1999) 'BugKEY: Insects and Mites of Pipfruit and Stonefruit'. Webpage: Web Page: http://www.hortnet.co.nz/key/pipfruit.htm,

HortResearch (2007) 'BugKEY: Insects and mites of pipfruit and stone fruit'. Webpage: http://www.hortnet.co.nz/key/pipfruit.htm, Accessed: 06/07/2007.

Howell JF (1991) Reproductive Biology. In 'Tortricid Pests: Their Biology, Natural Enemies and Control' (Eds LPS van der Geest and HH Evenhuis). Elsevier Science Publishers, Amsterdam, Oxford, New York and Tokyo pp. 157-174.

Howell JF, Schmidt RS (2002) Codling moth (Lepidoptera: Tortricidae): Development at constant and at orchard temperatures. *Journal of Agricultural and Urban Entomology* **19,** 15-23.

Hoy LE, Whiting DC (1997) Low-temperature storage as a postharvest treatment to control *Pseudococcus affinis* (Homoptera: Pseudococcidae) on Royal Gala apples. *Journal of Economic Entomology* **90,** 1377-1381.

Hubbard JL, Potter DA (2002) 'Biology and Management of Calico Scale, a Severe Pest of Trees in Kentucky', 2002 Nursery and Landscape Program Research Report,Kentucky Agricultural Experiment Station, University of Kentucky, Levington.

Hughes J, Dorn S (2002) Sexual differences in the flight performance of the oriental fruit moth, *Cydia molesta*. *Entomologia Experimentalis et Applicata* **103,** 171-182.

Hughes KM (1976) Notes on the nuclear polyhedrosis viruses of tussock moths of the genus *Orgyia* (Lepidoptera). *Canadian Entomologist* **108,** 479-484.

INRA (2006) 'HYPP Zoology. *Agriotes lineatus* (L.) Click beetle, Striped elaterid beetle'. Webpage: http://www.inra.fr/hyppz/RAVAGEUR/6agrlin.htm, Accessed: 16/10/2007.

International Atomic Energy Agency (2003) Trapping Guidelines for Area-Wide Fruit-Fly Programmes,Insect Pest Control Section, International Atomic Energy Agency, Vienna.

Jaffee BA, Nyczepir AP, Golden AM (1987) *Criconemella* spp. in Pennsylvania peach orchards with morphological observations of *C. curvata* and *C. ornata*. *Journal of Nematology* **19,** 420-423.

James D, Varga A, Thompson D, Hayes S (2003) Detection of a new and unusual isolate of Plum pox virus in plum (*Prunus domestica*). *Plant Disease* **87,** 1119-1124.

Jock S, Rodoni B, Gillings M, Kim WS, Copes C, Merriman P, Geider K (2000) Screening of ornamental plants from the Botanic Gardens of Melbourne and Adelaide for the occurrence of *Erwinia amylovora*. *Australian Journal of Plant Pathology* **29,** 120-128.

Johanns M (2007) Declaration of Extraordinary Emergency Because of Plum Pox Virus, Docket APHIS-2007-0065. Office of the Federal Register, National Archives and Records Administration, Washington D.C.

Jones AL (1995) Cherry Leaf Spot. In 'Compendium of Stone Fruit Diseases' (Eds JM Ogawa, EI Zehr, GW Bird, DF Ritchie, K Uiru, and JK Uyemoto). The American Phytopathological Society, St. Paul, Minnesota pp. 21-22.

Jones DR (2005) Plant viruses transmitted by thrips. *European Journal of Plant Pathology* **113,** 119-157.

Jones VP, Eastburn CC, Wilburn TD, Brunner JF (2005) Instar-specific phenology of *Pandemis pyrusana* and *Choristoneura rosaceana* (Lepidoptera: Tortricidae) in Washington apple orchards. *Journal of Economic Entomology* **98,** 875-883.

Jridi C, Martin J-F, Marie-Jeanne V, Labonne G, Blanc S (2006) Distinct viral populations differentiate and evolve independently in a single perennial host plant. *Journal of Virology* **80,** 2349-2357.

Kasana A, AliNiazee MT (1994) Effect of constant temperatures on development of the walnut husk fly, *Rhagoletis completa*. *Entomologia Experimentalis et Applicata* **73,** 247-254.

Kearns D, Wright G, Loghry J (2004) Omnivorous leafroller (*Platynota stultana*). In 'Citrus Arthropod Pest Management in Arizona' (Ed. A Fournier). The University of Arizona, College of Agriculture, Tuscon.

Keitt GW, Blodgett EC, Wilson EE, Magie RO (1937) The epidemiology and control of cherry leaf spot. *Wisconsin Research Bulletin* **132,** 1-117.

Kennedy GG, Smitley DR (1985) Dispersal. In 'Spider Mites, Their Biology, Natural Enemies and Control' (Eds W Helle and MW Sabelis). Elsevier Science Publishers, Amsterdam, Oxford, New York and Tokyo pp. 233-242.

Ker KW and Walker GM (1990) 'Scale Insect Pests of Tree Fruit'. Webpage: http://www.omafra.gov.on.ca/english/crops/facts/90-120.htm, Accessed: 24/10/2007.

Khairi SM, Preece TF (1975) *Podosphaera clandestina*. *CMI Descriptions of Pathogenic Fungi and Bacteria* **478**.

Kosztarab M (1963) The armored scale insects of Ohio (Homoptera: Coccoidea: Diaspididae). *Bulletin of the Ohio Biological Survey (New Series)* **2,** 1-120.

Kosztarab M (1990) Economic Importance. In 'Armoured Scale Insects, Their Biology, Natural Enemies and Control' (Ed. D Rosen). Elsevier Science Publishers, Amsterdam pp. 307-311.

Kosztarab M (1996) Scale Insects of North-Eastern North America. Identification, Biology, and Distribution. Virginia Museum of Natural History, Martinsville.

Koteja J (1990) Life history. In 'Armored Scale Insects: Their Biology, Natural Enemies and Control' (Ed. D Rosen). Elsevier Science Publishers, Amsterdam pp. 243-254.

Krainacker DA, Carey JR (1990) Ambulatory dispersal and life history response to food deprivation in twospotted spider mites . *Entomologia Experimentalis et Applicata* **56,** 139-144.

Kumm S (2002) Reproduction, progenesis, and embrogenesis of thrips (Thysanoptera, Insecta). 'Thesis for Doktor rerum naturalium,' Mathematisch-Naturwissenschaftlich-Technischen Fakultät, der Martin-Luther-Universität Halle-Wittenberg.

Labonne G, Yvon M, Quiot JB, Avinent L, Llacer G (1995) Aphids as potential vectors of plum pox virus: comparison of methods of testing and epidemiological consequences. *Acta Horticulturae* **386,** 207-218.

Lacey LA, Arthurs SP, Unruh TR, Headrick H, Fritts Jr R (2006) Entomopathogenic nematodes for control of codling moth (Lepidoptera: Tortricidae) in apple and pear orchards: Effect of nematode species and seasonal temperatures, adjuvants, application equipment, and post-application irrigation. *Biological Control* **37,** 214-223.

LaGasa EH, Vernon B, Wraspir J, Hertzog P, Kamping H (2001) 2000 Western Washington Exotic Wireworm Survey, a Preliminary Detection and Delimiting Survey for *Agriotes obscurus* and *A. lineatus* (Coleoptera: Elateridae), WSDA PUB 047 (N/1/01). Washington State Department of Agriculture, Olympia.

Levy L, Damsteegt V, Welliver R (2000) First report of plum pox virus (Sharka disease) in *Prunus persica* in the United States. *Plant Disease* **84,** 202.

Lewis T (1973) Thrips: Their Biology, Ecology and Economic Importance. Academic Press, London and New York.

Lewis T (1997) Thrips as Crop Pests. CAB International, Wallingford.

Li WB, Pria WD, Lacava PM, Qin X, Hartung JS (2003) Presence of *Xylella fastidiosa* in sweet orange fruit seeds and its transmission to seedlings. *Phytopathology* **93,** 953-958.

Liang AP, Fletcher MJ (2002) Morphology of the antennal sensilla in four Australian spittlebug species (Hemiptera: Cercopidae) with implications for phylogeny. *Australian Journal of Entomology* **41,** 39-44.

Little S (1987) *Cercospora circumscissa*. In 'IMI Descriptions of Fungi and Bacteria' CAB International, Wallingford.

Llacer G (2006) Hosts and symptoms of plum pox virus: herbaceous hosts. *Bulletin OEPP/EPPO Bulletin* **36,** 227-228.

Lorenz III GM, Johnson DR, Edmund R, Fisher A, Page L, Hopkins JD (2000) Management of the tarnished plant bug, *Lygus lineolaris*, with traditional and new insecticides. In 'Proceedings of the Beltwide Coton Conference.' pp. 954-955.

Lott TB, Keane FWL (1960) Twisted leaf and ring pox viruses found in Choke-cherries near diseased orchards. Twisted leaf virus indigenous in Chokecherry. Some seedlings of the Van Cherry found to be superior to Bing as indicators for the twisted leaf virus. *Plant Disease Reporter* **44,** 331.

Luck J, van Rijswijk B, and Williamson V (2002) 'Post-entry quarantine protocols for host plants of *Xylella fastidiosa:* National awareness and response strategy for Pierce's Disease'. Webpage: Web Page: http://www.gwrdc.com.au/downloads/ResearchTopics/DNR%2001-01.pdf, Accessed: 11/03/2008.

López-Moya JJ, Fernández-Fernández MR, Cambra M, García JA (2000) Biotechnological aspects of plum pox virus. *Journal of Biotechnology* **76,** 121-136.

Mallampalli N, Isaacs R (2002) Distribution of egg and larval populations of cranberry fruitworm (Lepidoptera: Pyralidae) and cherry fruitworm (Lepidoptera: Tortricidae) in highbush blueberries. *Environmental Entomology* **31,** 852-858.

Manachini B, Casati B, Aliverti I, Cinanni L (2004) Transission of PPV-M to *Prunus persica* by *Brachycaudus schwartzi* and *Phorodon humili* (Hem., Aphididae). *Journal of Applied Entomology* **128,** 677-680.

Mantey KD, Moffitt HR, Neven LG (2000) Laboratory rearing of lesser appleworm (Lepidoptera: Tortricidae). *Journal of Economic Entomology* **93,** 1021-1024.

Martin JH and Gillespie PS (2001) 'Australian Faunal Directory. Hemiptera Aleyrodoidea. White Flies'. Webpage: http://www.environment.gov.au/cgi-bin/abrs/fauna/details.pl?pstrVol=ALEYRODOIDEA;pstrTaxa=1;pstrChecklistMode=1, Accessed: 16/10/2007.

May TW, Milne J, Shingles S, and Jones RH (2003) Catalogue and bibliography of Australian Fungi Part 2. Basidiomycota p.p. & Myxomycota p.p. Fungi of Australia Volume 2B. ABRS & CSIRO Melbourne, Australia.

May TW, Wood AE (1997) Fungi of Australia. Volume 2A: Catalogue and Bibliography of Australian Macrofungi 1. Basidiomycota p.p. CSIRO Publishing, Collingwood, Australia.

McClure MS (1990) Seasonal history. In 'Armoured Scale Insects, Their Biology, Natural Enemies and Control' (Ed. D Rosen). Elsevier Science Publishers, Amsterdam pp. 315-318.

McDonald JR, Bale JS, Walter KFA (1997) Rapid cold hardening in the Western Flower Thrips *Frankliniella occidentalis*. *Journal of Insect Physiology* **43,** 759-766.

McDonald JR, Head J, Bale. J.S., Walters KFA (2000) Cold tolerance, overwintering and establishment potential of *Thrips palmi*. *Physiological Entomology* **25,** 159-166.

McElfresh JS, Millar JG (1993) Establishment and rearing of *Anarsia lineatella* (Lepidoptera: Gelechiidae) on a meridic diet. *Journal of Economic Entomology* **86,** 1399-1404.

McKenry M, Buzo T, Kaku S (1995) First-year evaluation of tree and vine growth and nematode development following 17 pre-plant treatments. *Kearney Plant Protection Group, Plant Protection Quarterly* **5,** 2-3 .

McKenry MV (1989) Damage and development of several nematode species in a plum orchard. *Applied Agricultural Research* **4,** 10-14.

McKenry MV (1991) Marigolds and Nematode management. *Kearney Plant Protection Group, Plant Protection Quarterly* **1,** 1-5 .

McLaren GF, Grandison G, Wood GA, Tate G, Horner I (1999) Summerfruit in New Zealand. HortResearch, AGMARDT/Summerfruit New Zealand Inc, University of Otago Press, Dunedin.

McLaren GF and Walker AK (1998) 'HortFACT - New Zealand Flower Thrips Life Cycle'. Webpage: http://www.hortnet.co.nz/publications/hortfacts/hf401053.htm, Accessed: 24/10/2007.

McLeod R, Reay F, Smyth J (1994) Plant Nematodes of Australia Listed by Plant and by Genus,NSW Agriculture and Rural Industries Research and Development Corporation, Sydney.

McManus PS, Proffer TJ, Berardi R, Gruber BR, Nugent JE, Ehret GR, Ma ZH, Sundin GW (2007) Integration of copper-based and reduced-risk fungicides for control of *Blumeriella jaapii* on sour cherry. *Plant Disease* **91,** 294-300.

Mead FW (2004) 'Citrus Flatid Planthopper - *Metcalfa pruniosa* (Say)'. Webpage: http://creatures.ifas.ufl.edu/orn/shrubs/citrus_flatid_planthopper.htm, Accessed: 29/10/2007.

Meagher RLJ, Hull LA (1986) Techniques to measure azinphosmethyl resistance in *Platynota idaeusalis* (Lepidoptera: Tortricidae). *Journal of Economic Entomology* **79,** 1130-1133.

Merrifield K (2000) 'Biology, Host Ranges, and Damage Levels of Root-parasitic Nematodes on Oregon Nursery Crops (Draft)'. Webpage: http://mgd.nacse.org/hyperSQL/squiggles/other/NurseryDamage.html, Accessed: 21/02/2006.

Michailides TJ, Morgan DP, Day KR (2004) First report of sour rot of California peaches and nectarines caused by yeasts. *Plant Disease* **88,** 222.

Miller D and Ben-Dov Y (2006) 'ScaleNET'. Webpage: http://www.sel.barc.usda.gov/scalenet/scalenet.htm, Accessed: 2006.

Miller DR, Davidson JA (2005) Armored Scale Insect Pests of Trees and Shrubs (Hemiptera: Diaspididae). Cornell University Press, Ithaca.

Miller DR, Miller GL, Watson GW (2002) Invasive species of mealybugs (Hemiptera: Pseudococcidae) and their threat to U.S. agriculture. *Proceedings of the Entomological Society of Washington* **104,** 825-836.

Miller SE, Hodges RW (1995) *Platynota stultana*, the omnivorous leaf-roller, established in the Hawaiian Islands (Lepidoptera: Tortricidae). *Records of the Hawaii Biological Survey* **42,** 36.

Mizell RF (2005) Stink Bugs and Leaffooted Bugs are Important Fruit, Nut, Seed and Vegetable Pests, ENY-718. University of Florida, IFAS Extension, Gainesville.

Mizell RF, Andersen PC, Tipping C, and Brodbeck B (2003) '*Xylella fastidiosa* Diseases and Their Leafhopper Vectors'. Webpage: http://edis.ifas.ufl.edu/in174, Accessed: 17/10/2007.

Mohan SK Natural incidence of shoot blight in Pluot® caused by *Erwinia amylovora* . In '11th International Workshop on Fire Blight: Workshop Program' Acta Horticulturae ISHS, p. 64.

Mohan SK, Thomson SV (1996) An outbreak of fire blight in plums. In 'Acta Horticulturae (ISHS)' pp. 73-76.

Moorman G (2005) 'Plant Disease Facts. Powdery Mildew'. Webpage: http://www.ppath.cas.psu.edu/EXTENSION/PLANT_DISEASE/pmildew.html, Accessed: 20/6/2006.

Moorman GW (2002) 'Plant Disease Facts - Powdery Mildew '. Webpage: http://www.ppath.cas.psu.edu/extension/plant_disease/pdf%20Misc/Powdery%20mildew.pdf, Accessed: 17/10/2007.

Morgan CVG, Angle BJ (1968) Notes on the habits of the San Jose scale and the European fruit scale (Homoptera: Diaspididae) on harvested apples in British Columbia. *Canadian Entomologist* **100,** 499-503.

Morris MG (1997) Broad-nosed Weevils. Coleoptera: Curculionidae (Entiminae). Royal Entomological Society, Devon.

Morse JG, Hoddle MS (2006) Invasion biology of thrips. *Annual Review of Entomology* **51,** 67-89.

Moulds MS and Cowan S (2004) 'Australian Faunal Directory. Hemiptera Cicadoidea: Cicadidae. Cicadas'. Webpage: http://www.environment.gov.au/cgi-bin/abrs/fauna/details.pl?pstrVol=CICADOIDEA;pstrTaxa=1;pstrChecklistMode=1, Accessed: 16/10/2007.

Mound L (2005a) 'Pear thrips (*Taeniothrips inconsequens*) Pest and Disesases Image Library'. Webpage: http://www.padil.gov.au/viewPestDiagnosticImages.aspx?id=245, Accessed: 29/10/2007.

Mound LA (2005b) Thysanoptera: diversity and interactions. *Annual Review of Entomology* **50,** 247-269.

Mound LA, Gillespie P (1997) Identification Guide to Thrips Associated with Crops in Australia. NSW Agriculture, Orange.

Mueller SC, Summers CG, and Goodell PB (2003) 'A field key to the most common *Lygus* species found in the agronomic crops of the central San Joaquin Valley of California'. Webpage: Web Page: http://lygus.uckac.edu/PDF/ANR%208104.pdf, Accessed: 11/03/2008.

Mueller SC, Summers CG, Goodell PB (2005) Composition of *Lygus* species found in selected agronomic crops and weeds in the San Joaquin Valley, California. *Southwestern Entomologist* **30,** 121-127.

Mukerji KG (1968) Podosphaera tridactyla. *CMI Descriptions of Pathogenic Fungi and Bacteria* **187**.

Myrta A, Di Terlizzi B, Savino V (1998) Study on the transmission of plum pox potyvirus through seeds. *Phytopathologia Meditteranea* **37,** 41-44.

Myrta A, Varga A, James D (2006) The complete genome sequence of an El Amar isolate of plum pox virus (PPV) and its phylogenetic relationship to other PPV strains. *Archives of Virology* **151,** 1189-1198.

Nakahara S (1982) Checklist of the armored scales (Homoptera: Diaspididae) of the Conterminous United States,Animal & Plant Health Inspection Service, U.S. Department of Agriculture, Hoboken.

National Agriculture Statistics Service (2007) Noncitrus Fruits and Nuts 2006 Summary, Fr Nt 1-3 (07). Noncitrus Fruits and Nuts 2006 Summary,

Nemchinov L, Hadidi A (1996) Characterization of the sour cherry strain of plum pox virus. *Phytopathology* **86,** 575-580.

Neven LG (2004) Effects of low temperature on egg and larval stages of the lesser appleworm (Lepidoptera: Tortricidae). *Journal of Economic Entomology* **97,** 820-823.

Neven LG, Mantey KD (2004) Biology and development of the wild and golden sport of *Grapholita prunivora* (Lepidoptera: Tortricidae). *Environmental Entomology* **33,** 506-512.

New Zealand Ministry of Agriculture and Forestry (2000) 'Import Health Standard Commodity Sub-class: Fresh Fruit/Vegetables Peach and Nectarine, *Prunus persica, P. persica* var. *nucipersica* from the United States of America - State of California '. Webpage: http://www.biosecurity.govt.nz/files/imports/plants/standards/peach-nectarine-us-ca.pdf, Accessed: 24/10/2007.

Newman KL, Almeida RPP, Purcell AH, Lindow SE (2004) Cell-cell signalling controls *Xylella fastidiosa* interactions with both insects and plants. *Proceedings of the National Academy of Sciences of the United States of America* **101,** 1737-1742.

Nielsen ES, Edwards ED, Rangsi TV (1996) Checklist of the Lepidoptera of Australia. In 'Monographs on Australian Lepidotera' CSIRO Publishing, Melbourne pp. xiv, 529.

Norrbom AL (2003) 'The Diptera Site: *Anastrepha striata* Schiner'. Webpage: http://www.sel.barc.usda.gov/diptera/tephriti/Anastrep/striata.htm, Accessed: 24 August 2006.

Norrbom AL (2004) 'Genus Rhagoletotrypeta (Diptera: Tephritidae).'. Webpage: http://www.sel.barc.usda.gov/diptera/tephriti/Rhagtryp/Rhagtryp.htm, Accessed: 29/10/2007.

Nucifora A, Vacante V (2004) Citrus mites in Italy. VII. The family tarsonemidae. Species collected and notes on ecology. *Acarologia* **44,** 49-67.

Nur U (1990) Parthenogenesis. In 'Armoured Scale Insects: Their Biology, Natural Enemies and Control' (Ed. D Rosen). Elsevier Science Publishers, Amsterdam pp. 191-197.

Nyczepir AP (1991) Nematode management strategies in stone fruits in the United States. *Journal of Nematology* **23,** 334-341.

Nyczepir AP, Halbrendt JM (1993) Nematode pests of deciduous fruit and nut trees. In 'Plant Parasitic Nematodes in Temperate Agriculture' (Eds K Evans, DL Trudgill, and JM Webster). CAB International, Wallingford pp. 381-425.

Nyland G, Thomas HE (1959) A new strain of ring pox virus in Royal Apricot. *Phytopathology* **49,** 338-339.

Németh M (1986) Virus, Mycoplasma and Rickettsia Disease of Fruit Trees. Martinus Nijhoff Publishers, Dordrecht, Boston and Lancaster.

Németh M (1994) History and importance of plum pox in stone-fruit production. *Bulletin OEPP/EPPO Bulletin* **24,** 525-536.

Oehlke B (2006) 'Antheraea Polyphemus: Larval Food Plants'. Webpage: http://www3.pei.sympatico.ca/oehlkew/public_html/xpollarv.htm, Accessed: 16 June 2006.

Oejlke B (2006) '*Sphinx drupiferanum*, The wild cherry sphinx'. Webpage: http://www.silkmoths.bizland.com/ssdrupif.htm, Accessed: 29/10/2007.

Ogawa JM, Zehr EI, Bird GW, Ritchie DF, Uriu K, Uyemoto JK (1995) Compendium of Stone Fruit Diseases. APS Press, St Paul.

Ohlendorf B (2000) 'Spider Mites Management Guidelines--UC IPM'. Webpage: http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7405.html, Accessed: 15/10/2007.

Oklahoma State University EaPP (2007) 'Forbes Scale, *Quadraspidiotus forbesi*'. Webpage: http://www.ento.okstate.edu/ddd/insects/fscale.htm, Accessed: 24/10/2007.

Oldfield GN (1970) Mite transmission of plant viruses. *Annual Review of Entomology* **15,** 343-380.

Olmos A, Bertolini E, Gil M, Cambra M (2005) Real-time assay for quantitative detection of non-persistently transmitted Plum pox virus RNA targets in single aphids. *Journal of Virological Methods* **128,** 151-155.

Olsen J (2006) 'Plum and Prune Pests'. Webpage: http://pnwpest.org/pnw/insects, Accessed: 29/10/2007.

Olsen JL (2002) Oregon State University's integrated pest management program for the Oregon hazelnut industry. *HortTechnology* **12,** 623-625.

Ontario Ministry of Agriculture and Food (2004) 'Scouting Corner'. Webpage: http://www.omafra.gov.on.ca/english/crops/hort/news/hortmatt/2004/13hrt04.pdf, Accessed: 29/10/2007.

Opler PA, Pavulaan H, Stanford RE, and Pogue M (2006) 'Butterflies and Moths of North America'. Webpage: http://www.butterfliesandmoths.org/, Accessed: 16/10/2007.

Opp S, Zermeno J, Wilkerson C, and Durbin M (2003) 'Flight capacity and dispersal of walnut husk flies ini laboratory and field trials.'. Webpage: Web Page: http://walnutresearch.ucdavis.edu/2003/2003_203.pdf, Accessed: 06/03/08.

Oregon State University (2005) 'Codling Moth Information Support System: Natural Enemies of Codling Moth and Leafrollers of Pome and Stone Fruits'. Webpage: http://www.ippc.orst.edu/codlingmoth/biocontrol/natural/, Accessed: 08/02/2006.

Osborne LS (2000) 'Mealybugs'. Webpage: Web Page: http://mrec.ifas.ufl.edu/lso/Mealybugs.htm, Accessed: 27/02/2008.

Pasquini G, Barba M (1996) Plum Pox potyvirus strains: an overview. In 'Proceedings of the Middle European Meeting '96 on Plum Pox.' Plant Health and Soil Conservation Station of the Ministry of Agriculture, Budapest.

Pasquini G, Simeone AM, Conte L, Barba M (2000) RT-PCR evidence of the non-transmission through seed of Plum pox virus strains D and M. *Journal of Plant Pathology* **82,** 221-226.

PDI (2003) Pest and Disease Information Database - Pest Interception Records up to 31 December 2002. . Australian Government Department of Agriculture Fisheries and Forestry, Canberra

Pfeiffer D (2003) 'Plum Pox or Sharka Virus (PPV)'. Webpage: http://www.ento.vt.edu/Fruitfiles/plumpox.html, Accessed: 24/10/2007.

Pfeiffer DG, Killian JC (1988) Disruption of olfactory communication in Oriental fruit moth and lesser appleworm in a Virginia peach orchard. *Journal of Agricultural Entomology* **5,** 235-241.

Pickel C, Benlety WJ, Hasey JK, and Day KR (2006a) 'UC IPM: UC Management Guidelines for Prune Limb Borer and American Plum Borer on Peach'. Webpage: http://ipm.ucdavis.edu/PMG/r602300911.html, Accessed: 17/10/2007.

Pickel C, Bentley WJ, Hasey JK, and Day KR (2006b) 'UC IPM: UC Management for Pacific Flatheaded Borer on Peach'. Webpage: http://ipm.ucdavis.edu/PMG/r602300811.html, Accessed: 29/10/2007.

Pickel C, Bentley WJ, Hasey JK, and Day KR (2006c) 'UC IPM: UC Management Guidelines for Katydids on Peach'. Webpage: http://www.ipm.ucdavis.edu/PMG/r602301111.html, Accessed: 15/10/2006.

Pickel C, Bentley WJ, Hasey JK, and Day KR (2006d) 'UC IPM: UC Management Guidelines for Omnivorous Leafroller on Peach'. Webpage: http://www.ipm.ucdavis.edu/PMG/r602301011.html, Accessed: 15/10/2007.

Pickel C, Bentley WJ, Hasey JK, and Day KR (2006e) 'UC IPM: UC Management Guidelines for Peach Twig Borer on Peach'. Webpage: http://ipm.ucdavis.edu/PMG/r602300611.html, Accessed: 15/10/2007.

Pickel C, Bentley WJ, Hasey JK, and Day KR (2006f) 'UC IPM: UC Management Guidelines for Stink Bugs on Peach'. Webpage: http://www.ipm.ucdavis.edu/PMG/r602300111.html, Accessed: 24/10/2007.

Pickel C, Bentley WJ, Hasey JK, Day KR, and Rice RE (2006g) 'UC IPM: UC Management Guidelines for Plant Bugs on Peach'. Webpage: http://www.ipm.ucdavis.edu/PMG/r602300511.html, Accessed: 22/10/2007.

Pickel C, Niederholzer FJA, Olsen WH, Zalom FG, Buchner RP, and Krueger WH (2006h) 'UC IPM: UC Management Guidelines for Cankerworms on Prune'. Webpage: http://www.ipm.ucdavis.edu/PMG/r606301411.html, Accessed: 24/10/2007.

Pickel C, Niederholzer FJA, Olson WH, Zalom FG, Buchner RP, and Krueger WH (2006i) 'UC IPM: UC Management Guidelines for Branch and Twig Borer on Prune'. Webpage: http://www.ipm.ucdavis.edu/PMG/r606302611.html, Accessed: 14/06/2006.

Pickel WJ, Bentley WJ, Hasey JK, Day KR, and Rice RE (2006j) 'UC IPM: UC Management Guidelines for Webspinning Spider Mites on Peach'. Webpage: http://ipm.ucdavis.edu/PMG/r602400111.html, Accessed: 15/10/2007.

Pickett CH, Coutinot D, Hoelmer KA, Kuhlmann U (2005) Establishment of *Peristenus* spp. in northern California for the control of *Lygus* spp. In '2nd International Symposium on Biological Control of Arthropods.' (Ed. MS Hoddle) pp. 116-125. USDA Forest Service, Riverside.

Pine TS (1966) Apricot ring pox in foreign apricot varieties. *Plant Disease Reporter* **50,** 289-291.

Poe SR (2002) 'Background for the plum pox virus national surveillance program'. Webpage: http://ceris.purdue.edu/napis/pests/ppox/survey/ppv00-survey.html, Accessed: 24/10/2007.

Poole MC (2006) An Annotated Catalogue of Insect and Allied Species of Economic Significance or of Potential Export Quarantine Concern for Western Australian Primary and Related Industries.,Department of Agriculture, Perth.

Powell JA (1983) Expanding geographical and ecological range of *Platynota stultana* in California (Lepidoptera: Tortricidae). *Pan-Pacific Entomologist* **59,** 233-239.

Prado EC (1991) Arthropods and the Natural Enemies Associated with Plants Cultivated in Chile. Instituto de Investigaciones Agropecuarias, Chile.

Prokopy RJ, Papaj DR (2000) Behaviour of Flies of the Genera *Rhagoletis*, *Zonosemata*, and *Carpomyina* (Trypetinae: Carpomyina). In 'Fruit Flies (Tephritidae): Phylogeny and Evolution of Behaviour' (Eds M Aluja and AL Norrbom). CRC Press LLC, Boca Raton pp. 219-252.

Provencher LM, Geoffrey EM, Andrew RW, Benjamin BN (2005) Parthenogenesis in the *Aspidiotus nerii* complex (Hemiptera: Diaspididae): A single origin of a worldwide, polyphagous lineage associated with *Cardinium* bacteria. *Annals of the Entomological Society of America* **98,** 629-635.

Pscheidt JW (2007) 'Information on Cherry Leaf Spot, An online guide to Plant Disease Control, Oregon State University'. Webpage: http://plant-disease.ippc.orst.edu/disease.cfm?RecordID=282, Accessed: 24/10/2007.

Purcell AH, Hopkins DL (1996) Fastidious xylem-limited bacterial plant pathogens. *Annual Review of Phytopathology* **34,** 131-151.

Rabbinge R (1985) Aspects of damage assesment. In 'Spider Mites, Their Biology, Natural Enemies and Control' (Eds W Helle and MW Sabelis). Elsevier Science Publishers, Amsterdam, Oxford, New York and Tokyo pp. 261-272.

Rancourt B, Vincent C, De Oliveira D (2000) Circadian activity of *Lygus lineolaris* (Hemiptera: Miridae) and effectiveness of sampling techniques in strawberry fields. *Journal of Economic Entomology* **93,** 1160-1166.

Redak RA, Purcell AH, Lopes JRS, Blua MJ, Mizell RF, Anderson PC (2004) The biology of xylem fluid feeding insect vectors of *Xylella fastidiosa* and their relation to disease epidemiology. *Annual Review of Entomology* **49,** 243-270.

Rees D, Van Schagen J, Postle T (2001) Farmnote No. 9/95 European Earwigs Threaten High-Yield Crops. Department of Agriculture, Perth.

Reid CAM (2006) 'Australian Faunal Directory. Coleoptera: Chrysomeloidea: Chrysomelidae'. Webpage: http://www.environment.gov.au/cgi-bin/abrs/fauna/details.pl?pstrVol=CHRYSOMELOIDEA;pstrTaxa=1;pstrChecklistMode=1, Accessed: 16/10/2007.

Rentz DCF (2006) 'Australian Faunal Directory. Orthoptera. Grasshoppers, locusts'. Webpage: http://www.environment.gov.au/cgi-bin/abrs/fauna/details.pl?pstrVol=ORTHOPTERA;pstrTaxa=1;pstrChecklistMode=1, Accessed: 17/10/2007.

Rice RE, Jones RA, Hoffman ML (1976) Seasonal Fluctuations in Phytophagous and Predaceous Mit Populations on Stonefruit in California. *Environmental Entomology* **5,** 557-564.

Rieske LK, Raffa KF (2003) Evaluation of visual and olfactory cues for sampling three *Thrips* species (Thysanoptera: Thripidae) in deciduous forests of the northern United States. *Journal of Economic Entomology* **96,** 777-782.

Rings RW (1968) Contributions to the bionomics of the pyramidal fruitworm, *Amphipyra pyramidoides*. *Journal of Economic Entomology* **61,** 174-179.

Rings RW (1970) Contributions to the bionomics of the green fruitworms: the life history of *Orthosia hibisci*. *Journal of Economic Entomology* **63,** 1562-1568.

Rings RW (1973) Contributions to the bionomics of green fruitworms: the life history of *Lithophane antennata*. *Journal of Economic Entomology* **66,** 364-368.

Roberts WP, Proctor JR, Phillips JHH (1978) Effect of constant temperatures on the number of larval instars of the Oriental fruit moth, *Grapholitha molesta* (Lepidoptera: Tortricidae). *Canadian Entomologist* **110,** 623-626.

Roelofs W, Kochansky J, Anthon E, Rice R, Carde R (1975) Sex pheromone of the peach twig borer moth (*Anarsia lineatella*). *Environmental Entomology* **4,** 580-582.

Roelofs WL, Carde RT (1974) Oriental fruit moth and lesser appleworm attractant mixtures refined. *Environmental Entomology* **3,** 586-588.

Roelofs WL, Comeau A, Selle R (1969) Sex pheromone of the oriental fruit moth. *Nature* **224,** 723.

Rohrbach KG, Beardsley JW, German TL, Reimer NJ, Sanford WG (1988) Mealybug wilt, mealybugs and ants on pineapple. *Plant Disease* **72,** 558-565.

Rosen D (1990) Armored Scale Insects: Their Biology, Natural Enemies and Control. Elsevier Science Publishers, Amsterdam, Oxford, New York and Tokyo.

Rothschild GHL, Vickers RA (1991) Biology, ecology and control of the oriental fruit moth. In 'Tortricid Pests: Their Biology, Natural Enemies and Control' (Eds LPS van der Geest and HH Evenhuis). Elsevier Science Publishers, Amsterdam, Oxford, New York and Tokyo pp. 389-412.

Roy M, Brodeur J, Cloutier C (2005) Seasonal activity of the spider mite predators *Stethorus punctillum* (Coleoptera: Coccinellidae) and *Neoseiulus fallacis* (Acarina: Phytoseiidae) in raspberry, two predators of *Tetranychus mcdanieli* (Acarina: Tetranychidae). *Biological Control* **34,** 47-57.

Rudgers JA (2003) Inter-annual variation in above- and below ground herbivory on a native annual legume. *Plant Ecology* **169,** 105-120.

Rull J, Prokopy RJ (2000) Attraction of apple maggot flies, *Rhagoletis pomonella* (Diptera: Tephriditae) of different physiological states to odour-baited traps in the presence and absence of food. *Bulletin of Entomological Research* **90,** 77-88.

Sabelis MW (1985a) Predation on spider mites. In 'Spider Mites, Their Biology, Natural Enemies and Control' (Eds W Helle and MW Sabelis). Elsevier Science Publishers, Amsterdam, Oxford, New York and Tokyo pp. 103-129.

Sabelis MW (1985b) Reproductive Strategies. In 'Spider Mites, Their Biology, Natural Enemies and Control' (Eds W Helle and MW Sabelis). Elsevier Science Publishers, Amsterdam, Oxford, New York and Tokyo pp. 265-278.

Safonkin AF, Triseleva TA (2005) Fecundity of large fruit-tree tortrix *Archips podana* Scop. (Lepidoptera: Tortricidae) on different host plants. *Biology Bulletin* **32,** 207-210.

Sampson PJ, Walker J (1982) An Annotated List of Plant Diseases in Tasmania,Department of Agriculture, Hobart.

Schroeder NC, Chapman RB, Clifford PTP (1998) Effect of potato mirid (*Calocoris norvegicus*) on white clover seed production in small cages. *New Zealand Journal of Agricultural Research* **41,** 111-116.

Scott DR (1997) An annotated listing of host plants of *Lygus hesperus* Knight. *Bulletin of the Entomological Society of America* **23,** 19-22.

Scott N, De Barro P (2000) Report on Pierce's Disease and the Glassy Winged Sharpshooter,CSIRO report commissioned by Department of Agriculture, Fisheries and Forestry, Canberra.

Seemüller E, Schneider B (2004) '*Candidatus* Phytoplasma mali', '*Candidatus* Phytoplasma pyri' and '*Candidatus* Phytoplasma prunorum', the casual agents of apple proliferation, pear decline and European stone fruit yellows, respectively. *International Journal of Systematic and Evolutionary Microbiology* **54,** 1217-1226.

Semmens TD, McQuillan PB, Hayhurst G (1992) Catalogue of the Insects of Tasmania. Department of Primary Industry Tasmania, Hobart.

Seymour LM, Mowry TM, Day WH, Barbour JD (2005) Parasitism of *Lygus* spp. nymphs by the parasitoid wasp, *Peristenus howardi*, in the alfalfa seed-growing region of the Pacific Northwest. *Journal of Insect Science* **5,** 44.

Shattuck S (2000) Australian Ants: Their Biology and Identification. CSIRO Publishing, Collingwood, Australia.

Shivas RG (1989) Fungal and Bacterial Diseases of Plants in Western Australia. *Journal of the Royal Society of Western Australia* **72,** 1-62.

Shorey HH, Sisk CB, Gerber RG (1996) Widely separated pheromone release sites for disruption of sex pheromone communication in two species of Lepidoptera. *Environmental Entomology* **25,** 446-451.

Shull WE, Wakeland CC (1941) The Mineola Moth or Destructive Prune Worm. In 'Bulletin No. 242' (Ed. Idaho Agricultural Research Station). University of Idaho, Moscow.

Silverside AJ (2001) 'ERYSIPHALES (Powdery Mildews)'. Webpage: http://www-biol.paisley.ac.uk/bioref/Fungi_ascomycetes/profile_Erysiphales.html, Accessed: 10 February 2008.

Simmonds JH (1966) Host Index of Plant Diseases in Queensland,Queensland Department of Primary Industries, Brisbane.

Simonds AO (1951) Transmission of apricot ring pox to peaches and plums. *Plant Disease Reporter* **40,** 189-190.

Smiley RL, Gerson U (1995) A review of the Tenuipalpidae (Acari: Prostigmata) of Australia with descriptions of two new genera and four new species. *International Journal of Acarology* **21,** 33-45.

Smirle MJ (1993) Larval performance of two leafroller species on known and potential hosts. *Entomologia Experimentalis et Applicata* **67,** 223-231.

Smirle MJ, Lowery DT, Zurowski CL (2002) Resistance and cross-resistance to four insecticides in populations of obliquebanded leafroller (Lepidoptera: Tortricidae). *Journal of Economic Entomology* **95,** 820-825.

Smirle MJ, Lowery DT, Zurowski CL (2003a) Susceptibility of leafrollers (Lepidoptera: Tortricidae) from organic and conventional orchards to azinphosmethyl, spinosad, and *Bacillus thuringiensis*. *Journal of Economic Entomology* **96,** 879-884.

Smirle MJ, Lowery DT, Zurowski CL (2003b) Variation in response to insecticides in two species of univoltine leafrollers (Lepidoptera: Tortricidae). *Canadian Entomologist* **135,** 117-127.

Smirle MJ, Vincent C, Zurowski CL, Rancourt B (1998) Azinphosmethyl resistance in the obliquebanded leafroller, *Choristoneura rosaceana*: reversion in the absence of selection and relationship to detoxication enzyme activity. *Pesticide Biochemistry and Physiology* **61,** 183-189.

Smith BJ, Sivasithamparam K (2003) Morphological studies of Ganoderma (Ganodermataceae) from the Australasian and Pacific regions. *Australian Systematic Botany* **16,** 487-5003.

Smith D, Beattie GAC, Broadley R (1997) Citrus Pests and Their Natural Enemies: Integrated Pest Management in Australia. Queensland Department of Primary Industries, Brisbane.

Smith IM, Dunez J, Phillips DH, Lelliott RA, Archer SA (1988) European Handbook of Plant Diseases. Blackwell Scientific Publications, Oxford.

Smith LM, Summers FM (1948) Propagation of the oriental fruit moth under central California conditions. *Hilgardia* **18,** 369-387.

Smith TJ (2005) Western cherry fruit fly and its management in the Pacific Northwest United States. *Acta Horticulturae* **667,** 485-488.

Smith TJ, Dunley J, Beers EH, Brunner JF, Grove GG, Xiao C-L, Elfving D, Peryea F, Parker R, Bush MDC, Maxwell T, Foss S, USDA-APHIS (2006) 2006 Crop Protection Guide for Tree Fruits in Washington. Washington State University, Pullman.

Smith TM and Van Driesche R (2003) 'Floriculture: Fact Sheets: Pest Management: Western Flower Thrips and Tospoviruses'. Webpage: http://www.umass.edu/umext/floriculture/fact_sheets/pest_management/wft_03.html, Accessed: 24/10/2007.

Smitley DR, Kennedy GG (1988) Aerial dispersal of the two-spotted spider mite (*Tetranychus urticae*) in field corn . *Experimental and Applied Acarology* **5,** 33-46.

Snodgrass GL, McWilliams JM (1992) Rearing the tarnished plant bug (Heteroptera: Miridae) using a tissue paper oviposition site. *Journal of Economic Entomology* **85,** 1162-1166.

Snodgrass GL, Scott WP (1988) Tolerance of the tarnished plant bug to dimethioate and acephate in different areas of the Mississippi Delta. In 'Proceedings, Beltwide Cotton Production Conference.' (Eds DJ Herber and DA Richter) pp. 294-296. National Cotton Council of America, Memphis.

Sohati PH, Boivin G, Stewart RK (1992) Parasitism of *Lygus lineolaris* eggs on *Coronilla varia*, *Solanum tuberosum*, and three host weeds in southeastern Québec. *BioControl* **34,** 515-523.

Solomon ME (1991) Ecology and population dynamics. In 'Tortricid Pests: Their Biology, Natural Enemies and Control' (Eds LPS van der Geest and HH Evenhuis). Elsevier Science Publishers, Amsterdam, Oxford, New York and Tokyo pp. 209-234.

Spangler SM and Agnello A (1991) 'Comstock Mealybug Insect Identification Sheet No. 22'. Webpage: http://www.nysipm.cornell.edu/factsheets/treefruit/pests/cmb/cmb.asp, Accessed: 22/10/2007.

Spencer KA (1977) A revision of the Australian Agromyzidae. *Special Publications of the Western Australian Museum* **8,** 1–255.

Stabler N (1941) Psyllid galls on avocado. *Bulletin of the Department of Agriculture California* **30,** 1-217.

Stavisky J, Funderburk J, Brodbeck BV, Olson SM, Andersen PC (2002) Population dynamics of *Frankliniella* spp. and tomato spotted wilt incidence as influenced by cultural management tactics in tomato. *Journal of Economic Entomology* **95,** 1216-1221.

Stimmel JF (1998) 'Wax Scales, *Ceroplastes* spp. Homoptera: Coccidae'. Webpage: http://www.agriculture.state.pa.us/plantindustry/lib/plantindustry/pdfdocs/vol24_8.pdf, Accessed: 03/07/2007.

Stoetzel MB, Miller GL (1998) Aphids (Homoptera: Aphididae) colonizing peach in the United States or with potential for introduction. *Florida Entomologist* **81,** 325-345.

Stone MW (1982) The peach beetle, *Cotinis mutabilis* (Gory and Percheron), in California (Coleoptera: Scarabaeidae). *Pan Pacific Entomologist* **58,** 159-161.

Strickland JS (2002) 'University of Florida Featured Creatures: Peachtree borer'. Webpage: http://creatures.ifas.ufl.edu/fruit/borers/peachtree_borer.htm, Accessed: 29/10/2007.

Struttman JM (2005) 'Moths of California - *Antheraea polyphemus*'. Webpage: http://www.npwrc.usgs.gov/resource/dist/lepid/moths/ca/955.htm, Accessed: 8 February 2006.

Summerfruit Australia Limited (2006) 'Summerfruit Industry Overview'. Webpage: http://www.summerfruit.com.au/uploads/summerfruit_australia_limited_overview.pdf, Accessed: 25/10/2007.

Summers FM, Donaldson D, Togashi S (1959) Control of peach twig borer on almonds and peaches in California. *Journal of Economic Entomology* **52,** 637-639.

Suomi D (1999) 'Washington State University: Insect Answers - Apple and thorn skeletoniser (Publication EB1384E)'. Webpage: http://cru.cahe.wsu.edu/CEPublications/eb1384e/eb1384e.html, Accessed: 16 June 2006.

Swenson KG (1974) Host plants and seasonal cycle of a leafhopper *Fieberiella fiorii* in western Oregon. *Journal of Economic Entomology* **67,** 299-300.

Sztejnberg A (1995) Cercospora Leaf Spot. In 'Compendium of Stone Fruit Diseases' (Eds JM Ogawa, EI Zehr, GW Bird, DF Ritchie, K Uiru, and JK Uyemoto). The American Phytopathological Society, St. Paul, Minnesota pp. 21-22.

Tate KG, Ogawa JM (1975) Nitidulid beetles as vectors of *Monolinia fructicola* in California stone fruits. *Phytopathology* **65,** 977-983.

Taverner PD, Bailey PT (1995) Commercial trial of citrus post-harvest oil for the removal of surface pests,South Australian Research and Development Institute, Urrbrae.

Teulon DAJ, Penman DR (1996) *Thrips* (Thysanoptera) seasonal flight activity and infestation of ripe stone fruit in Canterbury, New Zealand. *Journal of Economic Entomology* **89,** 722-734.

Teviotdale BL, Gubler WD, and Koike ST (2001) 'Powdery Mildew on Fruits and Berries'. Webpage: http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7494.html, Accessed: 09/10/2007.

Texas A&M University (2006) 'Woody Ornamental Plants And Their Insect Pests'. Webpage: http://entowww.tamu.edu/woody/index.cfm, Accessed: 04/09/2006.

Thomidis T, Karajiannis I (2003) Using ELISA and PCR to test the potential for spread of plum pox virus by seeds of different stone fruit cultivars. *New Zealand Journal of Crop and Horticultural Science* **31,** 69-72.

Tomlinson Jr WE (1951) Control of insect larvae infesting immature blueberry fruit. *Journal of Economic Entomology* **44,** 247-250.

Tree Fruit Research and Extension Centre (2008) 'Oriental Fruit Moth in Stone Fruit'. Webpage: Web Page: http://entomology.tfrec.wsu.edu/Cullage_Site/Pages/OFM.html, Accessed: 11/03/2008.

Trenchev G, Pavlov A (1982) Morphological characteristics of *Orgyia antiqua* L. and *Orgyia gonostigma* F. (Lepidoptera, Lymantriidae) and methods of controlling the larvae. *Gradinarska i Lozarska Nauka* **19,** 53-58.

UC Davis '*Paratylenchus hamatus* - UC Davis Nematology'. Webpage: http://ucdnema.ucdavis.edu/imagemap/nemmap/ent156html/nemas/paratylenchushamatus, Accessed: 15/10/2007.

University of Alberta (2006) 'Species Page - *Otiorhynchus ovatus*'. Webpage: http://www.entomology.ualberta.ca/searching_species_details.php?s=5782, Accessed: 29/10/2007.

University of California (2007a) 'Managing Pests in Gardens: Fruit: Diseases:Cherry Leaf Spot - UCIPM'. Webpage: http://www.ipm.ucdavis.edu/PMG/GARDEN/FRUIT/DISEASE/cherrylfspot.html, Accessed: 24/10/2007.

University of California B (2007b) 'California Moth Specimen Database Essig Museum of Entomology Collections'. Webpage: http://essigdb.berkeley.edu/calmoth.html, Accessed: 12/09/2007.

University of Georgia (2002) 'Peach Insects'. Webpage: http://www.gaipm.org/id/peachesi.html, Accessed: 29/10/2007.

University of Illinois (2004) 'IPM: Fruits: Eastern Flower Thrips (*Frankliniella tritici*)'. Webpage: http://ipm.uiuc.edu/fruits/insects/eastern_flower_thrips/index.html, Accessed: 29/10/2007.

University of Missouri (2000) 'Crop Profile for Peaches in Illinois '. Webpage: http://www.ipmcenters.org/cropprofiles/docs/ILpeaches.html#TARNISHED%20PLANT%20BUG, Accessed: 29/10/2007.

USDA (1951) Virus Diseases and Other Disorders with Viruslike Symptoms of Stone Fruits in North America. USDA, Washington D.C.

USDA (2007) 'More information about plum pox outbreaks in the U.S.'. Webpage: http://www.ars.usda.gov/is/br/plumpox/more1.htm, Accessed: 24/10/2007.

Vakenti JM, Campbell CJ, Madsen HF (1984) A strain of fruittree leafroller, *Archips argyrospilus* (Lepidoptera: Tortricidae), tolerant to azinphos-methyl in an apple orchard region of the Okanagan Valley of British Columbia. *Canadian Entomologist* **116,** 69-73.

Van Steenwyk RA, Daane KM, and Grant JA (2006a) 'UC IPM: UC Management Guidelines for Cherry Leafhopper on Cherry'. Webpage: http://www.ipm.ucdavis.edu/PMG/r105301811.html, Accessed: 29/10/2007.

Van Steenwyk RA, Daane KM, and Grant JA (2006b) 'UC IPM: UC Management Guidelines for Mountain Leafhopper on Cherry'. Webpage: http://www.ipm.ucdavis.edu/PMG/r105301711.html, Accessed: 29/10/2007.

Van Steenwyk RA, Ferguson L, and Zalom F.G. (2004) 'UC IPM: UC Management Guidelines for Olive Black Scale (*Saissetia oleae*)'. Webpage: http://www.ipm.ucdavis.edu/PMG/r583300511.html, Accessed: 29/10/2007.

Varela LG, Elkins RB, Van Steenwyk RA, Ingels C, and Pickel C (2007) 'UC IPM: UC Management Guidelines for Apple Maggot on Pear'. Webpage: http://www.ipm.ucdavis.edu/PMG/r603301911.html, Accessed: 15/10/2007.

Veerman A (1985) Diapause. In 'Spider Mites, Their Biology, Natural Enemies and Control' (Eds W Helle and MW Sabelis). Elsevier Science Publishers, Amsterdam, Oxford, New York and Tokyo pp. 279-316.

Verma SP, Dinabandhoo CL (2005) Armoured scales (Homoptera: Diaspididae) associated with temperate and subtropical fruit trees in Himachal Pradesh. *Acta Horticulturae* **696,** 423-426.

Vickers RA, Rothschild GHL (1991) Use of sex pheromones for control of codling moth. In 'Tortricid Pests: Their Biology, Natural Enemies and Control' (Eds LPS van der Geest and HH Evenhuis). Elsevier Science Publishers, Amsterdam, Oxford, New York and Tokyo pp. 339-354.

Virginia Tech (2008) 'Oriental Fruit Moth, *Grapholita molesta* (Busck)'. Webpage: Web Page: http://www.virginiafruit.ento.vt.edu/OFM.html, Accessed: 11/03/2008.

Wagnon HK, Breece JR, Traylor JA, Williams HE (1961) The occurrence of apricot ring pox virus in plum in California. *Plant Disease Reporter* **45,** 796-797.

Walker KR, Welter SC (2004) Biological control potential of *Apanteles aristoteliae* (Hymenoptera: Braconidae) on populations of *Argyrotaenia citrana* (Lepidoptera: Tortricidae) in California apple orchards. *Environmental Entomology* **33,** 1327-1334.

Wallis CM, Fleischer SJ, Luster D, Gildow FE (2005) Aphid (Hemiptera: Aphididae) species composition and potential aphid vectors of plum pox virus in Pennsylvania peach orchards. *Journal of Economic Entomology* **98,** 1441-1450.

Wardle AR, Borden JH (2003) Sexual attraction among *Lygus* (Hemiptera: Miridae) species. *Canadian Entomologist* **135,** 733-735.

Washington State University (2001) 'Cherry Bark Tortrix or CBT (*Enarmonia formosana*)'. Webpage: http://ipm.wsu.edu/cat/pdf/2001IPMforInsects.pdf, Accessed: 08/02/2006.

Washington State University (2005) 'Market Diseases of Apples, Pears, and Quinces: Leaf Roller and Green Fruit Worm Injury'. Webpage: http://postharvest.tfrec.wsu.edu/marketdiseases/leafroller.html, Accessed: 15/10/2007.

Washington State University (2007) 'Hop, Grape, and Red Currant Entomology, Grape Insects and Mites'. Webpage: http://www.goodbugs.prosser.wsu.edu/grapes.htm, Accessed: 24/10/2007.

Washington WS, Nancarrow RJ (1983) List of Diseases Recorded on Fruit and Vegetable Crops in Victoria before June 30, 1980,Department of Agriculture, Victoria.

Watson GW (2005) 'Arthropods of economic importance: *Diaspidiotus juglansregiae*'. Webpage: http://ip30.eti.uva.nl/BIS/diaspididae.php?selected=beschrijving&menuentry=soorten&id=106, Accessed: 11/07/2006.

Watson GW (2006) 'Arthopods of economic importance: Diaspididae'. Webpage: http://ip30.eti.uva.nl/bis/diaspididae.php, Accessed: 11/07/2006.

Weakley CV, Kirsch PA, Zalom FG (1990) Within-orchard and within-tree distributions of peach twig borer (Lepidoptera: Gelechiidae) damage to peaches. *Journal of Economic Entomology* **83,** 505-510.

Wearing CH, Hansen JD, Whyte C, Miller CEBJ (2001) The potential for spread of codling moth (*Lepidoptera: Tortricidae*) via commercial sweet cherry fruit: a critical review and risk assessment. *Crop Protection* **20,** 465-488.

Webster RP, Carde RT (1982) Relationships among pheromone titre, calling and age in the omnivorous leafroller moth (*Platynota stultana*). *Journal of Insect Physiology* **28,** 925-933.

Webster RP, Carde RT (1984) The effects of mating, exogenous juvenile hormone and a juvenile hormone analogue on pheromone titre, calling and oviposition in the omnivorous leafroller moth (*Platynota stultana*). *Journal of Insect Physiology* **30,** 113-118.

Weems Jr HV and Fasulo TR (2002) 'University of Florida Featured Creatures: Apple maggot fly, *Rhagoletis pomonella* (Walsh). Publication EENY-261'. Webpage: http://creatures.ifas.ufl.edu/fruit/tropical/apple_maggot_fly.htm, Accessed: 17/10/2007.

Weems Jr HV and Heppner JB (2004) 'University of Florida Featured Creatures - Melon Fly, *Bactrocera curcubitae* Coquillett'. Webpage: http://creatures.ifas.ufl.edu/fruit/tropical/melon_fly.htm, Accessed: 15/10/2007.

Weems Jr HV, Heppner JB, and Steck GJ (2004) 'University of Florida Featured Creatures - Mexican Fruit Fly, *Anastrepha ludens* (Loew)'. Webpage: http://creatures.ifas.ufl.edu/fruit/tropical/mexican_fruit_fly.htm, Accessed: 20 June 2006.

Weires R, Riedl H (1991) Other Tortricides on Pome and Stone Fruits: North American Species. In 'Tortricid Pests: Their Biology, Natural Enemies and Control' (Eds LPS van der Geest and HH Evenhuis). Elsevier Science Publishers, Amsterdam pp. 416-434.

Welch JL, Kondratieff BC (1993) Leafhopper (Homoptera: Cicadellidae) species composition of western Colorado commercial peach orchards. *Southwest Entomologist* **18,** 203-211.

Welliver R (1999) Diseases Caused by Phytoplasmas, Plant Pathology Circular No. 92. Pennsylvania Department of Agriculture, Bureau of Plant Industry, Harrisburg.

Wells JM (1995) Phony Peach. In 'Compendium of Stone Fruit Diseases' (Eds JM Ogawa, EI Zehr, GW Bird, DF Ritchie, K Uiru, and JK Uyemoto). The American Phytopathological Society, St. Paul, Minnesota pp. 21-22.

Wenatchee WA (2005) 'Rain Beetles'. Webpage: http://www.tfrec.wsu.edu/InsectRef/RainBeetles/rain_beetles.htm, Accessed: 13 Jan 2006.

Westerdahl BB, McKenry MV, and Kodira UC (2006) 'UC IPM: UC Management Guidelines for Nematodes on Nectarine'. Webpage: http://ipm.ucdavis.edu/PMG/r540200111.html, Accessed: 6 July 2007.

White IM, Elson-Harris MM (1992) Fruit Flies of Economic Significance: Their Identification and Economics. CAB International and The Australian Centre for International Agricultural Research, Wallingford.

Wichman RL, Hopkins DL (2002) Differentiation of pathogenic groups of *Xylella fastidiosa* strains with whole-cell protein profiles. *Plant Disease* **86,** 875-879.

Wilkinson TK, Landis DA, Gut LJ (2004) Parasitism of obliquebanded leafroller (Lepidoptera:Tortricidae) in commercially managed Michigan apple orchards. *Journal of Economic Entomology* **97,** 1524-1530.

Williams DJ (1991) Superfamily COCCOIDEA. In 'The Insects of Australia: a textbook for students and research workers. Hemiptera.' (Eds M Carver, GF Gross, and TE Woodward). Melbourne University Press, Melbourne pp. 457-464.

Williams DJ (2004) Mealybugs of Southern Asia. Natural History Museum and Southdene, Kuala Lumpur.

Williams DJ, Watson GW (1988) The Armoured Scales. In 'The Scale Insects of the Tropical South Pacific Region' CAB International, Wallingford p. 289.

Williams MR (2003) 'Cotton insect losses 2002'. Webpage: http://www.msstate.edu/Entomology/CTNLOSS/2002/2002loss.htm, Accessed: 22/10/2007.

Willson HR, Trammel K (1975) Relationships between sex pheromone trapping of six Tortricids and a foliage index of apple orchard canopies. *Environmental Entomology* **4,** 361-364.

Wood SL (1982) The Bark and Ambrosia Beetles of North and Central America (Coleoptera: Scolytidae), a Taxonomic Monograph. University of Wisconsin, Madison.

Wood SL, Bright DE (1992) A Catalog of Scolytidae and Platypodidae (Coleoptera), Part 2: Taxonomic Index. University of Wisconsin, Madison.

Wrensch DL (1985) Reproductive parameters. In 'Spider Mites, Their Biology, Natural Enemies and Control' (Eds W Helle and MW Sabelis). Elsevier Science Publishers, Amsterdam, Oxford, New York and Tokyo pp. 165-170.

WTO (1995) 'Agreement on the application of sanitary and phytosanitary measures', Agreement on the application of sanitary and phytosanitary measures,World Trade Organisation, Geneva.

Xu XM, Robinson JD (2000) Effects of temperature on the incubation and latent periods of hawthorn powdery mildew (*Podosphaera clandestina*). *Plant Pathology* **49,** 791-797.

Yee WL, Goughnour R (2006) New host records for the apple maggot, *Rhagoletis pomonella* (Diptera: Tephritidae) in Washington State. *Pan Pacific Entomologist* **82,** 54-60.

Yee WL, Landolt PJ, Darnell TJ (2006) Attraction of *Rhagoletis pomonella* (Diptera: Tephriditae) and non-target flies to traps baited with ammonium carbonate and fruit volatile lures in Washington and Oregon. *Journal of Agricultural and Urban Entomology* 133-149.

Yokoyama VY, Miller GT (1989) Response of codling moth and oriental fruit moth (Lepidoptera: Tortricidae) immatures to low-temperature storage of stone fruits. *Journal of Economic Entomology* **82,** 1152-1156.

Yokoyama VY, Miller GT (1993) Pest-free period for walnut husk fly (Diptera: Tephritidae) and host status of stone fruits for export to New Zealand. *Journal of Economic Entomology* **86,** 1766-1772.

Yokoyama VY, Miller GT (1994) Walnut husk fly (Diptera: Tephritidae) pest-free and preovipositional periods and adult emergence for stone fruits exported to New Zealand. *Journal of Economic Entomology* **87,** 747-751.

Yokoyama VY, Miller GT (1996) Response of walnut husk fly (Diptera: Tephritidae) to low temperature, irrigation, and pest-free period for exported stone fruits. *Journal of Economic Entomology* **89,** 1186-1191.

Yokoyama VY, Miller GT (1997) Walnut Husk Fly (Diptera: Tephritidae) Pest-Free and Preovipositional Periods and Adult Emergence for Stone Fruits Exported to New Zealand. *Journal of Economic Entomology* **87,** 747-751.

Yokoyama VY, Miller GT (1999) Host status of fresh prunes by potential quarantine pests in laboratory tests and evaluation of packinghouse culls. *Journal of Economic Entomology* **92,** 485-489.

Yokoyama VY, Miller GT (2000) Response of omnivorous leafroller (Lepidoptera: Tortricidae) and onion thrips (Thysanoptera: Thripidae) to low-temperature storage. *Journal of Economic Entomology* **93,** 1031-1034.

Yokoyama VY, Miller GT, Crisosto CH (1999) Low temperature storage combined with sulfur dioxide slow release pads for quarantine control of omnivorous leafroller *Platynota stultana* (Lepidoptera: Tortricidae). *Journal of Economic Entomology* **92,** 235-238.

Yokoyama VY, Miller GT, Hartsell PL (1992) Pest-free period and methyl bromide fumigation for control of walnut husk fly (Diptera: Tephritidae) in stone fruits exported to New Zealand. *Journal of Economic Entomology* **85,** 150-156.

Young OP (1986) Host plants of the tarnished plant bug, *Lygus lineolaris* (Hereroptera: Miridae). *Annals of the Entomological Society of America* **79,** 747-762.

Zahradník J (1990) Other forests. In 'Armoured Scale Insects: Their Biology, Natural enemies and Control' (Ed. D Rosen). Elsevier Science Publishing, Amsterdam pp. 645-654.

Zalom FG, Phillips FA, Toscano NC, and Bolda M (2005) 'UC IPM: UC Management Guidelines for Lygus Bug on Strawberry'. Webpage: http://ipm.ucdavis.edu/PMG/r734300111.html#DEGDAY, Accessed: 22/10/2007.

Zalom FG, Walsh DB, Krueger W, Connell J (2002) Tolerance of peach twig borer, *Anarsia lineatella* Zeller, to organophosphate and pyrethroid insecticides. *Acta Horticulturae* 585-591.

Zhou S, Criddle RS, Mitcham EJ (2000) Metabolic response of *Platynota stultana* pupae to controlled atmospheres and its relation to insect mortality response. *Journal of Insect Physiology* **46,** 1375-1385.

Zhou S, Criddle RS, Mitcham EJ (2001) Metabolic response of *Platynota stultana* pupae during and after extended exposure to elevated CO_2 and reduced O_2 atmospheres. *Journal of Insect Physiology* **47,** 401-409.

Zhu YC, Snodgrass GL, Chen MS (2004) Enhanced esterase gene expression and activity in a malathion-resistant strain of the tarnished plant bug, *Lygus lineolaris*. *Insect Biochemistry and Molecular Biology* **34,** 1175-1186.