Australian Government

Biosecurity Australia

Draft Import Risk Analysis Report for Fresh Apple Fruit from the United States of America Pacific Northwest States

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Cover image: Apple in US orchard, photo by Biosecurity Australia

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:

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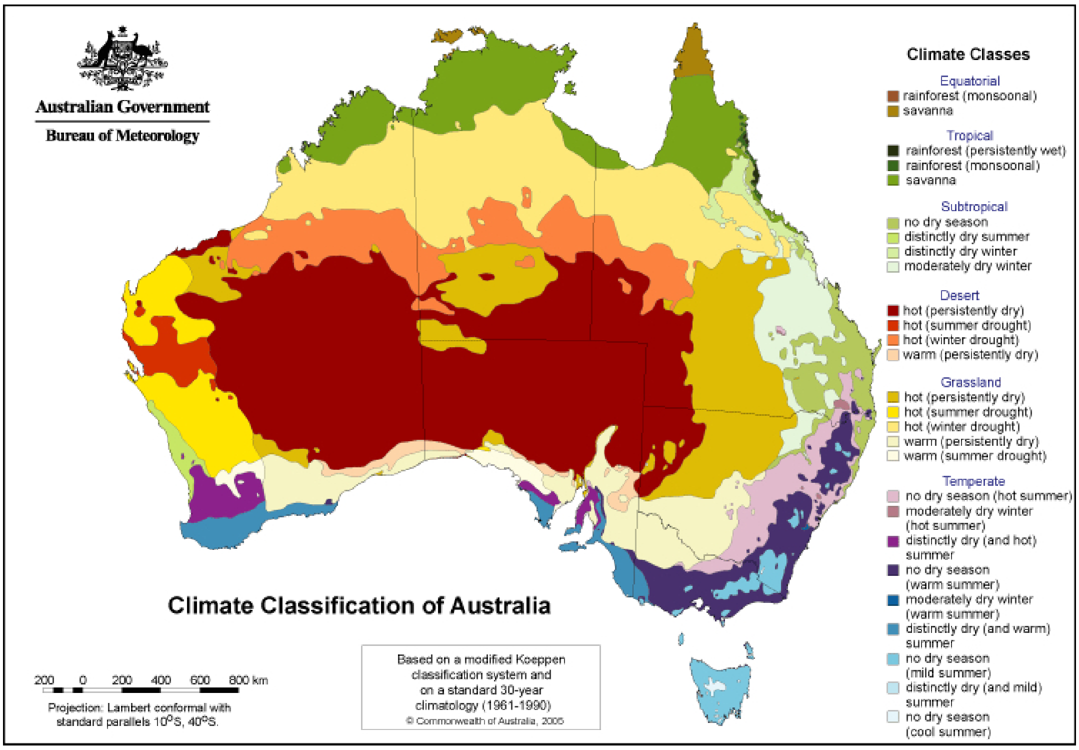


Acronyms and abbreviations

Term or abbreviation	Definition
ABS	Australian Bureau of Statistics
ACERA	Australian Centre of Excellence for Risk Analysis
ACT	Australian Capital Territory
ALOP	Appropriate level of protection
APAL	Apple and Pear Australia Limited
APHIS	Animal and Plant Health Inspection Service
APPD	Australian Plant Pest Database (Plant Health Australia)
AQIS	Australian Quarantine and Inspection Service
BA	Biosecurity Australia
BAA	Biosecurity Australia Advice
BSG	Biosecurity Service Group
CABI	CAB International, Wallingford, UK
CMI	Commonwealth Mycological Institute
CSIRO	Commonwealth Science and Industry Research Organisation
CT	Concentration time
DAFF	Australian Government Department of Agriculture, Fisheries and Forestry
DAFWA	Department of Agriculture and Food, Western Australia (formerly DAWA: Department of Agriculture, Western Australia)
DPIW	Department of Primary Industries and Water, Tasmania
EP	Existing policy
EPPO	European and Mediterranean Plant Protection Organization
FAO	Food and Agriculture Organization of the United Nations
FAS	The Foreign Agriculture Service in the United States Department of Agriculture
IDM	Integrated Disease Management
IPC	International Phytosanitary Certificate
IPM	Integrated Pest Management
IPPC	International Plant Protection Convention
IRA	Import Risk Analysis
IRAAP	Import Risk Analysis Appeals Panel
ISPM	International Standard for Phytosanitary Measures
MOU	Memorandum of Understanding
NASS	The National Agricultural Statistics Service in the United States Department of Agriculture
NPPO	National Plant Protection Organization
NSW	New South Wales
NT	Northern Territory
OEPP	Organisation européenne et méditerranéenne pour la protection des plantes
PIAPH	Product Integrity, Animal and Plant Health Division
PIMC	Primary Industries Ministerial Council
PNW	Pacific Northwest. Only the US Pacific Northwest states, i.e. Washington, Oregon and Idaho, are included in the scope of this IRA

PRA	Pest Risk Analysis
Qld	Queensland
SA	South Australia
SPS	Sanitary and phytosanitary
Tas.	Tasmania
US	The United States of America
USDA	United States Department of Agriculture
Vic.	Victoria
WA	Western Australia
WAFGA	Western Australia Fruit Growers' Association
WTO	World Trade Organisation

Abbreviations of units

Term or abbreviation	Definition
ºC	degree Celsius
g	gram
h	hour
ha	hectare
kg	kilogram
km	kilometre
L	litre
m	metre
m^3	cubic metre
mg	milligram
mm	millimetre
ppm	parts per million

Summary

This import risk analysis (IRA) assesses a proposal from the United States of America (US) for market access to Australia for fresh apple fruit produced in the US Pacific Northwest (PNW) states: Washington, Oregon and Idaho.

The draft report proposes that the importation of fresh apple fruit to Australia from all commercial production areas in the PNW be permitted, subject to a range of quarantine conditions, including the development of effective management measures for *Sphaeropsis pyriputrescens*, *Phacidiopycnis piri*, *Phacidiopycnis washingtonensis* and *Truncatella hartigii*.

The report takes account of stakeholders' comments on the issues paper circulated to stakeholders on 8 July 2008. A summary of stakeholders' comments on the issues paper and Biosecurity Australia's responses is provided in Appendix D.

Australia permits the importation of a variety of pome fruit (apples and pears) for human consumption provided they meet Australia's quarantine requirements, including pears from China, Korea and Japan, and apples from Japan and New Zealand for human consumption.

This draft report identifies pests that require quarantine measures to manage risks to a very low level in order to achieve Australia's appropriate level of protection (ALOP).

Arthropod pests requiring measures are *Cenopalpus pulcher* (flat scarlet mite), *Phenacoccus aceris* (apple mealybug), *Pseudococcus maritimus* (grape mealybug), *Frankliniella occidentalis* (western flower thrips), *Frankliniella tritici* (eastern flower thrips), nine species of leafroller moths, *Dasineura mali* (apple leafcurling midge), *Rhagoletis pomonella* (apple maggot), *Cydia pomonella* (codling moth), *Grapholita molesta* (oriental fruit moth), *Grapholita packardi* (cherry fruitworm) and *Grapholita prunivora* (lesser appleworm).

Pathogen pests requiring measures are *Erwinia amylovora* (fire blight), *Coprinopsis psychromorbida* (coprinus rot), *Phyllosticta arbutifolia* (apple blotch), *Gymnosporangium juniperi-virginianae* (cedar apple rust), *Gymnosporangium libocedri* (Pacific Coast pear rust), *Sphaeropsis pyriputrescens* (Sphaeropsis rot), *Phacidiopycnis piri* (Phacidiopycnis rot), *Phacidiopycnis washingtonensis* (speck rot), three *Mucor* species (Mucor rot), *Neonectria ditissima* (European canker), *Venturia inaequalis* (apple scab) and *Truncatella hartigii* (Truncatella leaf spot).

Cydia pomonella, *Grapholita molesta*, *Mucor piriformis*, *Mucor racemosus* and *Venturia inaequalis* have been identified as quarantine pests for Western Australia. The proposed quarantine measures take account of regional differences.

This draft report proposes a combination of risk management measures and operational systems that will reduce the risk associated with the importation of fresh apple fruit from the PNW states into Australia to achieve Australia's ALOP, specifically:

- A declaration by the US, prior to each year of trade, that the 28 pests listed in Table 4.1b are not present in the PNW. These pests are associated with apple fruit in the US, but had not been recorded in the PNW at the time this draft IRA was released.
- Mandatory pre-clearance arrangements during the initial trade with Australian Quarantine and Inspection Service (AQIS) officers involved in all risk management measures in the PNW and auditing of the systems and processes used by the US to certify exports.

- Orchard inspections undertaken for fire blight symptoms at an inspection intensity that would, at a 95% confidence level, detect visual symptoms if shown by 1% of the trees. This inspection should take place between 4 and 7 weeks after flowering when conditions for fire blight disease development are likely to be optimal. Orchards with any visual symptoms of fire blight would be disqualified from export.
- Use of disinfection treatment (e.g. chlorine solution) in packing houses to prevent contamination of apples with fire blight bacteria and with fungi causing Mucor rot.
- Inspection of all host trees in export orchards after leaf fall, during winter, for freedom from European canker disease. Orchards with any symptoms of European canker would be disqualified from export.
- Establishment of area freedom for apple leafcurling midge. If area freedom could not be established, inspection in the PNW of a random sample of 3000 fruit from each lot for freedom from this pest must be undertaken. Detection of apple leafcurling midge would result in rejection of the lot or a treatment such as fumigation. Alternatively, an effective treatment could be used for all export lots.
- Establishment of area freedom for apple maggot. Alternatively, an effective treatment could be used for all export lots.
- Establishment of areas of low pest prevalence for codling moth, oriental fruit moth, cherry fruitworm and lesser appleworm. Alternatively, an effective treatment could be used for all export lots.
- Inspection for all other quarantine pests with remedial action taken (treatment or withdrawal of the lot) if any are detected.
- Orchard control and surveillance.
- Orchard and packing house sanitation.

No satisfactory risk management procedures could be identified for apple scab disease. Therefore, it is proposed that imports of apples from the PNW into Western Australia would not be permitted.

Effective measures to manage the risks associated with *Sphaeropsis pyriputrescens*, *Phacidiopycnis piri*, *Phacidiopycnis washingtonensis* and *Truncatella hartigii* are yet to be proposed by the US, with supporting data, for review.

This draft IRA report contains details of the risk assessments for the quarantine pests and the 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[1] 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 formally consider the risks that could be associated with proposals to import new products into Australia. If the risks are found to exceed 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 involves consultation with stakeholders at various stages during the process. Biosecurity Australia provides recommendations for animal and plant quarantine policy to Australia’s Director of Animal and Plant Quarantine (the Secretary of the Australian Department of Agriculture, Fisheries and Forestry). The Director, or delegate, is responsible for determining whether or not an importation can be permitted under the *Quarantine Act 1908*, and if so, under what conditions. The Australian Quarantine and Inspection Service (AQIS) is responsible for implementing appropriate risk management measures.

More information about Australia’s biosecurity framework is provided in Appendix C of this report and in the *Import Risk Analysis Handbook 2007 (update 2009)* located on the Biosecurity Australia website www.biosecurityaustralia.gov.au.

[1] A pest is any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2009).

1.2 This import risk analysis

1.2.1 Background

This IRA was initiated following the receipt of a technical submission from the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) requesting access for fresh apple fruit from the US Pacific Northwest (PNW) states of Washington, Oregon and Idaho.

1.2.2 Scope

The scope of this IRA is to consider quarantine risks that may be associated with the importation of commercially produced mature fresh apple fruit, free of trash, from the States of Washington, Oregon and Idaho of the PNW. This IRA pertains to all commercial apple-producing counties and commercially produced apple cultivars from these three PNW states. Assessments of pests of quarantine concern for apple production occurring in the continental US, but currently not explicitly recorded from the PNW, are also included in this IRA. The lack of evidence of official control measures in place to prevent the spread of these pests into the PNW necessitates this inclusion.

1.2.3 Existing policy

International policy

Import policy exists for Fuji apples from Japan (AQIS 1998a). An IRA on apples from New Zealand has been completed (Biosecurity Australia 2006a). No apples have been imported into Australia under these policies.

Import policies also exist for Korean pears from Korea (AQIS 1999), ya pears and Asian pears from China's provinces of Hebei, Shandong and Shaanxi (AQIS 1998b), and fragrant pears from Xinjiang Uygur Autonomous Region (Biosecurity Australia 2005a).

The import requirements for these commodities can be accessed at AQIS Import Conditions database http://www.aqis.gov.au/icon.

Domestic arrangements

The Commonwealth Government is responsible for regulating the movement of plants and plant products in and out of Australia. However, the state and territory governments are responsible for plant health controls within Australia. Legislation relating to resource management or plant health may be used by state or territory government agencies to control interstate movement of plants or their products.

Currently, the state legislation in Western Australia prohibits the importation of fresh apples from other states and territories in Australia because of the presence of *Venturia inequalis* (apple scab). For this reason, apples are not permitted into Western Australia.

1.2.4 Contaminating pests

In addition to the pests of apples from Washington, Oregon and Idaho that are identified in this IRA, there are other organisms that may arrive with the commodity. 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 existing operational procedures.

1.2.5 Consultation

An issues paper was released on 8 July 2008 (Biosecurity Australia 2008) for comment and consultation with stakeholders as part of the process for an expanded IRA. The 60 day comment period closed on 5 September 2008. Written submissions received from nine stakeholders were considered and material matters raised have been incorporated into, or addressed in, this report. The submissions received have been placed on the public file and the Biosecurity Australia website.

A summary of stakeholders' comments on the issues paper and Biosecurity Australia's responses are included in Appendix D.

The Expert Panel for this IRA was consulted on 29–30 July and 28 August 2009 to review the draft IRA and issues raised by stakeholders. Summaries of these consultations have been placed on the public file and on the Biosecurity Australia website.

1.2.6 Next steps

This draft IRA report gives stakeholders the opportunity to comment and draw attention to any scientific, technical, or other gaps in the data, misinterpretations and errors.

Biosecurity Australia will consider submissions received on the draft IRA report and may consult informally with stakeholders. Biosecurity Australia will revise the draft IRA report as appropriate.

The Eminent Scientists Group (ESG) will review the revised draft IRA to ensure all submissions from stakeholders received in response to the draft IRA report have been properly considered and the conclusions of the revised draft IRA report are scientifically reasonable.

Biosecurity Australia will then prepare a provisional final IRA report, taking into account stakeholder comments and any recommendations made by the ESG.

State and territory governments will be consulted on the proposed outcomes of the IRA.

The report will be distributed to the proposer and registered stakeholders and the documents will be placed on the public file and the Biosecurity Australia website.

The regulated timeframe for an IRA ends when a provisional final IRA report is issued.

Stakeholders who believe there was a significant deviation from the IRA process set out in the *Import Risk Analysis Handbook 2007 (update 2009)* that adversely affected their interests may appeal to the Import Risk Analysis Appeals Panel (IRAAP). Appeals must be lodged within 30 days of the publication of the provisional final IRA report.

The appeals process is independent of Biosecurity Australia. It is a non-judicial review that is not regulated under the Quarantine Regulations 2000 made under the *Quarantine Act* 1908.

Further details of the appeal process may be found at Annex 6 of the IRA Handbook.

At the conclusion of the appeal process and after any issues arising from the IRAAP process have been addressed, the Chief Executive of Biosecurity Australia will provide the final IRA report and a recommendation for a policy determination to the Director of Animal and Plant Quarantine.

The Director of Animal and Plant Quarantine will then make a determination. The determination provides a policy framework for decisions on whether or not to grant an import permit and any conditions that may be attached to a permit.

A policy determination represents the completion of the IRA process.

The Director of Animal and Plant Quarantine notifies AQIS and Biosecurity Australia of the policy determination. In turn, Biosecurity Australia notifies the proposer and registered stakeholders, and the Department of Agriculture, Fisheries and Forestry notifies the WTO Secretariat, of the determination. The determination will also be placed on the public file and on the Biosecurity Australia website.

2 Method for pest risk analysis

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

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

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

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

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

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

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

2.1 Stage 1: Initiation

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

The pests assessed for their potential to be on the exported commodity (produced using commercial production and packing procedures) are listed in column 1 of Appendix A. Appendix A does not present a comprehensive list of all the pests associated with the entire plant, but concentrates on the pests that could be on the assessed commodity. Pests that are determined to not be associated with the commodity in column 3 are not considered further in the PRA. Contaminating pests that have no specific relation to the commodity or the export pathway have not been listed and would be addressed by Australia's current approach to contaminating pests.

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

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

For pests that had been considered by Biosecurity Australia in other risk assessments and for which import policies already exist, a judgement was made on the likelihood of entry of pests on the commodity and whether existing policy is adequate to manage the risks associated with its import. Where appropriate, the risk assessment from the previous policy has been adopted.

2.2 Stage 2: Pest risk assessment

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

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

2.2.1 Pest categorisation

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

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

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

The results of pest categorisation are set out in columns 4 – 7 in Appendix A. The steps in the categorisation process are considered sequentially, with the assessment terminating with a 'Yes' in column 4 or the first 'No' in columns 5 or 6. 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 2004). 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 host. It is based on pathway scenarios depicting necessary steps in the sourcing of the commodity for export, its processing, transport and storage, its use 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
- **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 lifecycle of the pest
- vulnerability of the life-stages of the pest during transport or storage
- incidence of the pest likely to be associated with a consignment
- commercial procedures (e.g. refrigeration) applied to consignments during transport and storage in the country of origin, and during transport to Australia.

Factors considered in the probability of distribution include:

- commercial procedures (e.g. refrigeration) applied to consignments during distribution in Australia
- dispersal mechanisms of the pest, including vectors, to allow movement from the pathway to a 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 hosts
- time of year at which import takes place
- intended use of the commodity (e.g. for planting, processing or consumption)
- Risks from by-products and waste.

Probability of establishment

Establishment is defined as the 'perpetuation for the foreseeable future, of a pest within an area after entry' (FAO 2004). In order to estimate the probability of establishment of a pest, reliable biological information (lifecycle, host range, epidemiology, survival, etc.) is 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 hosts, alternative hosts and vectors
- suitability of the environment
- reproductive strategy and potential for adaptation
- minimum population needed for establishment
- cultural practices and control measures.

Probability of spread

Spread is defined as 'the expansion of the geographical distribution of a pest within an area' (FAO 2004). 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 is obtained from areas where the pest currently occurs. The situation in the PRA area is then 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
- potential for movement with commodities, conveyances or by vectors
- intended use of the commodity
- potential vectors of the pest in the PRA area
- potential natural enemies of the pest in the PRA area.

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

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

Table 2.1 Nomenclature for qualitative likelihoods

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

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

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

Table 2.2 Matrix of rules for combining qualitative likelihoods

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

Time and volume of trade

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

Biosecurity Australia normally considers the likelihood of entry on the basis of the estimated volume of one year's trade. This is a convenient value for the analysis that is relatively easy to estimate and allows for expert consideration of seasonal variations in pest presence, incidence and behaviour to be taken into account. The consideration of the likelihood of entry, establishment and spread and subsequent consequences takes into account events that might happen over a number of years even though only one year's volume of trade is being considered. This difference reflects biological and ecological facts, for example where a pest or disease may establish in the year of import but spread may 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 Biosecurity Australia has an obligation to review the risk analysis and, if necessary, provide updated policy advice.

It is difficult to estimate the volume of trade for a commodity in absence of existing trade. For this IRA, the volume of trade has been estimated as up to 20% of the domestic fresh apple market.

2.2.3 Assessment of potential consequences

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

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

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

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

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

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

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

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

- **Indiscernible**: pest impact unlikely to be noticeable.

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

Values were translated into a qualitative impact score (A–G)[2] 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

Impact score	Local	District	Region	Nation
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
	Geographic scale			

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.

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

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.

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.

Table 2.5 Risk estimation matrix

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

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. The guiding principle for risk management is to manage risk to achieve Australia's ALOP. The effectiveness of any proposed phytosanitary measure (or combination of measures) is evaluated, using the same approach as used to evaluate the unrestricted risk, to ensure it reduces the restricted risk for the relevant pest or pests to meet Australia's ALOP.

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

Examples given of measures commonly applied to traded commodities include:

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

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

3 The United States of America's commercial production practices for apples

This chapter provides information on the pre-harvest, harvest and post-harvest practices of the US, particularly the PNW states, for fresh apple fruit considered to be commercial production practices. The export capability of the US PNW states is also outlined.

3.1 Assumptions used in estimating unrestricted risk

Biosecurity Australia took the following commercial production practices information into consideration when estimating the unrestricted risk of pests that may be associated with the import of this commodity.

3.2 Climate in production areas

The US PNW states of Washington, Oregon and Idaho are in the temperate climate zone. About 97% of the PNW apple crop is produced in Washington State (USDA/NASS 2008). The Cascade Range, which bisects Washington State from north to south, has a significant impact on climate in eastern and western Washington (NCDC 2005). In western Washington, summers are cool and comparatively dry and winters are mild, wet and cloudy. Eastern Washington is part of the large inland basin between the Cascades and the Rocky Mountains. While the lowest section of the Columbia Basin has near-desert conditions, precipitation generally increases with elevation (NCDC 2005). In general, summers are warmer, winters are colder, percent of possible sunshine received each month are higher particularly in summer, and precipitation is less in eastern Washington compared with western Washington (NCDC 2005). The major apple production regions of the PNW are the Yakima Valley, Wenatchee and the Columbia Basin which are all located in eastern Washington (Figure 3.1) (USDA/NASS 2006b). The climate in these regions has both continental and maritime climate characteristics, with cool winters and hot and dry summers. These conditions are similar to those found in many regions of Australia, including suburban areas where imported apples would be sold.

Climate data sourced from the US Western Regional Climate Centre for the major apple growing regions of the PNW are presented in Figure 3.2. Among these regions, the northern part of Wenatchee region is colder and wetter compared with the other regions (Figure 3.2). While specific temperatures and rainfall levels of the apple production regions in the PNW may differ from selected locations in Australia, the yearly weather patterns are similar, with comparable maximum and minimum temperatures. This similarity in weather patterns suggests that the pests found in the PNW would not be prevented from establishing in Australia based on climatic conditions alone.

3.3 Pre-harvest

3.3.1 Cultivars

Almost one hundred apple varieties are grown commercially in the US. In Washington State, apple planting areas totalled ~70 000 ha in 2006. The major varieties, each grown on more than 7500 ha, are Red Delicious (~30%), Gala (~16%), Granny Smith (~14%), Fuji (~13%) and Golden Delicious (~11%) (USDA/NASS 2006b). Braeburn, Cameo, Honeycrisp, Pink

Lady and Jonagold are also important varieties, each is grown on more than 850 ha. Varieties of lesser importance with planting areas of less than 350 ha each include Jazz, Rome, Ginger Gold, Ambrosia, Pacific Rose, Pinata and Golden Supreme (USDA/NASS 2006b).

3.3.2 Cultivation practices

The majority of orchards established prior to 1986 produce the varieties Red Delicious, Granny Smith and Golden Delicious, planted at densities of approximately 580, 1260 and 480 trees per hectare, respectively (USDA/NASS 2006b). Trees in older orchards are generally taller and wider, which makes pruning, spraying, fruit thinning and picking more difficult and labour intensive (Smith 2001). In newer orchards, trees are usually planted at higher density, for example, at densities of approximately 900, 2050 and 1550 trees per hectare for Red Delicious, Granny Smith and Golden Delicious, respectively (USDA/NASS 2006b). Trees in newer orchards usually are much smaller (Smith 2001). The majority of orchards established prior to 1986 used standard rootstock while the majority of newer orchards used dwarf rootstock (USDA/NASS 2006b).

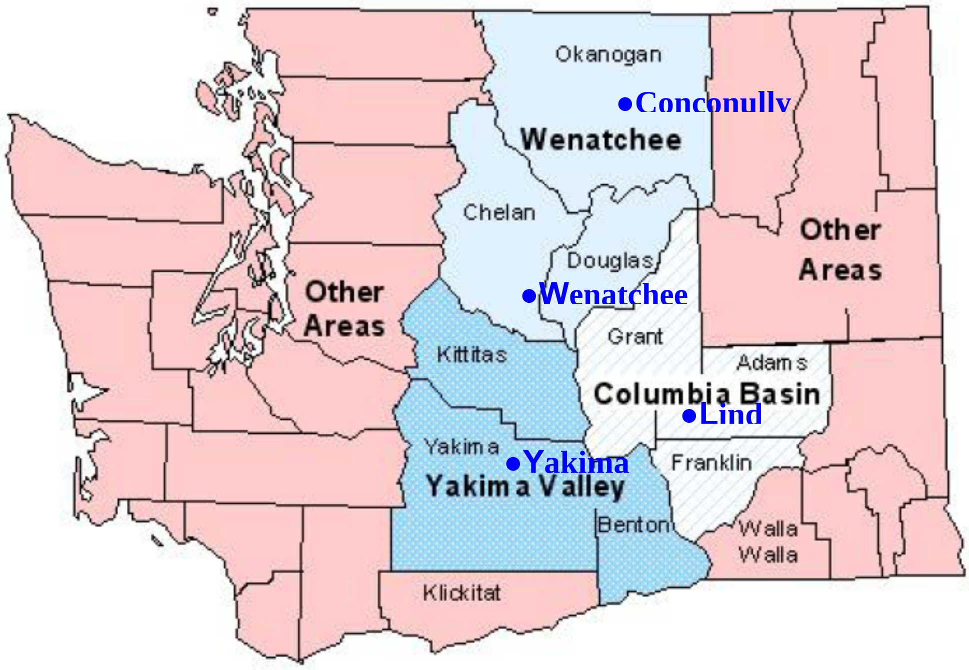
Honey bees are used to promote pollination; usually one to two hives per hectare are left in the orchard at flowering for four to five days, depending on weather conditions. The bees are transported from California to Oregon then Washington, following the cycle of the bloom (Smith 2001). This practice may aid the spread of some pests such as *Erwinia amylovora*, the cause of fire blight.

Fruit is thinned every spring to manage production and fruit quality. Chemical thinners are used during and shortly after the bloom period to manage fruit set, or to remove fruit that may have set in clusters (Smith 2001).

Orchard managers may use a variety of irrigation methods. These may include high pressure under tree irrigation, overhead, drip, trickle or surge irrigation systems. Overhead systems or high pressure under tree systems may complicate pest management by providing conditions suitable for disease infections or by removing protectant pesticides too quickly after application (Washington State University 2001). According to APHIS (2008), there has been an increasing use of drip irrigation or micro-sprinklers and a decline in the use of overhead or high pressure systems during the past several years.

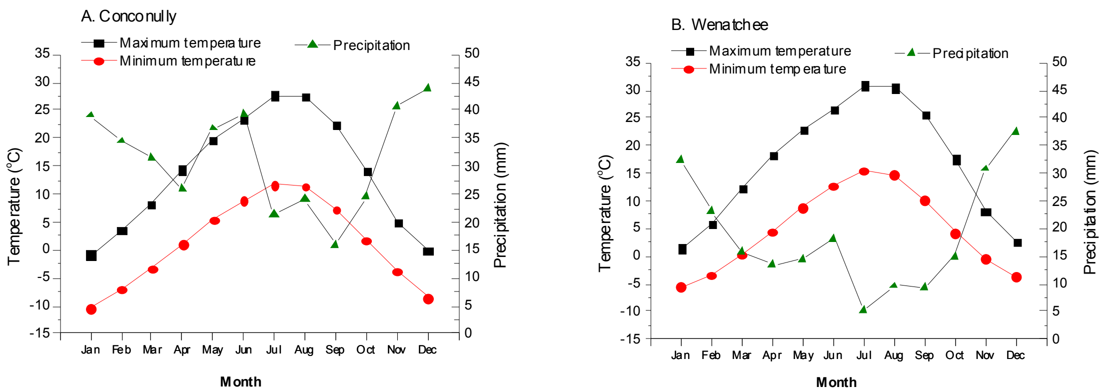
Other commercial apple orchard management practices include tree pruning, fertiliser application, orchard hygiene and weed and pest management (Colt *et al*. 2001; Smith 2001).

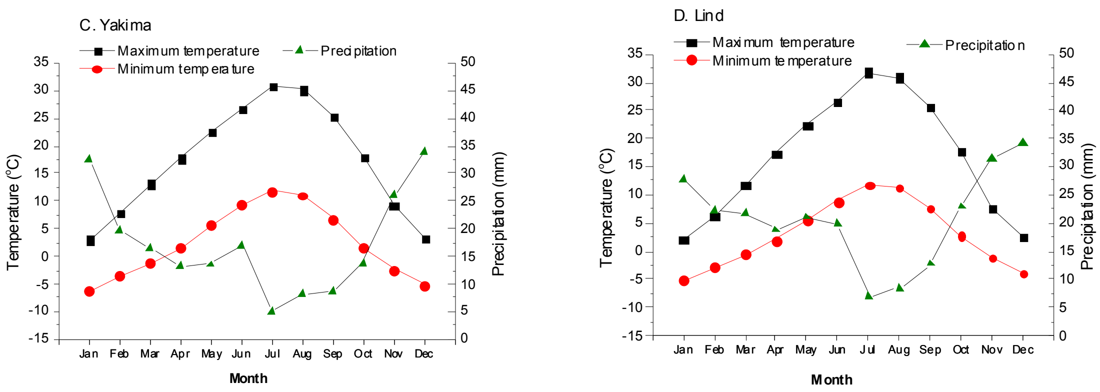
Figure 3.1 Map showing the major apple production regions of the Pacific Northwest, the Yakima Valley, Wenatchee and the Columbia Basin of Washington State



Based on USDA/NASS (2006b)

Figure 3.2 Mean maximum and minimum temperatures and mean precipitation in major apple producing regions of the Pacific Northwest, based on average monthly data, sourced from the US Western Regional Climate Centre, recorded at A. Conconully (1948-2005), B. Wenatchee (1931-2005), C. Yakima (1946-2005) and D. Lind (1931-2005). Approximate locations for these weather stations are shown in Figure 3.1.





3.3.3 Pest management

Common arthropod pests of apples in the PNW include codling moth, leafrollers, San Jose scale, Tetranychid mites, aphids, leafminers, western flower thrips, true bugs and white apple leafhoppers. Arthropod pests that cause sporadic damage in some areas include green and lacanobia fruitworms, cutworms, lesser appleworm, ten-lined June beetle, grape mealybug, fall webworm, oystershell scale, European fruit lecanium scale, Pacific flathead borer, apple ermine moth and grasshoppers (Smith 2001).

Diseases can cause severe losses in certain growing areas and during some seasons. The most important economic loss occurs as fruit rots in storage (Smith 2001). Powdery mildew and fire blight are the two most important diseases in most growing seasons (Smith 2001).

Pest management programs vary between states and even between counties depending on the conditions of growing areas and the pest types and pressures (Smith 2001). Most apple growers use a range of integrated pest management practices including pheromone disruption, timing of pesticide applications, and biological and cultural control methods to control insects, mites and pathogens. Chemical control is the main method used.

The pest control program for apples recommended by Washington State University Extension is presented in Table 3.1.

Table 3.1 Pest control program for apples recommended by Washington State University (Washington State University Extension 2009)

Apple stage/period	Pest/s to be controlled	Control materials (use any one of the listed material or combinations)
Dormant	San Jose scale	petroleum oil-dormant
Delayed-dormant	Apple mildew	myclobutanil triflumizole fenarimol kresoxim-methyl sulphur trifloxystrobin calcium polysulphide
	Apple scab	captan cyprodinil fenarimol kresoxim-methyl mancozeb sulphur myclobutanil trifloxystrobin triflumizole ziram metiram calcium polysulphide
	Cutworms	endosulfan chlorpyrifos indoxacarb methoxyfenozide
	European red mite	petroleum oil-dormant
	Grape mealybug	petroleum oil-dormant + diazinon chlorpyrifos + petroleum oil-dormant azinphos methyl + petroleum oil-dormant
	Aphid eggs, woolly apple aphids	petroleum oil-dormant + chlorpyrifos
	Lygus and stink bugs	endosulfan chlorpyrifos
	Leafrollers (Pandemis)	chlorpyrifos
	San Jose scale	petroleum oil-dormant + chlorpyrifos petroleum oil-dormant + methidathion petroleum oil-dormant + pyriproxyfen
Prepink	Apple mildew	calcium polysulphide myclobutanil fenarimol kresoxim-methyl trifloxystrobin triflumizole *Bacillus pumilus* strain QST 2808
	Apple scab	captan cyprodinil fenarimol kresoxim-methyl mancozeb sulphur

Apple stage/period	Pest/s to be controlled	Control materials (use any one of the listed material or combinations)
		myclobutanil trifloxystrobin ziram metiram triflumizole calcium polysulphide
	Cutworms	endosulfan indoxacarb methoxyfenozide
	Grape mealybug	azinphos methyl buprofezin thiacloprid acetamiprid
	Green apple aphid, apple grain aphid, rosy apple aphid	acetamiprid
	Green fruitworm	azinphos methyl
	Green apple aphid, apple grain aphid, rosy apple aphid	acetamiprid
	Green fruitworm	azinphos methyl
	Lygus and stink bugs	endosulfan diazinon
	Leaf rollers (Pandemis)	*Bacillus thuringiensis*
Pink	Apple mildew	calcium polysulphide myclobutanil fenarimol kresoxim-methyl trifloxystrobin triflumizole *Bacillus pumilus* strain QST 2808
	Apple rust mite	fenbutatin oxide spirodiclofen
	Apple scab	cyprodinil fenarimol kresoxim-methyl mancozeb sulphur myclobutanil trifloxystrobin triflumizole ziram metiram calcium polysulphide
	Campylomma	formetanate hydrochloride acetamiprid
	Codling moth	CM pheromone dispensers
	Lygus bug	endosulfan
	Leafrollers (Pandemis, obliquebanded)	*Bacillus thuringiensis*
	Rosy apple aphid	acetamiprid

Apple stage/period	Pest/s to be controlled	Control materials (use any one of the listed material or combinations)
Bloom	Campylomma	formetanate hydrochloride acetamiprid
	Fire blight	terramycin A-506 *Pseudomonas fluorescens*
	Leafrollers (Pandemis, obliquebanded)	*Bacillus thuringiensis* methoxyfenozide
	Codling moth	CM pheromone dispensers
Petal-fall	Apple mildew	fenarimol kresoxim-methyl calcium polysulphide sulphur myclobutanil trifloxystrobin triflumizole *Bacillus pumilus* strain QST 2808
	Apple scab	captan cyprodinil fenarimol kresoxim-methyl sulphur myclobutanil trifloxystrobin ziram metiram triflumizole
	Bull's eye rot	ziram captan
	Codling moth	methoxyfenozide pyriproxyfen novaluron chlorantraniliprole
	Rosy apple aphid	imidacloprid acetamiprid
	Spider mites	hexythiazox clofentezine bifenazate etoxazole pyridaben spirodiclofen fenpyroximate
	Grape mealybug	azinphos methyl imidacloprid acetamiprid clothianidin thiacloprid buprofezin
	Lygus bug	endosulfan
	Leafrollers (Pandemis, obliquebanded)	*Bacillus thuringiensis* methoxyfenozide pyriproxyfen spinosad

Apple stage/period	Pest/s to be controlled	Control materials (use any one of the listed material or combinations)
		novaluron emamectin benzoate spinetoram chlorantraniliprole
	Western tentiform leafminer	abamectin spinosad
	White apple leafhopper	endosulfan formetanate hydrochloride imidacloprid indoxacarb kaolin clay
	Western flower thrips	formetanate hydrochloride spinosad
14 – 28 days after full bloom	Apple mildew	fenarimol kresoxim-methyl myclobutanil trifloxystrobin triflumizole *Bacillus pumilus* strain QST 2808
	Apple scab	captan cyprodinil fenarimol kresoxim-methyl metiram myclobutanil trifloxystrobin ziram triflumizole
	Codling moth	chlorantraniliprole spinetoram acetamiprid + petroleum oil-summer thiacloprid petroleum oil-summer methoxyfenozide CM granulosis virus spinosad phosmet azinphos methyl
	White apple leafhopper	petroleum oil-summer imidacloprid indoxacarb kaolin clay potassium salts of fatty acids thiacloprid
	Rosy apple aphid	acetamiprid imidacloprid
Late spring and summer	Apple scab	captan cyprodinil fenarimol kresoxim-methyl myclobutanil trifloxystrobin

Apple stage/period	Pest/s to be controlled	Control materials (use any one of the listed material or combinations)
		triflumizole
	Apple rust mite	endosulfan
	Codling moth	azinphos methyl acetamiprid + petroleum oil-summer phosmet thiacloprid novaluron petroleum oil-summer methoxyfenozide CM granulosis virus spinetoram spinosad chlorantraniliprole
	Cutworms	endosulfan indoxacarb
	Spider mites	bifenazate etoxazole hexythiazox pyridaben spirodiclofen fenpyroximate
	Grape mealybug	azinphos methyl imidacloprid phosmet acetamiprid buprofezin clothianidin thiacloprid
	Grasshoppers	carbaryl
	Green apple aphid	imidacloprid acetamiprid endosulfan
	Lacanobia fruitworm	endosulfan indoxacarb kaolin clay methoxfenzozide spinosad
	Leafrollers (Pandemis, obliquebanded)	*Bacillus thuringiensis* methoxyfenozide spinosad novaluron emamectin benzoate spinetoram chlorantraniliprole
	San Jose scale	diazinon
	Shothole borer	endosulfan
	Stink bugs	endosulfan fenpropathrin lambda-cyhalothrin
	Western tentiform leafminer	abamectin

Apple stage/period	Pest/s to be controlled	Control materials (use any one of the listed material or combinations)
		spinosad
	White apple leafhopper	carbaryl endosulfan petroleum oil-summer imidacloprid indoxacarb kaolin clay
	Woolly apple aphid	endosulfan diazinon petroleum oil-summer
	Apple maggot	azinphos methyl phosmet acetamiprid
Pre-harvest	Apple maggot	phosmet acetamiprid
	Apple scab	captan ziram
	Bull's eye rot	captan ziram
	Storage rots	pyraclostrobin + boscalid ziram
	Codling moth	carbaryl acetamiprid + petroleum oil-summer spinetoram spinosad
	Leafrollers (Pandemis, obliquebanded)	*Bacillus thuringiensis*

3.4 Harvesting and handling procedures

In the PNW, while peak harvest occurs in September, harvesting can commence from mid August and continue until late October depending upon the variety and regional conditions (Washington Apple Commission 2007a). Apples are picked by hand, placed in bags and emptied into harvest bins (Washington Apple Commission 2007a). Harvest bins are usually made of either plywood or plastic. Standard bin size is approximately 1.1 cubic metres, holding approximately 450 kg of apple fruit (Tao 2003). Most Washington packers clean the bins only when the fruit is floated from the bins at the time of packing (Kupferman 1999).

3.5 Post-harvest

3.5.1 Packing house

Once the fruit have been harvested, the bins are taken to a packing house mostly by truck or tractor-trailers (Tao 2003). On receival at a packing house, fruit are randomly checked, lot by lot, for flesh firmness and soluble solids, the fruit attributes commonly used as indicators of fruit maturity and quality. Most packing houses in the PNW store, sort, box and ship apples most months of the year, using either a direct pack system or a presize system (Kupferman 1996). The direct pack system takes apples from the bin and, in one operation, they are sorted, sized and packed into shipping boxes. The presize system consists of two operations: apples are sorted and sized, and apples of different sizes and grades are placed into separate bins for packing at a later time (Kupferman 1996). While many sizes and grades are packed at the same time in the direct pack system, only one grade and size is packed at any one time in the presize system. Other operations are generally the same for both systems. The presize system allows a greater volume of fruit to be run at one time.

Packing house operations, in general, include the following steps (Kupferman 1996):

- Apples are removed from the bin. This is usually done by submersion of the bin under water. Apples floated out of the bin are transported in a water stream to a small fruit eliminator, where small apples are removed from the stream and conveyed to a cull bin.
- Remaining apples are rinsed and passed onto a sorting table where they are visually inspected, and defect fruit and unwanted items are discarded.
- Apples are moved back into water in single-file columns, passing through an electronic eye that sorts apples by colour, size and weight.
- Sorted apples are conveyed over revolving brushes and pass under fresh rinse water.
- Soap or detergent is applied and brushed onto the fruit.
- The fruit is again rinsed, then passes over sponge rollers and under fans to remove the water.
- Apple wax may be applied at this point.
- Fruit may go through a hot air dryer.
- Labels or stickers may be applied to the fruit at this point.
- Fruit are re-inspected and defect and unwanted items are removed.
- Fruit is placed onto trays by hand or automatically.
- Trays are placed into boxes, top pads applied and the box is weighed.
- In-house quality control and state/federal inspectors may examine the fruit at this point.
- The boxes are palletised and placed into cold storage held for shipment.

Apples may be stored before being packed, or after being packed, or both. They may be kept in refrigerated storage (0–2°C, depending on variety) or in controlled atmosphere (CA) storage (Kupferman 1996). Storage time may vary from 1 day to more than 11 months, depending on the quality of the fruit and the marketing program (Kupferman 1996). Approximately 35% of the fruit are kept in refrigerated storage for selling in the autumn and early winter, and the remainder is stored under CA storage for shipping from December to the following September (Smith 2001; US Apple Association 2001). The specific atmosphere for CA storage is set according to the variety and capability of the storage facility (Kupferman 2001). For example, optimum levels for CA storage in Washington State were reported to be 1.5% oxygen, 0.5% carbon dioxide, 0–1°C for Braeburn and Granny Smith; 2.0% oxygen, 0.5% carbon dioxide, 1°C for Fuji; and 2% oxygen, 1.5% carbon dioxide, 0–1°C for Golden Delicious and Royal Gala (Kupferman 2001).

A fungicide, thiabendazole (TBZ), has been commonly used either as a drench treatment prior to storage or an online treatment at packing to control post-harvest diseases (Li and Xiao

2008), particularly those caused by *Penicillium* and *Botrytis* species (Smith 2001). However, losses due to fruit rots may still be excessive during some storage seasons (Smith 2001). Resistance to benzimidazole fungicides (benomyl or TBZ) was reported for fungal species associated with post-harvest diseases such as *Penicillium expansum*, the primary causal agent of blue mould (Rosenberger *et al.* 1991; Li and Xiao 2008). Two new fungicides registered in 2004 for post-harvest use on pome fruits in the US, fludioxonil and pyrimethanil, were recommended as effective in controlling blue mould (Li and Xiao 2008 and references therein). An antioxidant such as diphenylamine (DPA) is often used, in combination with fungicides as a pre-storage drench treatment, to cultivars susceptible to scald, a physiological disorder (Smith 2001; Li and Xiao 2008). Most isolates of *P. expansum* are, however, resistant to the DPA/benzimidazole combination (Sholberg *et al*. 2005).

Most packing lines are cleaned and sanitised daily. Storage rooms are cleaned and sanitised annually, when empty of fruit. Hot water delivered through a pressure hose is the most common method used (Kupferman 1999).

3.5.2 Export procedures

In the US, apple is one of the commodities which require inspection and have minimum grade and size requirements (USDA 2002). Apples for export need to meet the US Condition Standards for Export, including degrees of maturity, physical injury, injury from pests and disorders, and packing requirements (USDA 2002). The Fruit and Vegetable Inspection Program, within the Commodity Inspection Division of Washington State Department of Agriculture, provides verification services of product quality, condition, and volume as well as certification on the freedom from quarantine pests and diseases for international export markets. The program operates on delegated authority from USDA through the agencies of the Agricultural Marketing Service and APHIS.

3.5.3 Transport

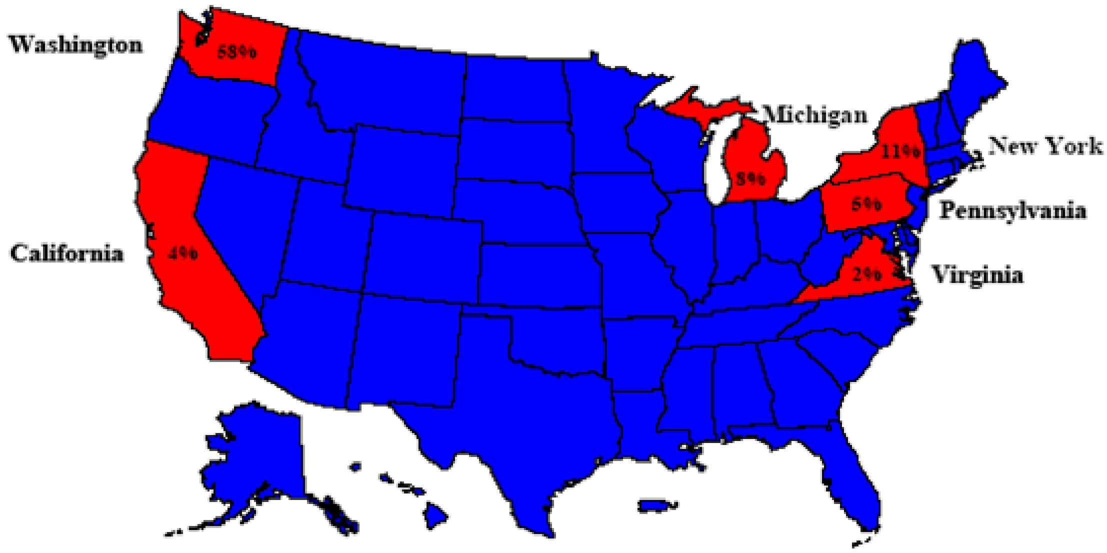
Apples from the PNW for export are usually transported in refrigerated trucks to export ports such as in Seattle, Tacoma and Portland. The commodity may be transported to Australia by air or ship. This travel is estimated to take a minimum of 1–3 weeks.

3.6 Export capability

3.6.1 Production statistics

Apple production in the US is valued at more than US$2.5 billion each year. It is regarded as the third most valuable horticultural crop in the US, after grapes and oranges (Geisler 2008). Total production in 2007 was approximately 4.13 million metric tonnes (USDA/NASS 2008). More than 60% of the apples produced are marketed as fresh fruit (Geisler 2008). Apples are grown in every state in the continental US; the major six apple producing states are Washington (58%), New York (11%), Michigan (8%), Pennsylvania (5%), California (4%) and Virginia (2%) (USDA/FAS 2006) (Figure 3.3). Apple production in 2007 from the top fifteen US states is listed in Table 3.2.

Figure 3.3 Map of the United States showing the major apple production states: Washington State, New York, Michigan, California, Pennsylvania and Virginia



Source: USDA/FAS (2006)

Table 3.2 Apple production in 2007 from the top fifteen US states

State	Million pounds[1]	Million kilograms[2]
Washington	5200.0	2358.7
New York	1310.0	594.2
Michigan	770.0	349.3
Pennsylvania	470.0	213.2
California	345.0	156.5
Virginia	215.0	97.5
Oregon	135.0	61.2
West Virginia	80.0	36.3
North Carolina	60.0	27.2
Wisconsin	59.0	26.8
Ohio	55.6	25.2
New Jersy	42.0	19.1
Maine	40.0	18.1
Massachusetts	38.5	17.5
Vermont	38.0	17.2
United States	9113.9	4134.0

[1]: sourced from USDA/NASS (2008)
[2]: converted data

In 2007, Washington State produced approximately 2.36 million metric tonnes of apples (USDA/NASS 2008). Washington's major apple producing areas are located in the east of the Cascade Mountains, including the Yakima Valley, Wenatchee and the Columbia Basin (USDA/NASS 2006b) (Figure 3.1).

Oregon produced 61 235 metric tonnes of apples in 2007 (USDA/NASS 2008). In Oregon, apples are grown state wide. However, the major producing areas are in Umatilla, Hood River and Wasco Counties (Thomson *et al.* 1999).

Idaho produced 15 876 metric tonnes of apples in 2007 (USDA/NASS 2008). Main apple producing areas in Idaho are the southwestern counties of Canyon, Gem, Owhyee, Payette and Washington as well as the south central counties of Jerome and Twin Falls (Colt *et al.* 2001).

3.6.2 Export statistics

The US is the world's fourth largest apple exporter behind the European Union, China and Chile (USDA/FAS 2007). In 2007, approximately 16% of the US apple production was exported (Geisler 2008; USDA/NASS 2008). The largest exporting state is Washington. Major export markets are Mexico, Canada, Taiwan, the United Kingdom, Indonesia, India and Hong Kong (Geisler 2008).

3.6.3 Export season

In the PNW, apples are harvested from mid August to end of October depending on cultivars and climate conditions of the production areas (Smith 2001). The US exporters and Australian importers have predicted that most volume would be shipped between harvest (August – October) and the New Year, although the US requested the market to be open all twelve months.

4 Pest risk assessments for quarantine pests

Quarantine pests associated with mature fresh apple fruit from the US are identified in Appendix A. This chapter assesses the probability of the entry, establishment and spread of these pests and the likelihood of associated potential economic consequences.

Pest categorisation identified 51 quarantine pests (31 arthropods and 20 pathogens) associated with mature fresh apple fruit from the US PNW states; 43 pests are of national concern and eight pests are of regional concern. Table 4.1a identifies these quarantine pests and full details of the pest categorisation are provided in Appendix A. Assessments of risks associated with these pests are presented in sections 4.1–4.31.

Pest categorisation also identified ten arthropods, one bacterium, three fungi and one complex of fungi as quarantine pests associated with apple fruit from the US, but currently not recorded in the PNW. Table 4.1b identifies these pests and full details of the pest categorisation are provided in Appendix A. There is no evidence of official control measures in place to prevent the spread of these pests into the PNW. Therefore, risks associated with these pests were considered in this IRA. These are presented in sections 4.32–4.38.

Pest risk assessments already exist for some of the pests considered here as they have been assessed previously by Biosecurity Australia. There are three types of existing assessments for pests considered in this IRA report.

The first type is where there is no change to the risk ratings from previous assessments (for example, fire blight, European canker and apple scab).

The second is where there is a change to the likelihood of entry (importation and/or distribution) from previous assessments due to differences in the commodity and/or country assessed (for example, Grapholita moths and codling moth).

The third is where an assessment was carried out before the introduction of Biosecurity Australia's current risk assessment method (for example, apple fruit moth and apple scar skin viroid).

The three types of assessments are reflected in the introduction and layout of the risk assessments that follow. To highlight the pests for which previous assessments have led to the establishment of existing policy, the superscript '**EP**' has been used.

Some pests identified in this assessment have been recorded in some regions of Australia, and due to interstate quarantine regulations are considered pests of regional concern. These organisms are identified with a superscript, such as '**WA**', for the state for which the regional pest status is considered.

Table 4.1a Quarantine pests for apple fruit from the US Pacific Northwest states (Washington, Oregon and Idaho). Pests are listed according to their taxonomic classification, consistent with Appendix A.

Pest	Common name
DOMAIN BACTERIA	
Fire blight (Enterobacteriales: Enterobacteriaceae)	
Erwinia amylovora (Burrill 1882) Winslow *et al*. 1920	Fire blight [EP]
DOMAIN EUKARYA	
Flat scarlet mite (Acariformes: Tenuipalpidae)	
Cenopalpus pulcher (Canestrini & Fanzago, 1876)	Flat scarlet mite
Spider mites (Acariformes: Tetranychidae)	
Tetranychus mcdanieli McGregor, 1931	McDaniel spider mite
Tetranychus pacificus McGregor, 1919	Pacific spider mite
Tetranychus turkestani (Ugarov & Nikolskii, 1937)	Strawberry spider mite
Apple curculio (Coleoptera: Curculionidae)	
Anthonomus quadrigibbus Say, 1831	Apple curculio
Apple leafcurling midge (Diptera: Cecidomyiidae)	
Dasineura mali Kieffer, 1904	Apple leafcurling midge [EP]
Apple maggot (Diptera: Tephritidae)	
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
Chaff scale (Hemiptera: Diaspididae)	
Parlatoria pergandii Comstock, 1881	Chaff scale [WA, EP]
Mealybugs (Hemiptera: Pseudococcidae)	
Phenacoccus aceris (Signoret, 1875)	Apple mealybug [EP]
Pseudococcus maritimus (Ehrhorn, 1900)	Grape mealybug [EP]
Dock sawfly (Hymenoptera: Tenthredinidae)	
Ametastegia glabrata (Fallén, 1808)	Dock sawfly [WA]
Leafroller moths (Lepidoptera: Tortricidae)	
Archips argyrospila (Walker, 1863)	Fruit tree leafroller
Archips podana (Scopoli, 1763)	Great brown twist moth, large fruit tree tortrix
Archips rosana (Linnaeus, 1758)	European leafroller
Argyrotaenia franciscana (Walsingham, 1879)	Orange tortrix, tortrix citrana
Choristoneura rosaceana (Harris, 1841)	Oblique-banded leafroller
Hedya nubiferana (Haworth, 1811)	Green budworm
Pandemis heparana (Denis & Schiffermüller, 1775)	Dark fruit tree tortrix
Pandemis pyrusana Kearfott, 1907	Pandemis leafroller
Spilonota ocellana (Denis & Schiffermüller, 1775)	Eyespotted bud moth
Apple fruit moth (Lepidoptera: Yponomeutidae)	
Argyresthia conjugella Zeller, 1839	Apple fruit moth [EP]
Codling moth (Lepidoptera: Tortricidae)	

Pest	Common name
Cydia pomonella (Linnaeus, 1758)	Codling moth [WA, EP]
Grapholita moths (Lepidoptera: Tortricidae)	
Grapholita molesta (Busck, 1916)	Oriental fruit moth [WA, EP]
Grapholita packardi Zeller, 1875	Cherry fruitworm
Grapholita prunivora (Walsh, 1868)	Lesser appleworm
Lacanobia fruitworm (Lepidoptera: Noctuidae)	
Lacanobia subjuncta (Grote & Robinson, 1868)	Lacanobia fruitworm
Thrips (Thysanoptera: Thripidae)	
Frankliniella occidentalis (Pergande, 1895)	Western flower thrips
Frankliniella tritici (Fitch, 1855)	Eastern flower thrips
DOMAIN FUNGI	
Coprinus rot (Agaricales: Psathyrellaceae)	
Coprinopsis psychromorbida (Redhead & Traquair) Redhead, Vilgalys & Moncalvo	Coprinus rot
Apple blotch (Dothideales: Botryosphaereaceae)	
Phyllosticta arbutifolia Ellis & G. Martin	Apple blotch [EP]
Sphaeropsis rot (Dothideales: Botryosphaereaceae)	
Sphaeropsis pyriputrescens C.L. Xiao & J.D. Rogers	Sphaeropsis rot
Hawthorn powdery mildew (Erysiphales: Erysiphaceae)	
Podosphaera clandestina (Wallr.:Fr) Lév.	Hawthorn powdery mildew
Bull's eye rot (Helotiales: Dermateaceae)	
Cryptosporiopsis curvispora (Peck) Gremmen	Bull's eye rot, anthracnose
Cryptosporiopsis perennans (Zeller & Childs) Wollenw.	Bull's eye rot, perennial canker [WA]
Phacidiopycnis and speck rot (Helotiales: Incertae sedis)	
Phaciodiopycnis piri (Fuckel) Weindlm.	Phacidiopycnis rot
Phacidiopycnis washingtonensis C.L. Xiao & J.D. Rogers	Speck rot
European canker (Hypocreales: Nectriaceae)	
Neonectria ditissima (Tul. & C. Tul.) Samuels & Rossman	European canker [EP]
Mucor rot (Mucorales: Mucoraceae)	
Mucor mucedo Fresen.	Mucor rot
Mucor piriformis E. Fisch.	Mucor rot [WA]
Mucor racemosus Fresen.	Mucor rot [WA]
Black pox (Pleosporales: Pleomassariaceae)	
Helminthosporium papulosum Anth. Berg	Black pox
Apple scab (Pleosporales: Venturiaceae)	
Venturia inaequalis (Cooke) G. Winter	Apple scab [WA, EP]
Thread blight (Tulasnellales: Ceratobasidiaceae)	
Ceratobasidium ochroleuca	Thread blight

Pest	Common name
Gymnosporangium rusts (Uredinales: Pucciniaceae)	
Gymnosporangium juniperi-virginianae Schwein.	Cedar apple rust
Gymnosporangium libocedri (Henn.) F. Kern	Pacific Coast pear rust
Truncatella leaf spot (Xylariales: Amphisphaeriaceae)	
Truncatella hartigii (Tubeuf) Steyaert	Truncatella leaf spot
Tobacco necrosis viruses	
Tobacco necrosis virus A, Tobacco necrosis virus D, tobacco necrosis virus Nebraska isolate and related viruses	Tobacco necrosis viruses
Apple scar skin	
Apple scar skin viroid	Apple scar skin, dapple apple [EP]

[WA]: Quarantine pest for state of Western Australia

[EP]: Species has been assessed previously and for which import policy already exists

Table 4.1b Quarantine pests for apple fruit from the US, currently not recorded in the Pacific Northwest states (Washington, Oregon and Idaho).* Pests are listed according to their taxonomic classification, consistent with Appendix A.

Pest	Common name
DOMAIN BACTERIA	
Blister spot (Pseudomonadales: Pseudomonadaceae)	
Pseudomonas syringae pv. *papulans* (Rose 1917) Dhanvantari 1977	Blister spot
DOMAIN EUKARYA	
Armoured scales (Hemiptera: Diaspididae)	
Lopholeucaspis japonica (Cockerell, 1897)	Japanese baton shaped scale
Parlatoria oleae (Colvée, 1880)	Olive parlatoria scale [WA]
Mealybugs (Hemiptera: Pseudococcidae)	
Pseudococcus calceolariae (Maskell, 1879)	Citrophilus mealybug [WA, EP]
Pseudococcus comstocki (Kuwana, 1902)	Comstock's mealybug [EP]
Leafroller moths (Lepidoptera: Tortricidae)	
Argyrotaenia velutinana (Walker, 1863)	Redbanded leafroller
Platynota flavedana Clemens, 1860	Variegated leafroller, Rusty brown tortricid
Platynota idaeusalis (Walker, 1859)	Tufted apple budworm
Platynota stultana Walsingham, 1884	Omnivorous leafroller
Pseudexentera mali Freeman, 1942	Pale apple leafroller
European corn borer (Lepidoptera: Pyralidae)	
Ostrinia nubilalis (Hübner, 1796)	European corn borer
DOMAIN FUNGI	
Sooty blotch and flyspeck complex (Capnodiales)	
Colletogloeum sp. (FG2.1, FG2.2, FG2.3)	Sooty blotch and flyspeck complex
Dissoconium sp. (DS1.1, DS1.2, DS2, FG4, FG5)	
Mycelia sterilia (RS1, RS2)	
Passalora sp. FG3	
Peltaster fructicola E.M. Johnson, T.B. Sutton & Hodges	
Peltaster sp. (P2.1, P2.2, CS1)	
Pseudocercospora sp. (FS4, FG1.1, FG1.2)	
Pseudocercosporella sp. (RH1, RH2.1, RH2.2)	
Ramularia sp. P5	
Xenostigmina sp. (P3, P4)	
Zygophiala cryptogama Batzer & Crous	
Zygophiala tardicrescens Batzer & Crous	
Zygophiala wisconsinensis Batzer & Crous	
Geastrumia polystigmatis Bat. & M.L. Farr	

Pest	Common name
Gymnosporangium rusts (Uredinales: Pucciniaceae)	
Gymnosporangium clavipes (Cooke & Peck) Cooke & Peck	Quince rust
Gymnosporangium globosum (Farl.) Farl.	Hawthorn rust
Gymnosporangium yamadae Miyade ex G. Yamada	Japanese apple rust

*: There is no evidence of official control measures in place to prevent the spread of these pests into the PNW. Therefore, risks associated with these pests were considered in this IRA. They are presented in sections 4.31–4.37.

[WA]: Quarantine pest for state of Western Australia

[EP]: Species has been assessed previously and for which import policy already exists

Assessments for quarantine pests recorded in the PNW

4.1 Fire blight

Erwinia amylovora

Fire blight is a bacterial disease of apple, pear and other rosaceaous hosts caused by *Erwinia amylovora* (Beer 1990). *Erwinia amylovora* is a significant economic pest that has caused serious devastation to the world's apple and pear industries and to ornamental plantings of some Rosaceae (Bonn 1999; Vanneste 2000). It is also a serious pathogen of quince and loquat (CABI 2007).

Most of the affected hosts belong to the subfamily Maloideae of the familiy Rosaceae (CABI 2007). Plants belonging to the subfamilies Rosoideae and Amygdaloideae can also be affected (Momol and Aldwinckle 2000).

Fire blight is considered to be of American origin and by the 1900s, it had spread to most areas in the US where apples and pears are grown (Douglas 2006). It spread northward from California into Washington, Oregon and Idaho early in the 1900s (Bonn and van der Zwet 2000). It is considered one of the most serious diseases in modern apple production in Washington (Smith 2001).

Erwinia amylovora was detected on *Cotoneaster* in the Melbourne Royal Botanic Garden in 1997, and its eradication was confirmed by a national survey conducted over three years (Rodoni *et al*. 1999; Jock *et al*. 2000).

Although outbreaks of fire blight are sporadic, they often result in significant losses when they do occur. For example, a US$42 million total economic loss has been reported, and 350 000–450 000 apple trees had to be removed, for the outbreak in Michigan in 2000. For the 1998 outbreaks in Washington and northern Oregon, losses over US$69 million have been reported (Douglas 2006). A single severe outbreak can disrupt orchard production for several years (Vanneste 2000).

A susceptible host, a virulent pathogen and favourable weather conditions are required for a disease outbreak to occur (Beer 1990). Current orchard management practices, and the market demand for new apple varieties that are highly susceptible to fire blight, seem to lead to more frequent and devastating outbreaks (Douglas 2006).

Disease outbreaks occurred in Michigan in 1991 and 2000, in Connecticut, throughout New England and New York in 2000 and 2001, and in Washington and northern Oregon in 1998 (Douglas 2006). There have been minor limited outbreaks in apple orchards in Washington almost every season since 1991, and serious damage in about 5–10% of the orchards in 1993, 1997 and 1998 (Smith 2009).

Primary hosts are pome fruit, including *Cydonia* spp. (quince), *Malus* spp. (apple) and *Pyrus* spp. (pear), and rosaceous ornamentals, including *Cotoneaster* spp. (cotoneaster), *Crataegus* spp. (hawthorn), *Pyracantha* spp. (firethorn) and *Sorbus* spp. (mountain ash, rowan) (Beer 1990; Douglas 2006; CABI 2007).

Erwinia amylovora infects flowers, fruit, leaves, stems and woody plant parts. Affected plant parts appear scorched by fire. Ooze, a watery exudate produced by infected plant parts under humid conditions, is a typical sign of the pathogen (Beer 1990). Symptoms on infected fruit differ depending on when the fruit was infected. They range from fruit showing red, brown or black lesions to fruit being very small, shrivelled and dark, and firmly attached to the cluster base. Infection of succulently growing vegetative tissues often produces a characteristic shepherd's crook symptom (Beer 1990). The pathogen can cause five types or phases of infection during an outbreak: canker, blossom, shoot, trauma and rootstock blight (Douglas 2006).

The bacterium is readily spread by wind, rain, insects and human activities, including dissemination through planting material (Beer 1990; Douglas 2006). It is capable of growing between 6ºC and 36ºC with optimum temperatures for growth being 25ºC to 27.5ºC (Billing *et al.* 1961).

Erwinia amylovora overwinters almost exclusively in previous season's cankers (Beer and Norelli 1977). In spring, it multiplies at the margins of cankers and the adjacent bark tissues giving rise to primary inoculum. Rain or insects can disseminate the bacterium to infection courts, typically open flowers, growing vegetative shoot tips or young leaves (Beer 1990). The bacterium enters the host through wounds or, in the presence of sufficient moisture, through natural openings (nectaries, hydathodes or lenticels) (Beer 1990; Thomson 2000). Secondary cycles of disease may occur on later-opening flowers, vegetative shoots or fruit (Beer 1990). Bees are the primary agents for secondary spread of inoculum from infested flowers to newly opened ones (Thomson 2000).

Erwinia amylovora can live as an epiphyte growing and multiplying on plant surfaces, regardless of whether the plant is resistant or susceptible to infection (Douglas 2006). As a result, fruit sourced from infected orchards have the potential to carry epiphytic bacteria in the remnant flower parts present at the calyx-end of the fruit (Hale *et al.* 1987). There is evidence that the bacterium can survive in a viable but nonculturable state and is able to regain its culturability and pathogenicity (Ordax *et al*. 2009). Endophytic infections in fruit are rare (van der Zwet *et al*. 1990).

Management practices for the control of fire blight include removing primary and secondary sources of inoculum, monitoring weather factors in the orchard, applying bactericides, following appropriate cultural practices and using resistant varieties (Douglas 2006).

The risk posed by *Erwinia amylovora* is that fruit which carry epiphytic bacteria may be exported and result in the establishment of this pathogen in Australia.

Erwinia amylovora was assessed in the Final Import Risk Analysis Report for Apples from New Zealand (Biosecurity Australia 2006a). In that assessment, the overall probability of entry, establishment and spread was assessed to be 'very low' using a semiquantitative method and the consequences assessed to be 'high'. As a result, the unrestricted risk was assessed to be 'low' and specific risk management measures were determined to be necessary.

Erwinia amylovora is abundant in the PNW (Douglas 2006). The likelihood of *E. amylovora* occuring epiphytically on mature, symptomless apple fruit is comparable to that for New Zealand. The timing of imports of apples from the US coincides with the flowering period of rosaceous hosts in Australia, a particularly receptive stage for *E. amylovora* infections (Thomson 2000). Pest management procedures for this pathogen (including sorting, packing and shipping procedures) are similar for both countries. Transport of apple fruit from the US will normally take longer than from New Zealand. However, *E. amylovora* has been shown to survive cold storage for months (Sholberg *et al*. 1998). For these reasons, Biosecurity Australia considers that the probability of importation of *E. amylovora* on apple fruit from the PNW would be in the same range as that for apple fruit from New Zealand. Factors affecting the distribution of the commodity (and with it the pathogen) in Australia are similar for both countries. The probability of establishment and of spread of *E. amylovora* in Australia, and the consequences it may cause will be the same for any commodity with which the species is imported into Australia. Therefore, the existing pest risk assessment for *E. amylovora* is proposed for the importation of apple fruit from the PNW as the unrestricted risk estimate is considered to be in the same range.

4.1.1 Unrestricted risk estimate

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 12.

Biosecurity Australia considers the unrestricted risk of *E. amylovora* through the importation of apple fruit from the PNW is the same as the risk of this pathogen through the importation of apple fruit from New Zealand. Therefore, the existing pest risk assessment for *E. amylovora* has been adopted for the importation of apple fruit from the PNW.

Unrestricted risk estimate for *Erwinia amylovora*	
Overall probability of entry, establishment and spread	Very low
Consequences	High
Unrestricted risk	Low

As indicated, the unrestricted risk estimate for *Erwinia amylovora* has been assessed as ‘low’, which is above Australia’s ALOP. Therefore, specific risk management measures are required for this pest.

4.2 Flat scarlet mite

Cenopalpus pulcher

Cenopalpus pulcher belongs to the family Tenuipalpidae. It has five life stages: egg, larval, two nymph stages (protonymphal and deutonymphal) and adult (Zaher *et al.* 1974). The scarlet-coloured adult females are about 0.32 mm long and 0.16 mm wide (Dosse 1953; Jeppson *et al*. 1975; Bajwa *et al.* 2001). The adult males are shorter and paler than the females, and their abdomens are almost transparent and curving upward (Dosse 1953). Females deposit eggs on the striations and natural pits and grooves of leaves, buds, and fruits of apples and other trees (Zaher *et al*. 1974; Bajwa and Kogan 2003). *Cenopalpus pulcher* is arrhenotokous, i.e. unfertilised eggs develop into haploid males (Zaher *et al*. 1974).

Mating occurs through summer until late summer/autumn (Dosse 1953; Zaher *et al*. 1974). *Cenopalpus pulcher* produces one generation in a year in cool-temperate climates such as those of Germany (Dosse 1953) and Oregon (Bajwa and Kogan 2003) and up to three generations in a year in warm-temperate or mediterranean climates such as those of Egypt (Zaher *et al.* 1974) or Iraq (Elmosa 1971). Before winter, the short-lived males die, while females enter hibernation as adults or nymphs (Dosse 1953; Elmosa 1971).

Cenopalpus pulcher may cause stippling of injured tissue, leaf and fruit drop or twig die-back (Jeppson *et al*. 1975). The mite can also feed on fruit (Bajwa and Kogan 2003).

The risk posed by *Cenopalpus pulcher* is that eggs, larvae, nymphs or adults, including fertilised females, may be found on imported apple fruit.

4.2.1 Probability of entry

Probability of importation

The likelihood that *Cenopalpus pulcher* will arrive in Australia with the importation of the commodity: **HIGH**.

Supporting information for this assessment is provided below:

- *Cenopalpus pulcher* is present in at least seven counties in Oregon, principally in the Willamette Valley (USDA-APHIS 2000a; Bajwa *et al*. 2001). There, it has become a dominant mite species (USDA-APHIS 2000a).
- Apple is a major host for *C. pulcher* throughout its natural range (CABI 2007).
- Females may oviposit in grooves and pits of fruits (Zaher *et al.* 1974; Bajwa and Kogan 2003). Nymph and adult stages can feed on fruit (Bajwa and Kogan 2003).
- Adult females of *C. pulcher* overwinter on structures remaining on trees during winter (Dosse 1953; Zaher *et al*. 1974), and are known to occur on fruit (Bajwa and Kogan 2003). Mites may shelter in the stem end and calyx of apple fruit before harvest.
- *Cenopalpus pulcher* is unlikely to be detected or dislodged from fruit by harvesting and grading activities because of its small size.

- Dormant adult female mites present on apples are likely to survive temperatures used in cold storage and during transportation to Australia, as they may survive temperatures as cold as -30°C in their native habitats (Jeppson *et al.* 1975).

The small size of the mite and the presence of eggs, larvae, nymphs and adults on apple fruit support a risk rating for importation of 'high'.

Probability of distribution

The likelihood that *Cenopalpus pulcher* will be distributed in Australia, in a viable state, as a result of the processing, sale or disposal of the commodity: **MODERATE**.

Supporting information for this assessment is provided below:

- Apple fruit destined for human consumption, the mites may stay on the fruit during wholesale and retail distribution in Australia. Mites present on apples are likely to occupy sheltered positions, such as the stem end and the calyx.
- The cores of apple fruit, including the stem end and calyx, are not normally consumed by humans and are disposed of as waste.
- Apple waste products disposed of as municipal waste and compost are unlikely to distribute *C. pulcher* into the environment.
- Apple waste disposed of as litter may be deposited into urban, peri-urban and agricultural situations, as well as areas of natural vegetation, throughout Australia.
- *Cenopalpus pulcher* cannot fly and is unlikely to move from fruit waste to a host by crawling because of its small size. However, *C. pulcher* (especially nymphs) may be able to access hosts in the environment via air currents (Pedgley 1982).
- Most of the above environments are known to contain suitable hosts, including fruit crops such as *Corylus avellana* (hazel), *Cydonia oblonga* (quince), *Juglans regia* (walnut), *Malus pumila* (apple), *Prunus armeniaca* (apricot), *Prunus domestica* (plum), *Punica granatum* (pomegranate), *Pyrus communis* (pear) and *Vitis vinifera* (grape) (Elmosa 1971; USDA-APHIS 2000a; Mazzone and Ragozzino 2006) and amenity trees such as *Platanus orientalis* (plane) and *Salix* spp. (willow) (USDA-APHIS 2000a) which are commonly found in temperate and irrigation areas of southern Australia (Hnatiuk 1990).

The wide distribution and availability of hosts, moderated by the limited mobility of *C. pulcher*, support a risk rating for distribution of 'moderate'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that *Cenopalpus pulcher* will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **MODERATE**.

4.2.2 Probability of establishment

The likelihood that *Cenopalpus pulcher* will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **HIGH**.

Supporting information for this assessment is provided below:

- Overwintering populations of *C. pulcher* are adult females, which produce successive generations the following spring (Dosse 1953; Zaher *et al*. 1974). Individuals distributed in Australia via apples from the US are likely to be gravid females capable of establishing a new generation from very few founders.

- *Cenopalpus pulcher* is capable of feeding on a range of fruit crops and amenity trees widely planted in southern areas of Australia (see Appendix B). Host availability, especially in urban and rural areas, is high in southern Australia (Hnatiuk 1990).

- *Cenopalpus pulcher* populations occur in a range of climatic zones, including arid tropical and subtropical in north Africa, arid subtropical and warm temperate in the Middle East, and from cold temperate to subarctic in the Middle East, north Asia and eastern Europe. Within Australia, *C. pulcher* may be capable of occupying a range of habitats in subtropical and temperate areas where suitable hosts also grow, often as naturalised plants (Hnatiuk 1990).

- Developmental time for a single generation of *C. pulcher* (egg to mature adult) is 38.3 days at an average temperature of 25.5°C, and 25.8 days at an average temperature of 29.2°C. Pairing occurs soon after adult emergence and both sexes pair more than once (Zaher *et al.* 1974).

- The number of generations completed by *C. pulcher* varies according to climate. Populations in cold temperate Europe complete one generation annually (Jeppson *et al.* 1975), while as many as three may be completed in warm temperate, mediterranean or subtropical climates in Iran and Iraq (Elmosa 1971; Zaher *et al*. 1974; Jeppson *et al*. 1975). Populations of *C. pulcher* introduced to Australia may be capable of breeding in most months of the year, especially in mediterranean and subtropical areas.

- The presence of *C. pulcher*, if introduced to Australia, may not be immediately identified, as its feeding damage is similar to that produced by other agricultural pests. This is especially true of populations establishing on feral fruit trees in regional areas, or on amenity plantings. This may allow populations of *C. pulcher* to rapidly reach high numbers before being detected.

- Control measures for *Tetranychus urticae* and other *Tetranychus* spp. in orchards in Australia may have some impact on the establishment of *C. pulcher*, but these measures are not commonly used in home gardens and amenity plantings, or on feral trees, or weeds.

The availability of hosts, its adaptability to a wide range of climates and its high reproductive rate, support a risk rating for establishment of ‘high’.

4.2.3 Probability of spread

The likelihood that *Cenopalpus pulcher* will spread based on a comparison of factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pest: **MODERATE**.

Supporting information for this assessment is provided below:

- *Cenopalpus pulcher* occurs in many subtropical and temperate parts of Asia, Europe, North America and Africa (Jeppson *et al.* 1975). This indicates that there would be suitable environments for its spread in subtropical and temperate regions of Australia.

- Host plants are widely grown in all states of Australia. The distribution of hosts by the roadside and in home gardens, parks and orchards could assist the spread of this mite.
- Geographical areas such as arid regions between the western and eastern parts of Australia could be natural barriers for the spread of *C. pulcher*.
- Crawling is the common mode of movement of the mite on host plants. This restricted mobility may limit its ability to spread.
- First instar nymphs of *C. pulcher* may be able to access hosts in the environment via air currents (Pedgley 1982). However, there is no strong evidence that the mite has been transferred over long distances by unaided dispersal mechanisms (USDA-APHIS 2000a).
- The movement of vegetative propagative material, such as nursery stock or budwood, could be a means of dispersal (USDA-APHIS 2000a).
- Apples and other fruits for human consumption would be distributed around the country. Such human assisted distribution would lead to spread of the mite.
- Known natural enemies of *C. pulcher* are predatory mites. Of the predatory mites known to associate with *C. pulcher* (Bajwa *et al*. 2001; Bajwa and Kogan 2003), only *Typhlodromus pyri* is established in Australia (Halliday 1998), where it is a biological control agent. This relative lack of natural enemies may allow populations of *C. pulcher* to increase without regulation.

The wide distribution of hosts and the ability of first instar nymphs to be carried by wind currents moderated by the restricted mobility of the mite and the lack of evidence of unaided dispersal over long distances, support a risk rating for spread of 'moderate'.

4.2.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *Cenopalpus pulcher* will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **LOW**.

4.2.5 Consequences

The consequences of the establishment of *Cenopalpus pulcher* in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision described in Table 2.4 on page 12, that is, where the consequences of a pest with respect to one or more criteria are '**E**', the overall consequences are estimated to be **MODERATE**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**E – Significant at the regional level:** *Cenopalpus pulcher* feeds on many host plants including apple, pear, quince, loquat, walnut, oriental sycamore, apricot, prune, pomegranate and willow (USDA-APHIS 2000a). It feeds on leaves, soft twigs and fruits (Bajwa and Kogan 2003). Although *C. pulcher* is an occasional pest of neglected apple, pear, prune, and walnut trees in England and Europe (Jeppson *et al*. 1975) and is considered unlikely to become economically damaging in northern North America (Mahr 2001), it seriously damages apple, pear and other fruit trees in China (Wang 1981), is a very dangerous pest of quince trees in Georgia (Arabuli and Tskitshvili 2008), is the most dominant and economically important mite on pear trees in Egypt (Osman and Mahmoud 2008), and was included among the six most injurious mite species associated with economic plants in Iran (Rahmani *et al*. 2008).
Other aspects of the environment	**B – Minor significance at the local level:** There are no known direct consequences of this pest on any other aspects of the environment but its introduction into a new environment may lead to competition for resources with native species.
Indirect	
Eradication, control etc.	**D – Significant at the district level:** Indirect effects of eradication or control as a result of the introduction of *C. pulcher* may include: (i) additional cost of crop monitoring and consultative advice to producers; (ii) an increase in the use of acaricides for control of the pest due to the unclear critical time of application; (iii) disruption to integrated pest management; (iv) potential to develop resistance to acaricides as a result of the use of numerous acaricides to control *C. pulcher* and other mites; (v) use of additional control measures and impacts on existing production practices that could alter the economic viability of some crops.
Domestic trade	**D – Significant at the local level:** If *C. pulcher* is established in Australia, it is likely to result in some interstate trade restrictions on many commodities such as apple, pear, apricot, loquat, plum, pomegranate and quince. This could lead to loss of markets or additional costs to manage the pest on the commodities.
International trade	**D – Significant at the local level:** The presence of *C. pulcher* in commercial production areas of a wide range of commodities (e.g. apple, pear, apricot, loquat, plum, pomegranate and quince) may limit access to overseas markets where this pest is not present. *Cenopalpus pulcher* is present in many countries in Asia and Europe.
Environmental and non-commercial	**B – Minor significance at the local level:** Additional pesticide applications would be required to control this pest on susceptible crops, which would have minor impact on the environment.

4.2.6 Unrestricted risk estimate

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 12.

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

As indicated, the unrestricted risk estimate for *Cenopalpus pulcher* has been assessed as ‘low’, which is above Australia’s ALOP. Therefore, specific risk management measures are required for this pest.

4.3 Spider mites[3]

Tetranychus mcdanieli*; *Tetranychus pacificus*; *Tetranychus turkestani

The spider mite species considered in this assessment are recognised as pests of apple production in the PNW states (Hoyt and Beers 1993; Colt *et al.* 2001; Smith 2001; Mellott and Krantz 2008). These species have been grouped together because of their related biology and taxonomy. They are predicted to pose a similar risk and require similar mitigation measures. The most economically important species of spider mite assessed here is *T. mcdanieli* (Hoyt and Beers 1993; Smith 2001). Unless explicitly stated otherwise, the information presented is considered 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 (Colt *et al.* 2001; Caprile *et al*. 2006). This disrupts a plant's ability to photosynthesise and consequently reduces the vitality of the plant (Colt *et al*. 2001; Berry 1998 in Hollingsworth 2008). Fruits may fail to colour and size properly, and yields for the following year may decrease (Caprile *et al.* 2006).

Adult spider mites range from 0.25–0.5 mm in length, and the accurate identification of each species can be difficult, often relying on examination of male genitalia. 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 (Smith 2001; Caprile *et al*. 2006; Berry 1998 in Hollingsworth 2008). Overwintering females emerge in early spring and lay eggs on the underside of leaves (Smith 2001). The eggs typically hatch within 4–6 days (Berry 1998 in Hollingsworth 2008) and adult female spider mites lay eggs continually until they die. A complete life cycle is 1–3 weeks (Berry 1998 in Hollingsworth 2008), with many overlapping generations in summer (Van de Vrie 1985; Smith 2001).

All *Tetranychus* species are capable of both sexual reproduction and parthenogenesis (development of an egg without the need for fertilisation), with unfertilised females being arrhenotokous, i.e. producing only male offspring (Helle and Pijnacker 1985).

While principally found on the leaves of host plants, spider mites may also be present on fruit, particularly if population densities are high (Hoyt and Beers 1993; Smith 2001).

The risk posed by the assessed spider mites is that juvenile (nymphal) or adult spider mites may be present on imported apple fruit.

4.3.1 Probability of entry

Probability of importation

The likelihood that the spider mites assessed will arrive in Australia with the importation of the commodity: **HIGH**.

[3] In this section, the common name spider mites will be used to refer to all three species. The scientific names will be used when the information is about a specific species.

Supporting information for this assessment is provided below:

- Spider mites are associated with apple production in the PNW states (Hoyt and Beers 1993; Colt *et al.* 2001; Mellott and Krantz 2008).
- Spider mite populations can rapidly increase, particularly in hot and dry conditions. Severe infestations can result in defoliation. Regular monitoring of spider mites and associated predators is recommended by crop monitors in the US (Caprile *et al.* 2006). 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 found primarily on the leaves of plants where they feed and lay eggs (Caprile *et al*. 2006; Berry 1998 in Hollingsworth 2008). However, they are highly mobile and can move onto all parts of the plant, especially when population densities are high (Kennedy and Smitley 1985).
- *Tetranychus mcdanieli* is prone to occur at the calyx end of apple fruit (Hoyt and Beers 1993; Smith 2001).
- 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.
- After packing, fruit is placed in cold storage.
- Transport of fruit to Australia would be either by air freight or by sea freight and would result in fruit being in transit for a minimum of 1–3 weeks.
- Female spider mites, as well as eggs, may overwinter and can survive sub-zero temperatures (Jeppson *et al*. 1975). This suggests that cold storage 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 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 packing house procedures and in-transit cold storage.

The small size of the mites and the presence of nymphs and adults in the calyx or stem-end of the apple fruit, support a risk rating for importation of ‘high’.

Probability of distribution

The likelihood that the spider mites assessed will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **MODERATE**.

Supporting information for this assessment is provided below:

- Spider mites associated with fruit are likely to be in the nymphal or adult life stage (Hoyt and Beers 1993; Smith 2001).
- Females that survive cold storage would be capable of laying eggs (Veerman 1985), but a suitable host would need to be located if a population were to be established. From the release of imported apple fruit at the point of entry to Australia, through to the retailing of

apple fruit, there would be limited opportunities where suitable hosts are likely to be in close proximity to the imported commodity.

- Apple fruit is destined for human consumption and the mites may stay on the fruit during wholesale and retail distribution in Australia. Mites present on apples are likely to occupy sheltered positions, such as the stem end and the calyx.
- The cores of apple fruit, including the stem end and calyx, are not normally consumed by humans and are disposed of as waste.
- *Tetranychus mcdanieli* and *T. pacificus* have a wide host range including *Acer* spp. (maples), *Asclepias* spp. (milkweed), *Asparagus* spp. (asparagus), *Ceanothus* spp. (California lilac), *Cucurbita* spp. (squashes and pumpkins), *Fragaria* spp. (strawberries), *Lonicera japonica* (Japanese honeysuckle), *Malus pumila* (apples), *Medicago sativa* (lucerne), *Morus* spp. (mulberries), *Phaseolus* spp. (beans), *Prunus* spp. (stone fruit), *Ribes* spp. (gooseberries and currants), *Rubus* spp. (blackberries and raspberries), *Syringa* spp. (lilacs), *Trifolium* spp. (clovers) and *Vitis vinifera* (grapevine) (Hoyt and Beers 1993; Baker and Tuttle 1994; Bolland *et al.* 1998). *Tetranychus turkestani* has been reported on most of these hosts and hundreds of other species (Bolland *et al.* 1998) (see Appendix B).
- Many of these hosts can be found in domestic gardens, in urban environments, as amenity plants, or naturalised in the environment as weeds. At the time of importation of the commodity, most of the deciduous hosts would be in leaf and receptive to spider mites.
- 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 for a reproductively viable population 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 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 fall out of the air currents fairly soon after they are carried aloft (Kennedy and Smitley 1985). The probability of mites dispersing from a colony surviving long enough from entry to locating a suitable host would be reduced when considering the short dispersal range.

The wide host range of the mites and the high potential prevalence of mites in apple calyces, and their ability to withstand the temperatures experienced during cold storage, moderated by the limited mobility of the mites, support a risk rating for distribution of 'moderate'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that the assessed spider mites will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **MODERATE**.

4.3.2 Probability of establishment

The likelihood that the assessed spider mites will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **HIGH**.

Supporting information for this assessment is provided below:

- 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) (see Appendix B).
- The spider mites in this assessment are found throughout the PNW states and across North America (Baker and Tuttle 1994). *Tetranychus mcdanieli* is also found in France (Bolland *et al*. 1998), and *T. turkestani* is widespread in Europe, Asia, and Africa (Bolland *et al.* 1998). The survival of these mites in a wide range of climates from cool coastal regions to hot, dry inland regions suggests that temperate and arid regions of Australia are likely to be suitable for the establishment of these species.
- Mites can reproduce both sexually and via parthenogenesis (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 for a population to develop. Parthenogenesis may enable a large population of male mites to develop quickly and thus increase the probability of finding a mate.
- Reproductively viable populations can start from a single mated female (Sabelis 1985a). Spider mites have many generations per year and each female can lay up to 100 eggs (Sabelis 1985a). This increases the ability of the mite to establish populations in small 'windows of opportunity' when conditions are suitable.
- 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 species that are considered resistant to mites (Gould 1979).
- Spider mite populations are often controlled by natural or introduced predators (Sabelis 1985b; Ohlendorf 2000). 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.

The availability of hosts, its adaptability to a wide range of climates and its high reproductive rate, support a risk rating for establishment of 'high'.

4.3.3 Probability of spread

The likelihood that the assessed spider mites will spread based on a comparison of factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pest: **MODERATE**.

Supporting information for this assessment is provided below:

- The assessed species have been reported from a variety of environments in North America, including the PNW states (Baker and Tuttle 1994). There are similar environments in temperate and arid Australia that would be suitable for their spread.
- Higher fecundity rates and reduced development times have been reported with increasing temperature and humidity in some *Tetranychus* species (Wrensch 1985). Additionally, spider mites can diapause to survive periods of unfavourable conditions such as cold winter temperatures (Veerman 1985). The comparatively warmer Australian environment may provide a larger range of suitable habitats for spider mites to expand in.
- 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.
- 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. However, 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.
- 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.

The ready availability of hosts, the ability to disperse by wind currents, moderated by the limited mobility of the mites, support a risk rating for spread of ‘moderate’.

4.3.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of ‘rules’ for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that the spider mites assessed will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in the PRA area and subsequently spread within Australia: **LOW**.

4.3.5 Consequences

The consequences of the establishment of the assessed spider mites in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision described in Table 2.4 on page 12, 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**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D – Significant at the district level:** The assessed spider mites can cause direct damage to host plants and are recognised agricultural pests requiring control measures. Some of the spider mites are 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. It is not known if the assessed spider mites could become pests of some native plant species, but given the wide host range of these pests this is highly likely.
Other aspects of the environment	**B – Minor significance at the local level:** There are no known direct consequences of the assessed spider mites on any other aspects of the environment but their introduction into a new environment may lead to competition for resources with native species.
Indirect	
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) increased costs for crop monitoring and consultative advice to producers; (ii) an increase in the use of acaricides for control of the pest due to difficulties involved in estimating optimum times for application; (iii) 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); (iv) additional applications of costly pesticides that may alter the economic viability of some crops; (v) increases in control measures and impacts on existing production practices; (vi) some of the reported natural enemies of spider mites such as the phytoseiid mites *Phytoseiulus persimilis or Neoseiulus fallacis*, predatory thrips and ladybird beetles (*Stethorus* species) which are present in Australia are adversely affected by acaricides/pesticides (Azam 2002); (vii) subsequent increases in costs of production 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. apples, 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.
Environmental and non-commercial	**B – Minor significance at the local level:** Additional pesticide applications would be required to control this pest on susceptible crops, which would have minor impact on the environment.

4.3.6 Unrestricted risk estimate

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 12.

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

As indicated, the unrestricted risk estimate for the assessed spider mites has been assessed as ‘very low’, which achieves Australia’s ALOP. Therefore, no specific risk management measures are required for these pests.

4.4 Apple curculio

Anthonomus quadrigibbus

Anthonomus quadrigibbus is a pest of apple and is present in all three of the exporting states assessed here.

Anthonomus quadrigibbus is a beetle of the weevil family Curculionidae and can be distinguished from other beetles by its long narrow rostrum which contains the chewing mouthparts at the apex. *Anthonomus quadrigibbus* has four life stages: egg, larva, pupa and adult. Adult weevils are 5–11 mm long, of which the rostrum can be one third to one half of the overall body length (Hammer 1936). *Anthonomus quadrigibbus* is reddish-brown, has four small humps on its back and lacks the white markings of the related plum curculio (*Conotrachelus nenuphar*). Mature larvae are the same size as adults, legless, and white with a brown head (MAL 2006). Larvae eat the apple’s pulp and seed (University of Missouri Extension 2008).

Feeding damage by adults appears as raised russeted areas on apple fruit (early season feeding injury) or as circular depressed areas around small, dark, corky spots or holes (late season feeding injury) (MAL 2006). Females lay eggs singly within the fruit pulp during May and June, where the larvae develop, pupate in the excavated cavity and emerge from the fruit as fully developed adults from mid-July to mid-August. It is also recorded that *A. quadrigibbus* pupates in the soil and debris around the base of trees (Davidson and Lyon 1979), and pupae may be spread with soil on products or machinery. Adults hibernate overwinter on the ground under debris near the host trees (MAFRI 2008; University of Missouri Extension 2008) and emerge the following spring when the ground temperature reaches 15.5°C (University of Missouri Extension 2008). Then, they mate and lay their eggs in small fruitlets (Crandall 1905; MAL 2006). This assessment considers that the highest risk will come from larvae that pupate inside the apple rather than exiting the apple to pupate in the soil.

Anthonomus quadrigibbus is associated with a wide range of plants in the Rosaceae, although *Malus* and *Crataegus* species are the usual host plants (Burke and Anderson 1989). *Crataegus* is a common host in eastern but not in western North America (CABI/EPPO 1997a). MAL (2006) also mentions pear, saskatoon, quince, cherry and crabapple (*Malus* spp.) are hosts.

The risk posed by *Anthonomus quadrigibbus* is that pupae and adults may be present within mature apple fruit (CABI/EPPO 1997a).

4.4.1 Probability of entry

Probability of importation

The likelihood that *Anthonomus quadrigibbus* will arrive in Australia with the importation of the commodity: **LOW**.

Supporting information for this assessment is provided below:

- *Anthonomus quadrigibbus* is widespread in the US and has been recorded from Washington, Oregon and Idaho (Burke and Anderson 1989).

- Apple and *Crataegus* species are the usual host plants (Burke and Anderson 1989). Apples serve as hosts in the eastern and midwestern regions of the weevil's range (CABI/EPPO 1997a).
- The fact that there is little recent information about *A. quadrigibbus* from North America suggests that modern insecticide treatment regimes have reduced it to minor significance (CABI/EPPO 1997a).
- Larvae feed primarily on the seeds (Burke and Anderson 1989), although they may be found in the flesh of the fruit (CABI/EPPO 1997a).
- A large portion of the infested fruit drops from the tree to the ground. However, some apples remain on the tree where larvae continue to develop successfully (CABI/EPPO 1997a). This reduces but does not eliminate the chance of infested fruit being harvested.
- Peak emergence occurs in late July or early August (University of Missouri Extension 2008) at the start of harvest in the PNW. In British Columbia, adults emerge from late July to early September (MAL 2006), while in New York, the last emerge in mid-September (Hammer 1936), well into harvest time.
- In Illinois, Crandall (1905) found the average duration for the larval stage to be 20 days and of the pupa to be approximately 7 days. The time taken from egg deposition to the start of emergence of the adults ranged from 27–48 days; the period of adult emergence occurred over 60 days.
- Adults cause feeding and egg laying damage to plant tissue (MAL 2006). Initial damage by adult *A. quadrigibbus* is visible as raised, russeted areas on apple fruit or as circular depressed areas around small, dark, corky spots or holes (MAL 2006). Such fruit would be noticed and removed during the harvesting, quality assurance and packing process.
- *Anthonomus quadrigibbus* larvae feed internally within the apple (Davidson and Lyon 1979; Campbell *et al*. 1989) and they would not be removed by external washing or brushing in the packing house.
- Sorting and grading would remove most of the damaged fruit since the presence of russetting, dark, corky spots or holes may be noticeable.
- Larval development and pupation occur in fruit that remain on the plant (MAFRI 2008) and larvae can also develop in mummified apples remaining on the tree (CABI/EPPO 1997a).
- Late instar larvae and adults overwinter in apples, in the ground, or under litter in areas with cold climates such as that found in northern US (including Washington and Oregon) and southern Canada (British Columbia, Manitoba, Ontario and Saskatchewan) (MAFRI 2008). This suggests that they can survive cold storage and low-temperature transportation.

The fact that *A. quadrigibbus* infests apple fruit in the US and can survive and overwinter in cold temperatures, moderated by the fact that a large portion of infested fruit drops to the ground, support a risk rating for importation of 'low'.

Probability of distribution

The likelihood that *Anthonomus quadrigibbus* will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **MODERATE**.

Supporting information for this assessment is provided below:

- Distribution of the commodity would be for wholesale or retail sale as the intended use of the commodity is human consumption. Fruit could be sent to all parts of Australia including apple, pear and cherry growing regions.
- Pupae and adults residing in the apple fruit are likely to travel unnoticed to their destination.
- It is expected that during commercial transport, storage and distribution some apples will be discarded as waste. Consumers will dispose small quantities of fruit, especially apple cores in urban, rural and wild environments close to suitable hosts. However, consumers are only likely to discard infested apples one at a time, rather than eat several infested apples at once and discard infested apples in one place. Domestic consumers might dispose all of their cores in one bin. Therefore a founder population could establish from these cores.
- *Anthonomus quadrigibbus* could enter the environment directly from discarded fruit during distribution and sale before the fruit desiccates or decays.

Information that the larvae may be present unnoticed within the apple fruit, increasing the likelihood of dispersal support a risk rating for distribution of 'moderate'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that *Anthonomus quadrigibbus* will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **LOW**.

4.4.2 Probability of establishment

The likelihood that *Anthonomus quadrigibbus* will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **LOW**.

Supporting information for this assessment is provided below:

- *Anthonomus quadrigibbus* is associated with a wide range of plants in the Rosaceae, although apples (*Malus*) and hawthorn (*Crataegus* spp.) are the usual host plants (CABI/EPPO 1997a). Other host plants include chokecherry (*Prunus virginiana*), saskatoon (*Amelanchier alnifolia*), crabapple, quince (*Cydonia oblonga*) and pear (*Pyrus* spp.) (MAFRI 2008) (see Appendix B). Some of these hosts are widely distributed in Australia in commercial, urban/domestic environments as well as wild situations where *A. quadrigibbus* could establish.
- *Anthonomus quadrigibbus* is distributed throughout Canada (Nova Scotia to British Columbia), US (except Nevada and Wyoming) and Mexico (Burke and Anderson 1989). The range of climatic conditions from temperate to arid and subtropical is represented in Australia, suggesting that the Australian environment is suitable for the establishment of *A. quadrigibbus*.
- Adults overwinter in debris on the ground in and around orchards, but especially under the host trees (Davidson and Lyon 1979).

- *Anthonomus quadrigibbus* has only one generation a year (Davidson and Lyon 1979; MAFRI 2008) and females lay from 18 to 122 eggs during their lifetimes (Crandall 1905).
- Existing control programs in Australia, such as broad spectrum insecticide application, may be effective for preventing establishment of *A. quadrigibbus* on some hosts, but these are not routinely applied to all hosts or all host habitats, or may not be applied to the hosts along roadsides or in wild situations.
- While similar chemicals to those used by US orchardists may be used in Australian orchards, they are targeted at other pests. Therefore, the timing of these sprays may not be efficacious against *A. quadrigibbus*. Further, such controls are not used by many backyard gardeners for their fruit trees.

The widespread availability of several host plants, adaptability over a range of climatic types, moderated by the necessity to find a mate for sexual reproduction, the fairly low fecundity of female *A. quadrigibbus* and a single generation per year, support a risk rating for establishment of 'low'.

4.4.3 Probability of spread

The likelihood that *Anthonomus quadrigibbus* will spread based on a comparison of factors in the area of origin and in Australia that affect the geographic distribution of the pest: **MODERATE**.

Supporting information for this assessment is provided below:

- Although adults are capable of strong flight, they usually do not migrate very far in any one season, and one part of a field may be severely infested while another part remains undamaged. *Anthonomus quadrigibbus* may only spread to several rows of trees over a period of several years (Steeves *et al*. 1979).
- CABI/EPPO (1997a) recommends that plants of host species transported with roots should be free from soil, or the soil should be treated against the pest, and they should not carry fruit.
- *Anthonomus quadrigibbus* has a fairly wide host range that includes several species of *Crataegus* and *Prunus* (see Appendix B), all of which could serve as hosts for a reservoir population to develop, facilitating their spread in Australia.
- *Anthonomus quadrigibbus* is widespread throughout Canada and the US, and many of the regions where this pest is prevalent have similar environments to apple growing regions of Australia. This suggests that *A. quadrigibbus* may spread within Australia wherever suitable host species occur.
- Natural barriers such as arid areas, climatic differences and long distances between production areas exist in Australia, and may limit the spread of *A. quadrigibbus* by natural means. Restrictions on the movement of some hosts may limit the chance of spread through trade, but movement of infested fruit could occur within a region.

The widespread distribution of several species of host plants, including *Malus*, *Crataegus* and *Prunus* across southern Australia, of *Anthonomus quadrigibbus* and its strong flight ability, moderated by the information that this pest is unlikely to migrate for very long distance in any one season, support a risk rating for spread of 'moderate'.

4.4.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *Anthonomus quadrigibbus* will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to a susceptible host, establish in that area and subsequently spread within Australia: **VERY LOW**.

4.4.5 Consequences

The consequences of the establishment of *Anthonomus quadrigibbus* in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision rules described in Table 2.4 on page 12, 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**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D – Significant at the district level:** *Anthonomus quadrigibbus* can cause direct harm to the fruit of several hosts including apples and pears (Davidson and Lyon 1979), affecting fruit quality and plant health. Infestation by *A. quadrigibbus* results in malformed, knotty and undersized fruit (Davidson and Lyon 1979). In the past, prior to the introduction of modern pesticides and IPM programs, *A. quadrigibbus* has been recorded as one of the most destructive insect pests of apple in Ontario and Quebec, causing damage to 50% of the apples in certain orchards (Petch 1928). In British Columbia, it has caused 80% of small pears of some trees to fall and deformed most of the remaining pears, thus rendering them unmarketable at harvest time (Buckell 1930). *Anthonomus quadrigibbus* has steadily declined in numbers and has become a much less important pest in Canada, with only occasional outbreaks (MacNay 1953) despite it not being the target of a control program. It is not known if any native plant species would be susceptible to this pest.
Other aspects of the environment	**B – Minor significance at the local level:** There are no known direct consequences of this pest on any other aspects of the environment but their introduction into a new environment may lead to competition for resources with native species.
Indirect	
Eradication, control etc.	**D – Significant at the district level:** Additional programs to eradicate *A. quadrigibbus* on their host plants may be necessary. Existing control programs may be effective for some hosts (e.g. broad spectrum pesticide applications) but not all hosts (e.g. *Malus* and *Pyrus* where specific integrated pest management programs are used) (APAL 2009). 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 the cost of production. Additionally, costs for crop monitoring and consultant's advice to manage these pests may be incurred by the producer.
Domestic trade	**B – Minor significance at the local level:** The presence of this pest in commercial production areas of commodities, such as apples and pears, may be of minor significance at the local level due to resulting trade restrictions on the sale or movement of a wide range of commodities between states/territory. These restrictions may lead to a loss of markets. The decision to apply restrictions to the local level or district level is dependent on the assessment of how far the invading pest has spread and whether any lure is available for trapping.
International trade	**C – Significant at the local level:** The presence of *A. quadrigibbus* in commercial production areas of a range of commodities would have a significant effect at the local level due to limitations of accessing international markets where this pest is absent.
Environmental and non-commercial	**B – Minor significance at the local level:** Insecticides such as synthetic pyrethroids are already registered for and used in Australian orchards to control other weevil species. Additional pesticide applications or other control activities would be required to control apple curculio on susceptible host plants. Any additional insecticide usage may affect the environment.

4.4.6 Unrestricted risk estimate

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 12.

Unrestricted risk estimate for *Anthonomus quadrigibbus*	
Overall probability of entry, establishment and spread	Very low
Consequences	Low
Unrestricted risk	Negligible

As indicated, the unrestricted risk for Anthonomus quadrigibbus has been assessed as 'negligible' which achieves Australia's ALOP. Therefore, no specific risk management measures are required for this pest.

4.5 Apple leafcurling midge

Dasineura mali

Dasineura mali is a small fly with four life stages: egg, larva (or maggot), pupa and adult. Apple trees (including crabapple) are the only hosts of *D. mali*. This species occurs in northern Europe, and has been introduced to both North America and New Zealand (Gagné 2007).

Dasineura mali first reached eastern Canada and the northeastern US in the 1960s before its arrival in western Washington. The midge was discovered in Washington State from a commercial apple orchard in northern Whatcom County in July 1994 and has since spread into much of western Washington (Antonelli and Glass 2005). Its current distribution in the Northwest includes Whatcom and Skagit Counties in western Washington, and the Frasier River Delta and parts of the Okanogan Valley in British Columbia, Canada (LaGasa 2007).

The adult is a small fly, 1.5–2.5 mm long, with dusky wings covered by fine dark hairs. Adult females have a characteristic red abdomen. Larvae are tiny legless maggots, initially pale-yellow but becoming reddish-orange as they develop inside rolled leaves (galls). Full grown larvae are 1.5–2.5 mm long (LaGasa 2007). Pupation takes place in a white silken cocoon 2–2.5 mm in length; mature pupae are brown (LaGasa 2007).

The adult female deposits her eggs in the leaf folds of immature apple leaves. After hatching, the tiny pinkish-orange larvae begin feeding causing the margins of the apple leaves to become tightly curled. Infested leaves eventually roll into distorted tubes and may discolor becoming red to brown and then brittle, before they finally drop from the tree. Terminal shoots are stunted as a result of this leaf damage. Some of the larvae pupate in the damaged or rolled leaves, while others drop to the ground to pupate and overwinter, emerging as adults the following spring. The midge can complete two or three generations per year (Antonelli and Glass 2005; LaGasa 2007).

In the PNW, two or three generations are produced each season, and overlapping of generations has been reported (LaGasa 2007). Timing of generations has been little studied. In Europe, lack of rain is reported to delay larvae from exiting hardened leaves to pupate, which can prolong development time (LaGasa 2007). Similar events have been observed in New Zealand (HortResearch 1999).

The risk posed by *Dasineura mali* is that mature larvae and pupae may be present on apple fruit. The larvae prefer to pupate in the ground, and although there is no mention of *D. mali* larvae or pupae occurring on apple fruit in the US (Antonelli and Glass 2005; LaGasa 2007), in New Zealand some larvae falling from leaves become caught on apples, where they pupate (Smith and Chapman 1995). The pupal cocoon is firmly attached to the apple at either the stalk or calyx end of the fruit (Smith and Chapman 1995).

Dasineura mali was assessed in the Final Import Risk Analysis Report for Apples from New Zealand (Biosecurity Australia 2006a). In that assessment, the overall probability of entry, establishment and spread was assessed to be ‘high’ using a semiquantitative method and the consequences were assessed to be ‘low’. As a result, the unrestricted risk was assessed to be ‘low’ and specific risk management measures were determined to be necessary.

Dasineura mali has been reported in Whatcom and Skagit counties in Washington state (Antonelli and Glass 2005; LaGasa 2007). It has not been reported in Idaho, Oregon and the

Wenatchee, Columbia Basin and Yakima Valley areas in Washington state. The likelihood of *D. mali* occurring on apple fruit from Whatcom and Skagit counties is comparable to that from New Zealand. The timing of imports of apples from the US can occur at a receptive stage for *D. mali* emerging from cocoons, when leaves of host trees are flushing. Pest management procedures for *D. mali* (including sorting, packing and shipping procedures) are similar for both countries. Transport of apple fruit from the US will normally take longer than from New Zealand. However, *D. mali* pupae can overwinter (Antonelli and Glass 2005) and therefore survive long cold periods. For these reasons, Biosecurity Australia considers that the probability of importation of *D. mali* on apple fruit from the PNW would be in the same range as that for apple fruit from New Zealand. Factors affecting the distribution of the commodity (and with it the pest) in Australia are similar for both countries. The probability of establishment and of spread of *D. mali* in Australia, and the consequences it may cause will be the same for any commodity with which the species is imported into Australia. Therefore, the existing pest risk assessment for *D. mali* is proposed for the importation of apple fruit from the PNW as the unrestricted risk estimate is considered to be in the same range.

4.5.1 Unrestricted risk estimate

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 12.

Biosecurity Australia considers the unrestricted risk of *D. mali* through the importation of apple fruit from the PNW is the same as the risk of this pest through the importation of apple fruit from New Zealand. Therefore, the existing pest risk assessment for *D. mali* has been adopted for the importation of apple fruit from the PNW.

Unrestricted risk estimate for *Dasineura mali*	
Overall probability of entry, establishment and spread	High
Consequences	Low
Unrestricted risk	Low

As indicated, the unrestricted risk for *Dasineura mali* has been assessed as ‘low, which is above Australia’s ALOP. Therefore, specific risk management measures are required for this pest.

4.6 Apple maggot

Rhagoletis pomonella

Rhagoletis pomonella is native to eastern North America (Weems and Fasulo 2007; Zhao *et al*. 2007). It was first reported to have made the transition from its native host, hawthorns (*Crataegus* spp.) to apples (*Malus pumila*) in the north-eastern US and Mexico in 1866 (Porter 1928; Bush 1966). Host records for this species are all from the Rosaceae family and include apples, pears, plums, cherries, apricots, hawthorns, and crabapples (Yee and Goughnour 2006; Zhao *et al*. 2007). In the US, regulations are in place which restrict the movement of these commodities as well as a range of other commodities (Idaho State Department of Agriculture 1990; Washington State Department of Agriculture 2006).

The first reports of *R. pomonella* infesting commercial apple crops in the PNW were in Oregon in 1979 (Fisher and Olsen 2002; Bush *et al*. 2005). *Rhagoletis pomonella* is now recognised as a serious pest of apples and present in the PNW states (Zhao *et al*. 2007).

Eggs are deposited under the skin of the fruit (Fisher and Olsen 2002), and eggs hatch within a few days. Larvae feed internally, making the fruit unmarketable (Boller and Prokopy 1976). As larvae develop, they pass through three discrete stages (Beers *et al*. 1996). Larval development times range from two weeks to several months (Weems and Fasulo 2007). Once fully developed, larvae exit the fruit and form pupae in the upper levels of the soil (Bush *et al*. 2005). Pupae may overwinter and remain in the soil until the following spring or, if conditions are favourable, may emerge as adults within the same season (Bush 1966). A proportion of pupae may also overwinter for two winters (Weems and Fasulo 2007).

Adults begin emerging from the soil in late June and may survive for up to 30 days. Adults are present in the field from June to October (Fisher and Olsen 2002). During these months, commercial apple trees in the PNW are bearing fruit (USDA/NASS 2006b).

The risk posed by *Rhagoletis pomonella* is that apple fruit containing eggs or larvae may be exported to Australia.

4.6.1 Probability of entry

Probability of importation

The likelihood that *Rhagoletis pomonella* will arrive in Australia with the importation of the commodity: **HIGH**.

Supporting information for this assessment is provided below:

- *Rhagoletis pomonella* is present in all the three PNW states (White and Elson-Harris 1992; Thornburg 2003). It was first detected in Oregon in 1979 (Fisher and Olsen 2002), Washington in 1980 (Washington State Department of Agriculture 2008), and Idaho in 1986 (Idaho State Department of Agriculture 1990). Rigorous insecticide management programs are now required to produce fruit free from apple maggot injury and contamination (Fisher and Olsen 2002).
- Apple fruit provides suitable host material for the survival and development of *R. pomonella* eggs and larvae (Bush 1966; Rogg *et al*. 2006; Weems and Fasulo 2007;

Yee 2007). The host material may be green or ripening fruit (McPheron *et al.* 1988; Weems and Fasulo 2007).

- In the US, commercial apples are recognised as a quarantine risk for *R. pomonella*. Regulations are in place for the movement of apples from areas where this species is present (Krissoff *et al*. 1997; USDA/NASS 2006b).
- The females deposit eggs singly under the skin of the fruit and then excrete a marker pheromone on each fruit to deter other females from ovipositing into the same fruit (Boller and Prokopy 1976). This enables the species to fully exploit all available fruit hosts for larval development and consequently only a limited number of insects per fruit may be present.
- Eggs hatch 3–7 days after oviposition (Boller and Prokopy 1976), and larvae pass through three life stages (Beers *et al*. 1996). Larval development can take from two weeks to several months (Weems and Fasulo 2007)
- Harvest of apples in the PNW commences in mid-August and generally continues until the end of October. Allowing for the time taken to reach sexual maturity and for mating to take place, there is potential for gravid females to be present in the field from July through to the end of September (Boller and Prokopy 1976; Zhao *et al*. 2007). Furthermore, *R. pomonella* may undergo a second generation with adults emerging in late summer or early autumn (Bush 1966). Commercial apples are therefore susceptible to attack for the entire harvest period.
- Fruit containing late instar larvae may show obvious signs of infestation and be culled during harvesting although eggs and early instar larvae would not be detected by visual inspection. Although females excrete a marker pheromone on each fruit (Boller and Prokopy 1976), Chapman and Hess (1941) reported a large degree of variability of stinging in apples ranging from 1–89 punctures per fruit. Therefore the deterrence mechanism may not be entirely effective. Fruit with low rates of infestation would not show obvious signs of damage, allowing infested fruit to pass through the harvesting process undetected.
- Following harvest, apples may be stored before being sorted and packed, or after being sorted and packed, or both. Storage time may vary from one day to more than eleven months (Kupferman 1996). They may be kept in refrigerated storage (0–2°C, depending on variety) or in controlled atmosphere (CA) storage (Kupferman 1996). Optimum conditions for CA storage in Washington were reported to be 0–1°C, 1.5–2% oxygen and 0.5–1.5% carbon dioxide (Kupferman 2001). The lethal effects of these specific storage conditions upon *R. pomonella* are not completely understood. Elevated levels of carbon dioxide have been shown to be effective in killing the immature life stages of *R. pomonella* (Agnello *et al*. 2002) and cold storage for 40 days at 0°C is approved by regulatory agencies as a quarantine treatment (Hallman 2004).
- Eggs and larvae are present under the skin and would not be removed through post-harvest procedures.
- The post-harvest sorting, rinsing, brushing, waxing, labelling, and packaging procedures are likely to cull fruit showing obvious symptoms of infestation with late instar larvae. However, eggs and early instar larvae would not be detected during these processes.

- Most fruit are treated with the fungicide drench, thiabendazole, to reduce rots caused by *Penicillium* spp. and *Botrytis* spp. and diphenylamine is used to prevent storage scald (Washington State University 2002). These post-harvest treatments would not inhibit the development of *R. pomonella* eggs and larvae.
- The use of fungicides may delay the development of the symptoms of fungal fruit decay associated with the presence of *R. pomonella*, reducing the telltale signs of infestation.
- After packing, fruit is stored under cold storage or controlled atmosphere conditions, or transported directly to Australia via either air freight or sea freight. Consignments would spend a minimum of 1–3 weeks in transit.
- The commonly used storage and transportation conditions would only be sub-lethal to the immature life stages of *R. pomonella*.
- There is a strong potential for *R. pomonella* larvae to survive transport and be present in apples on arrival in Australia.

The evidence that *R. pomonella* is present in the export states, the presence of larvae at the time of harvest, the suitability of apple fruit as host material and the ability for eggs and larvae to survive handling, storage and transport conditions support a risk rating for importation of ‘high’.

Probability of distribution

The likelihood that *Rhagoletis pomonella* will be distributed in Australia as a result of the processing, sale or disposal of the commodity: **MODERATE**.

Supporting information for this assessment is provided below:

- After arriving in the Australian ports, *R. pomonella* larvae would need to complete their development, exit the fruit, pupate in a suitable substrate and emerge as adults. During the marketing chain, sufficient refrigeration capacity is not always available. Consequently, maintenance of fruit pulp temperatures would not be sufficient to kill *R. pomonella* eggs and larvae.
- Formation of *R. pomonella* pupae may take place in a variety of substrates including sand, soil, leaf litter, compost heaps and grass clippings. It is feasible that infested fruit may be disposed of in sites where pupation and adult eclosion could occur. Inedible and unmarketable fruit would be disposed of via landfill and compost heaps or as animal feed, or discarded where it was being eaten.
- *Rhagoletis pomonella* has a strong ability to overwinter as pupae, and diapause may last up to two years (Fisher and Olsen 2002). Boller and Prokopy (1976) reported that the pupae of *Rhagoletis* species were resistant to predation from ants.
- In the US, adult eclosion occurs in spring (Fisher and Olsen 2002). Temperature ranges in the PRA area are also conducive to the emergence and survival of *R. pomonella*.
- Proteinaceous food is required for sexual maturity, and adult flies begin feeding within two hours of emergence (Boller and Prokopy 1976). Appropriate food sources include insect honeydew, plant liquids, bacteria, yeasts, fungi and animal excrement (Boller and Prokopy 1976). Detection of these substances is made through chemoreceptors (Boller and Prokopy 1976), and availability of these food sources would not be a limiting factor.

- Bush (1966) reported that both male and female flies are attracted to plant volatiles. As well as acting as a rendezvous stimulant, these volatiles help females locate suitable host plants.
- Availability of hosts would not be a limiting factor in the distribution of *R. pomonella*. Suitable host materials are available in the PRA area regardless of the season. Host records for *R. pomonella* include more than 30 species in the Rosaceae family (Yee and Goughnour 2006) (see Appendix B). The PRA area has a wide range of naturalised, commercial, home grown and ornamental rosaceous hosts. These include apples, pears, stone fruit, roses, cherries, quinces, loquats, and blackberries.

The association of the immature stages with apple fruit, the ability of adults to fly to find a host plant, moderated by the need to finish development, find a site to pupate as well as find a mate for reproduction, support a risk rating for distribution of 'moderate'.

Overall probability of entry

The overall probability of entry is determined by combining the probability of importation with the probability of distribution using the matrix rules shown in Table 2.2 on page 9.

The likelihood that *Rhagoletis pomonella* will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **MODERATE**.

4.6.2 Probability of establishment

The likelihood that *Rhagoletis pomonella* will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **HIGH**.

Supporting information for this assessment is provided below:

- *Rhagoletis pomonella* has been recorded on 23 host species across eight genera throughout North America (CABI 2007) (see Appendix B). The favoured commercial host is *Malus pumila* (apple), while the natural host is *Crataegus spp.* (hawthorn) (Bush 1966). This pest has also been recorded on *Aronia arbutifolia* (chokeberry), *Malus* spp. (crabapple), *Vaccinium macrocarpon* (cranberry), *Cornus florida* (dogwood), *Prunus* spp. (cherry), *Prunus angustifolia* (Chickasaw plum) and *Malus baccata* (Siberian crabapple) (Caprile *et al.* 2006; CABI 2007; Weems and Fasulo 2007). Other alternative hosts include *Rosa rugosa* (Japanese rose) and *Prunus cerasus* (sour cherry) (Weems and Fasulo 2007).
- Suitable hosts are present in Australia and are widespread. It is expected that the availability of hosts would not restrict the establishment of *R. pomonella*.
- The prevalence and spread of *R. pomonella* in diverse regions throughout North America where conditions are similar to some parts of Australia suggests that the environmental conditions in temperate Australia would be suitable for the establishment of *R. pomonella*.
- During early spring, 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 congregate on the fruit and produce a pheromone to attract the females. The pheromones released from the males and volatile compounds emitted from the ripening fruit trigger and facilitate mating (Prokopy and Papaj 2000).
- A limitation for the successful distribution of *R. pomonella* 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 multiple females (Aluja *et al*. 2001). Therefore, it is possible that insects of both sexes might be present in a piece of fruit and that mating partners could be found.

- A single mated female is capable of laying enough eggs to establish a population (Weems and Fasulo 2007). 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.
- Larval development takes 2–3 months depending on the host fruit (Weems and Fasulo 2007). The larvae leave the fruit and enter the soil to pupate and survive the winter.
- *Rhagoletis pomonella* has shown a capacity to adapt. Known host lists for this species are continually expanding (Yee and Goughnour 2006; Weems and Fasulo 2007).
- Currently, there are not any effective and/or selective traps to detect *R. pomonella*. However, various traps have been trialled in the US. These traps differ to the type used under the National Exotic Fruit Fly surveillance program in Australia.
- While biological control has been attempted with hymenopteran parasitoids in the US (Weems and Fasulo 2007), there is no evidence that existing parasitoids in Australia would parasitise *R. pomonella*.
- 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 to target other pests, the timing of these sprays may not be efficacious against *R. pomonella*. Further, these controls are not generally applied to feral hosts or backyard produce. The use of these controls is also not permitted in fruit fly pest free areas in Australia except in times of outbreak as this would compromise domestic and overseas markets, nor can they be used in organic systems.

The demonstrated ability of *Rhagoletis pomonella* to adapt, the wide host range and availability of suitable hosts in the PRA area, and the suitability of the climate in the PRA area, support a risk rating for establishment of ‘high’.

4.6.3 Probability of spread

The likelihood that *Rhagoletis pomonella* will spread based on a comparison of factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pest: **MODERATE**.

Supporting information for this assessment is provided below:

- *Rhagoletis pomonella* is widespread throughout North America (CABI 2007) and many of the regions where this pest is prevalent have similar environments to regions of Australia. This suggests that *R. pomonella* could spread within Australia.
- The wide host range within the Rosaceae (Caprile *et al*. 2006; CABI 2007; Weems and Fasulo 2007) (see Appendix B) suggests that the Australian environment would be potentially amenable to its spread, with many commercial crop and amenity species (apple, cherry, crabapple, dogwood, hawthorn, loquat, plum, quince, and rose) in Australia being potentially susceptible to infestation.

- *Rhagoletis pomonella* adults are known to disperse up to 1.5 km from their point of emergence in search of hosts (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 *R. pomonella* to spread between production areas, although it could use other rosaceous hosts in amenity plantings or feral populations.
- 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) localised dispersion is possible through wind assisted flight.
- The other major means of dispersal to previously uninfected areas are the transport of infested fruits (Zhao *et al*. 2007) and the movement of infested soil from beneath host plants such as nuresey stock.
- *Rhagoletis pomonella* has previously demonstrated the capacity to spread from its original range in eastern North America to the western US since 1979 (Bush *et al*. 2005).
- No early warning systems for incursions of this pest currently operate. The spread of *R. pomonella* would not be limited by existing fruit fly monitoring efforts.

The wide range and ready availability of many host plants both cultivated and wild and the ability of adults to locate host plants, moderated by the information that Rhagoletis species, in general, are not known to fly more than short distances, support a risk rating for spread of 'moderate'.

4.6.4 Overall 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 9.

The overall likelihood that *Rhagoletis pomonella* will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **LOW**.

4.6.5 Consequences

The consequences of the establishment of *Rhagoletis pomonella* in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision rules described in Table 2.4 on page 12, 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**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**F - Significant at the national level:** *Rhagoletis pomonella* is capable of causing direct harm to its hosts through feeding and oviposition. Minute external damage from egg punctures may be observed and larvae can tunnel through the fruit flesh, causing damage of major significance to susceptible hosts. *Rhagoletis pomonella* has more than 30 hosts in the family Rosaceae, including *Aronia* spp., *Crataegus* spp., *Malus* spp., *Pyrus* spp., *Prunus* spp. and *Rosa* spp. (see Appendix B). Some of these commercial hosts constitute major horticultural markets in Australia and given their size and distribution, the introduction of *R. pomonella* could cause considerable damage to these industries. It is not known if any native species of Rosaceae or amenity plants such as hawthorns (*Crataegus*) would be susceptible. This species has the potential to inhabit the cool temperate regions of Australia and other pest free areas where in field controls, other than monitoring, are generally not applied for fruit flies. Furthermore, the chemicals currently being applied by organic growers and home gardeners against endemic fruit flies may not control *R. pomonella*.
Other aspects of the environment	**B – Minor significance at the local level:** There are no known direct consequences of this species on any other aspects of the environment but its introduction into a new environment may lead to competition for resources with native species.
Indirect	
Eradication, control etc.	**E – Significant at the regional level:** Broad spectrum pesticide applications may be effective for this species and its hosts (e.g.). However, additional programs are likely to be necessary to minimise the impact of *R. pomonella* on amenity host plants. The limited effectiveness and selectivity of monitoring and trapping methods would also make this pest difficult to detect, eradicate and control.
Domestic trade	**D – Significant at the district level:** The introduction of *R. pomonella* 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. apples, stone fruit, ornamentals, trees and shrubs).
International trade	**D – Significant at the district level:** The presence *R. pomonella* in commercial production areas of a range of commodities (e.g. apples, 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.
Environmental and non-commercial	**B – Minor significance 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.

4.6.6 Unrestricted risk estimate

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 12.

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

As indicated, the unrestricted risk for *Rhagoletis pomonella* has been assessed as ‘moderate’, which is above Australia’s ALOP. Therefore, specific risk management measures are required for this pest.

4.7 Plant bugs[4]

Lygus elisus; *Lygus hesperus*; *Lygus lineolaris*

The three species of plant bugs of the genus *Lygus* considered in this assessment are recognised as pests of apple in the PNW states (Anthon 1993b) and are not present in Australia (Cassis and Gross 2002). 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, *Lygus lineolaris* 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 Extension 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 into fruit 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 *Lygus lineolaris* 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 (Caprile *et al*. 2006).

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 (Anthon 1993b; Caprile *et al*. 2006). Less well known, but of increasing importance, is the fact that *L. lineolaris* feeds on and damages conifer seedlings, such as and coniferous nursery stock in British Columbia, Oregon, Florida, Mississippi, Arkansas, and Oklahoma (Dixon 1989). Damage symptoms on most host plants attributed to Lygus bugs include leaf ragging, brown, discolored tissue, premature drop of buds, flowers, and fruit; cat-facing; increased number of vegetative branches; multiple crowns; elongation of internodes; split stem lesions; swollen nodes; and, leaf crinkling (Tingey and Pillemer 1977).

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 apple fruit. The principal risk from the assessed plant bugs is that eggs laid into fruit will enter Australia, and result in the establishment of exotic plant bugs in Australia.

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[4] In this section, the common name plant bugs will be used to refer to all three species. The scientific name will be used when the information is about a specific species.

4.7.1 Probability of entry

Probability of importation

The likelihood that the exotic plant bugs assessed will arrive in Australia with the importation of the commodity: **VERY LOW**.

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

- Lygus plant bugs are associated with apple production in the PNW states (Anthon 1993b).
- *Lygus lineolaris* is the most prevalent species infesting tree fruits in the northwest, but *L. hesperus* and *L. elisus* are also common (Anthon 1993b).
- Fruit is typically picked into picking bags or buckets before being transferred into field bins kept on the ground in the orchard for transportation of fruit to the packing house.
- Adult or nymphal plant bugs are highly mobile and easily disturbed. The process of picking fruit is very likely to dislodge any plant bugs associated with the fruit, but eggs in the fruit would not be affected.
- *Lygus* may migrate into the orchard at any time during the growing season and damage frequently appears first along orchard borders (Caprile *et al*. 2006).
- 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 such as *Amaranthus* spp. (pigweed), *Brassica* spp. (wild mustard), *Capsella bursa-pastoris* (shepherd's-purse), *Centaurea solstitialis* (yellow starthistle), *Chenopodium album* (lambsquarters), *Hemizonia* spp. (tarweed), *Melilotus officinalis* (sweet clover), *Raphanus raphanistrum* (wild radish), *Salsola tragus* (Russian thistle), and *Vicia* spp. (vetch) (Anthon 1993b; Caprile *et al*. 2006; CABI 2007).
- All harvested apple fruit is washed and brushed following harvest. These actions would almost certainly remove remaining 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.

The presence of the assessed *Lygus* species infesting tree fruits in the PNW and the known habit of females to lay eggs in apple fruit, moderated by the fact that females preferentially deposit their eggs in stems, leaf parts and flowers of orchard weeds, support a risk rating for importation of ‘very low’.

Probability of distribution

The likelihood that the exotic plant bugs assessed will be distributed in Australia, in a viable state, as a result of the processing, sale or disposal of the commodity: **MODERATE**.

Supporting information for this assessment is provided below:

- As stated in the probability of importation, the stage expected to be associated with fruit is the egg as adults or nymphs will 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). However, prolonged exposure over 30 and 45 days resulted in considerable egg mortality and fewer adults being produced (Snodgrass and McWilliams 1992).
- Reduced temperatures during storage and transport are expected to prevent the development of eggs. The lower developmental threshold for *Lygus hesperus* is 54°F (12°C) (Zalom *et al*. 2008). Therefore, egg development would only continue after fruit have been removed from cool storage.
- Following the movement of fruit from cool 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. *Lygus lineolaris* is known to feed on a wide selection of hosts besides apple fruit: *Fragaria* spp. (strawberries), *Glycine max* (soybeans), *Gossypium hirsutum* (cotton), *Prunus* spp. (stone fruit), *Solanum tuberosum* (potatoes) and more than 50 other crops, as well as commercially grown flowers, fruit trees, forest tree nurseries, and weeds (CABI 2007). *Lygus elisus* is recorded on 34 host plants comprising 14 families including crucifers, chenopods, composites and early vegetative stage of alfalfa although showing a preference for crucifers (Schwartz and Foottit 1992).

The extremely wide host range of the assessed plant bugs, especially of commercial food crops, cryptic habits moderated by their limited development and survival at the temperatures experienced during cold storage, support a risk rating for distribution of 'moderate'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that the assessed exotic plant bugs will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **VERY LOW**.

4.7.2 Probability of establishment

The likelihood that the assessed exotic plant bugs will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **HIGH**.

Supporting information for this assessment is provided below:

- *Lygus elisus* and *L. lineolaris* are found on a variety of species including wheat, flax, various nuts, stone fruit and other fruits and vegetables (CABI 2007). *Lygus hesperus* is a known pest of alfalfa seed, cotton, fruit and vegetable crops. It is also commonly found in alfalfa hay but is not a pest of that crop. It is fairly well confined to the areas where agriculture is carried on and probably attacks other agricultural crops similar to those attacked by *L. elisus*. It also feeds on a great variety of weeds and other herbaceous plants (Mueller *et al*. 2003).

- *Lygus lineolaris* is known to feed on a wide selection of hosts besides apple, including cotton, soybeans, strawberries, potatoes, stone fruit, and more than 50 other crops, plus commercially-grown flowers, fruit trees, forest trees and weeds (Young 1986; CABI 2007). It is suggested that *L. lineolaris* may have the widest host range of any arthropod (Young 1986).
- A large majority of the species known to be hosts of plant bugs are grown commercially in Australia while others are common weeds in a variety of habitats. There is sufficient availability of suitable hosts for the establishment of these pests.
- 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 the assessed plant bugs.
- *Lygus elisus* is present throughout western Canada, Alaska, western US (California, Oregon, Idaho, Nevada) and northern Mexico (Mueller *et al*. 2003; Mueller *et al*. 2005; CABI 2007). *Lygus hesperus* is predominantly distributed throughout western US (California, Arizona, Nevada, Washington) and Mexico (Mueller *et al*. 2003). *Lygus lineolaris* 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).
- 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 the assessed exotic plant bugs is likely to be very low.
- Female *Lygus lineolaris* lay from 50–150 eggs, which are laid singly in a sheltered location and hatch in 7–12 days (Dixon and Fasulo 2006). It takes approximately 15–25 days for nymphs to develop into adults during summer, with reproduction starting when adults are about 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 females 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 *et al*. 2000). However, *L. lineolaris* has built up resistance to treatments in the US (Zhu *et al*. 2004).
- The use of insecticides to control *Lygus* spp. has directly or indirectly (through control measures for other pests) led to increasing insecticide resistance in *L. hesperus* (Cleveland 1985; Snodgrass and Scott 1988).

- Successful approaches used in the US to control *L. lineolaris* 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 and refrain from mowing cover crops or weeds when lygus bugs are present or they will move into the trees (Caprile *et al*. 2006).
- 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 measures are not commonly used in home gardens and amenity plantings, or on feral trees, or weeds where these practices are not applied.

The extremely wide host range and availability of many of these hosts, adaptability to a wide range of climates, the exotic plant bugs' high reproductive rate, increasing insecticide resistance, support a risk rating for establishment of 'high'.

4.7.3 Probability of spread

The likelihood that the assessed exotic plant bugs will spread based on a comparison of factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pest: **MODERATE**.

Supporting information for this assessment is provided below:

- *Lygus lineolaris* 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 *L. lineolaris* (Sohati *et al*. 1992) and other *Lygus* species (Broadbent *et al*. 2006), it is not clear what role parasitoids would play in Australia.
- Geographical areas such as arid regions between the western and eastern parts of Australia could be natural barriers for the spread of exotic plant bugs.
- Research has shown that cotton pests such as *L. hesperus* 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).
- *Lygus lineolaris* and *L. hesperus* 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 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.
- The movement of vegetative propagative material, such as nursery stock or budwood, could be a means of dispersal (USDA-APHIS 2000b). However, restrictions on the movement of nursery stock exist between some regions of Australia, such as Western Australia and the eastern states. This is likely to restrict the spread of exotic plant bugs.

The wide distribution and ready availability of hosts, the ability of adults to travel between agricultural fields and adjacent areas, moderated by a lack of evidence of unaided dispersal over long distances, support a risk rating for spread of 'moderate'.

4.7.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that the exotic plant bugs assessed will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in the PRA area and subsequently spread within Australia: **VERY LOW**.

4.7.5 Consequences

The consequences of the establishment of the assessed exotic plant bugs in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision described in Table 2.4 on page 12, that is, where the consequences of a pest with respect to one or more criteria are '**E**', the overall consequences are estimated to be **MODERATE**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**E – Significant at the regional level:** *Lygus lineolaris* is regarded as having more plant hosts than any other arthropods (Young 1986). It significantly reduces plant vigour and crop yield. Thus, it can have a serious effect on many plants, both commercial and wild. In the US, Lygus bugs infested 53% of cotton crops and caused a 0.72% yield reduction in 2002 (Williams 2003) and a 1.003% yield reduction in 2008 (Williams 2009), but yield losses have been reported to reach 4.7% (Mississippi State University 2003). *Lygus hesperus* and *L. elisus* are the most serious pests of alfalfa grown for seed in the PNW and California, causing direct yield reductions by feeding on alfalfa flowers and seeds (Seymour *et al*. 2005). Economically *L. hesperus* is the most important *Lygus* pests in the west (Scott 1977) and is a frequent pest of many important crops including cotton (Barlow *et al*. 1999). *L. hesperus* is a key pest of cotton and strawberries, both highly valued crops in California (Pickett *et al*. 2005). *Lygus lineolaris* is a major pest of horticultural crops in the US including strawberries (Rancourt *et al*. 2000; Young 1986). In recent years *L. lineolaris* has been found feeding on conifer seedlings (Dixon 1989). In one southern US forest nursery it was reported causing damage to approximately 50% of the *Pinus taeda* (loblolly pine) seedlings; pine seedlings in a nursery severely damaged by this bug usually do not survive the growing season (Dixon 1989). It is not known if these plant bugs could become a pest of some native plant species given their wide host range.
Other aspects of the environment	**B – Minor significance at the local level:** There is no known direct impact of the assessed plant bugs on any other aspects of the environment but their introduction into a new environment may lead to competition for resources with native mirid plant bugs. Native grasses and ecological communities associated with these grasses may provide suitable hosts for these exotic plant bugs and may be impacted by establishment of new species.
Indirect	
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. Costs for crop monitoring and consultant's advice to manage the pest may be incurred by the producer. Additionally, 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 result in 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.
Environmental and non-commercial	**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. The introduction of new biocontrol agents might also affect existing biological control programs. The necessity to undertake cultural methods designed to counter overwintering exotic plant bugs 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.

4.7.6 Unrestricted risk estimate

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 12.

Unrestricted risk estimate for the assessed plant bugs	
Overall probability of entry, establishment and spread	Very Low
Consequences	Moderate
Unrestricted risk	Very Low

As indicated, the unrestricted risk estimate for the assessed exotic plant bugs has been assessed as ‘very low’, which meets Australia’s ALOP. Therefore, no specific risk management measures are required for these pests.

4.8 Chaff scale

Parlatoria pergandii

Parlatoria pergandii is a pest of apple production widespread in the US. It has been recorded from Washington State (Miller and Davidson 2005). It is a member of the Diaspididae family (armoured scales), which are named for their ability to produce a hard, fibrous, wax-like covering that attaches the scale to the host plant (Carver *et al*. 1991). 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, pathogens and other pests (Kosztarab 1990; McClure 1990). High populations of scales can cause the death of trees (Beardsley and Gonzalez 1975).

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 (Ben-Dov 1990). This contrasts with the male scale, which has a pupal stage, emerging as a winged adult form. The female life stages include adult, egg and nymph, but no pupal stage, while the male has adult, egg, nymph, pre-pupa and pupa stages. The mature adult female is approximately 1.0–1.5 mm in length (Takagi 1990). The mature male is seldom seen and is rarely more than 1 mm in length (Giliomee 1990). The male is winged, does not feed at all and lives for 1–3 days (Beardsley and Gonzalez 1975; Koteja 1990).

Crawlers (first instar larvae) 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 (Beardsley and Gonzalez 1975). 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 (Koteja 1990). Once the crawlers settle down on the plant to feed, they become immobile and develop a protective covering (McLaren *et al*. 1999).

Parlatoria pergandii has been reported from New South Wales and Queensland (Donaldson and Tsang 2002; CSIRO 2005). Consequently, it is only considered as a regional quarantine pest for Western Australia.

The risk posed by *P. pergandii* is the presence of crawlers, immobile juveniles or adult scales on imported apple fruit.

Parlatoria pergandii was assessed in the Final Report, Extension of Existing Policy for Sweet Oranges from Italy (Biosecurity Australia 2005b). The present assessment builds on this existing pest risk assessment. The probability of importation for *P. pergandii* was rated ‘high’.

The probability of distribution after arriving in Western Australia of *P. pergandii* with apples is assumed to be similar to that for sweet oranges. The probability of establishment and of spread in Western Australia, and the consequences it may cause will be the same for any commodity with which the species is imported. Accordingly, there is no need to re-assess these components. The risk ratings for distribution, establishment, spread, and consequences as set out for *P. pergandii* in the Extension of Existing Policy for Sweet Oranges from Italy (Biosecurity Australia 2005b) will be adopted for this assessment. However, differences in commodities, horticultural practices, climatic conditions and the prevalence of the pest between the US and other countries make it necessary to re-assess the likelihood that *P. pergandii* will be imported into Western Australia with apples from the US.

4.8.1 Probability of entry

Probability of importation

The likelihood that *Parlatoria pergandii* will arrive in Western Australia with the importation of the commodity: **LOW**.

Supporting information for this assessment is provided below:

- In the US, *P. pergandii* is widespread. In the PNW region, it is recorded from Washington (Miller and Davidson 2005).
- The principal host genus of *P. pergandii* is *Citrus*, but it has also been reported on apple as well as many other hosts in more than 30 plant families (Watson 2005; Miller and Gimpel 2009c).
- *Parlatoria pergandii* can be found on fruit as well as other aerial plant parts (Watson 2005).
- Crawlers would be present during the apple harvest period (August – October) (Miller and Davidson 2005).
- The principal scale pest in most production regions is *Diaspidiotus perniciosus*, which is a non-quarantine pest. Dormant sprays and biological control are generally effective in controlling this pest. Scales other than *D. perniciosus*, including *P. pergandii*, are also affected by measures to control *D. perniciosus*.
- *Parlatoria pergandii* infestations would likely cause visible symptoms on host fruits, resulting in most of the infested fruit being culled during quality assurance operations. Additionally, sorting and grading would remove some fruit infested with this pest as they are easily visible. However, some infested fruit with *P. pergandii* in the stem and calyx ends may remain undetected.
- The washing and brushing 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.
- After packing, fruit is stored at around 0ºC (Stebbins *et al*. 1997). Transport to Australia would be by either air freight or sea freight taking a minimum of 1–3 weeks.
- Low temperatures would likely slow or prevent the development of *P. pergandii*. However, mated adult females or second instar larval females may overwinter on bark (Miller and Davidson 2005). Furthermore, the worldwide distribution (see Appendix B) of

P. pergandii and its presence in regions with cold climates suggest that some life stages are likely to survive cold storage and transportation conditions.

The presence of *Parlatoria pergandii* in the PNW region, moderated by the minor host status of apples, obvious symptoms of fruit infestation, detectable size of scale insects, and the effective control measures implemented against this species, support a risk rating for importation of 'low'.

4.8.2 Probability of distribution, of establishment and of spread

As indicated above, the probability of distribution, of establishment and of spread for *P. pergandii* will be the same as those assessed for *Parlatoria pergandii* in sweet oranges from Italy (Biosecurity Australia 2005b). The ratings from the previous assessment are presented below:

Probability of distribution:	**LOW**
Probability of establishment:	**HIGH**
Probability of spread:	**MODERATE**

4.8.3 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *Parlatoria pergandii* will enter Western Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **VERY LOW**.

4.8.4 Consequences

The consequences of the establishment of *Parlatoria pergandii* in Western Australia have been estimated previously for sweet oranges from Italy (Biosecurity Australia 2005b). This estimate of impact is provided below. As the ratings in 2005 were conducted on a scale from A to F, they have been adjusted here to reflect a current rating scale from A to G.

Plant life or health	**D**
Any other aspects of the environment	**B**
Eradication, control, etc.	**D**
Domestic trade	**C**
International trade	**C**
Environment	**B**

Based on the decision rules described in Table 2.4 on page 12, 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**.

4.8.5 Unrestricted risk estimate

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 12.

Unrestricted risk estimate for *Parlatoria pergandii*	
Overall probability of entry, establishment and spread	Very low
Consequences	Low
Unrestricted risk	Negligible

As indicated, the unrestricted risk estimate for *Parlatoria pergandii* has been assessed as ‘negligible’, which achieves Australia’s ALOP. Therefore, no specific risk management measures are required for this pest.

4.9 Mealybugs[5]

Phenacoccus aceris; Pseudococcus maritimus

The two mealybug species assessed here 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 both species assessed here.

Phenacoccus aceris (apple mealybug) and *Pseudococcus maritimus* (grape mealybug) are pests on a large range of hosts, including apples and pears (Ben-Dov 2009a, d).

Reproduction of mealybugs is sexual, and there may be multiple generations a year. Although the nymphs and adults live mainly on the bark of apple trees, they can also be found on fruit (especially at high population pressures) and tend to live either around or in the calyx of fruit.

Mealybugs damage plants by sucking plant sap through their tubular stylets (CABI 2007). They also secrete honeydew, which may fall on fruits and serve as substrate for sooty mold (Spangler and Agnello 1991).

The risk posed by the assessed mealybugs is the presence of nymphs and/or adults on imported apple fruit, resulting in the establishment and spread of these species in Australia.

Phenacoccus aceris was included in the existing import policy for Korean pears from Korea (AQIS 1999). *Pseudococcus maritimus* was assessed in the Final Report for the Import Risk Analysis for Table Grapes from Chile (Biosecurity Australia 2005c). The assessment of mealybugs presented here builds on these existing pest risk assessments.

The probability of importation for *Pseudococcus maritimus* was rated as ‘high’ in the Chile Table Grape IRA (Biosecurity Australia 2005c), because the species is widespread in Chile.

The probability of distribution after arrival in Australia of the assessed mealybugs with apples is assumed to be similar to that for table grapes. The probability of establishment and of spread in Australia, and the consequences they may cause will be the same for any commodity with which the species is imported into Australia. Accordingly, there is no need to re-assess these components, and the risk ratings for distribution, establishment, spread, and consequences as set out for *Pseudococcus maritimus* in the Chile Table Grape IRA (Biosecurity Australia 2005c) will be adopted for this assessment. However, differences in commodities, horticultural practices, climatic conditions and the prevalence of the pest between the US and other countries make it necessary to re-assess the likelihood that the assessed mealybug species will be imported to Australia with apples from the US.

[5] In this section, the common name mealybugs will be used to refer to both species. The scientific names will be used when the information is about a specific species.

4.9.1 Probability of entry

Probability of importation

The likelihood that *Phenacoccus aceris* or *Pseudococcus maritimus* will arrive in Australia with the importation of the commodity: **HIGH**.

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

- *Phenacoccus aceris* is present in the PNW, and neighbouring British Columbia (Beers 2007b; Ben-Dov 2009a). Apple is one of its main hosts (Beers 2007b).
- *Pseudococcus maritimus* is widespread in the PNW (Burts and Dunley 1993; Ben-Dov 2009d).
- As the mealybugs can be concealed within the stem end or calyx of apple fruit, the sorting and packing processes may not remove them effectively.
- *Pseudococcus calceolariae*, a related species, has been detected at on-arrival inspection in the US on New Zealand apples exported to the US (USDA-APHIS 2003), and it is feasible that other mealybug species would also survive during transportation.

The association of mealybugs with fruit, their inconspicuousness, and the presence of a protective coating allowing them to withstand sorting and packing, support a risk rating for importation of 'high'.

4.9.2 Probability of distribution, of establishment and of spread

As indicated above, the probability of distribution, of establishment and of spread for the assessed mealybugs will be the same as for *Pseudococcus maritimus* for table grapes from Chile (Biosecurity Australia 2005c). The ratings from the previous assessments are presented below:

Probability of distribution:	**MODERATE**
Probability of establishment:	**HIGH**
Probability of spread:	**HIGH**

4.9.3 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *Phenacoccus aceris* and *Pseudococcus maritimus* will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **MODERATE**.

4.9.4 Consequences

The consequences of the establishment of *Pseudococcus maritimus* in Australia have been estimated previously for table grapes from Chile (Biosecurity Australia 2005c). This estimate of impact is provided below. As the ratings in 2005 were conducted on a scale from A to F, they have been adjusted here to reflect the current rating scale from A to G.

Plant life or health	**D**[6]
Any other aspects of the environment	**B**
Eradication, control, etc.	**D**
Domestic trade	**D**
International trade	**C**[7]
Environment	**B**

Based on the decision rules described in Table 2.4 on page 12, 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**.

4.9.5 Unrestricted risk estimate

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 12.

Unrestricted risk estimate for *Phenacoccus aceris and Pseudococcus maritimus*	
Overall probability of entry, establishment and spread	Moderate
Consequences	Low
Unrestricted risk	Low

As indicated, the unrestricted risk estimate for *Phenacoccus aceris* and *Pseudococcus maritimus* has been assessed as 'low', which is above Australia's ALOP. Therefore, specific risk management measures are required for these pests.

[6] *Phenacoccus aceris* is the only known vector for viruses associated with little cherry disease (Raine *et al*. 1986). Little cherry disease is present in the PNW (Bajet *et al*. 2008), but not in Australia. In British Columbia, Canada it reduced cherry production by 90% between 1947 and 1979 (Bajet *et al*. 2008). The impact on the cherry production of a given region in Australia, where cultivars are unlikely to be resistant to the associated viruses, could be of similar magnitude.

The viruses associated with little cherry disease, *Little cherry virus 1* and *Little cherry virus 2*, belong to the family Closteroviridae. *Little cherry virus 2* belongs to the genus *Ampelovirus* (Martelli *et al*. 2002; Bajet *et al*. 2008). Viruses in this genus are transmitted semi-persistently by coccid or pseudococcid mealybugs (Martelli *et al*. 2002). A related virus, *Grapevine leafroll-associated virus 3*, survives for less than four days in another mealybug species, *Planococcus ficus* (Tsai *et al*. 2008). It is extremely unlikely that an individual mealybug becomes infectious with *Little cherry virus 1* or *Little cherry virus 2* on a cherry, moves to an apple, and enters and establishes in Australia following the importation of apples, with the virus remaining infectious. This scenario is considered to not increase the rating for plant life or health.

[7] The rating of 'D' was given for *Pseudococcus maritimus* in table grapes from Chile (Biosecurity Australia 2005c). This rating has been reassessed as 'C' here, based on the information that both *Pseudococcus maritimus* and *Phenacoccus aceris* are currently widely distributed in many parts of the world.

4.10 Dock sawfly

Ametastegia glabrata

Ametastegia glabrata is not present in Western Australia and is a pest of regional quarantine concern for that state.

It is recognised as a pest of apple production in the US, including the PNW states.

Ametastegia glabrata is a sawfly from the Tenthredinidae family. Its larvae primarily feed on herbaceous hosts from the Chenopodiaceae and Polygonaceae families, including *Chenopodium*, *Fagopyrum*, *Polygonum*, *Rheum*, and *Rumex* spp. (Naumann *et al*. 2002; Carter 2004; Agnelo 2005) (see Appendix B). Its presence on other hosts is mostly incidental. Late generations of this pest may seek overwintering or pupation sites in canes and fruit in orchards, thereby gaining status as an economic pest (Malipatil *et al*. 1995; Naumann *et al*. 2002; Carter 2004). Historically, this pest has been reported to cause significant damage and losses to fruits in the Ukraine, Russia and the US (CABI 2007).

Ametastegia glabrata occurs widely throughout the Northern Hemisphere, including temperate Europe, the Mediterranean region, Siberia, North America, and it has also been recorded from Chile and eastern Australia (Naumann *et al*. 2002). In North America, *A. glabrata* larvae are a sporadic pest of apples, with the larvae burrow into apple fruit to overwinter (Foss and Antonelli 2003; Agnelo 2005). The harder, immature apples deter burrowing larvae, so injury to apples occurs in late summer and early autumn as the fruit approaches maturity (Foss and Antonelli 2003; Agnelo 2005). Consequently, although there are four generations a year, it is only the last of these that may cause concern to apple growers (Foss and Antonelli 2003; Agnelo 2005). *Ametastegia glabrata* larvae pupate in the apple fruit or in the stems of their hosts (Foss and Antonelli 2003).

Symptoms on herbaceous hosts caused by *A. glabrata* may include skeletonisation or holes in leaves, as well as frass deposition on stems (Agnelo 2005; CABI 2007). On secondary hosts, larvae burrow into the fruit, leaving small entrance holes on the external surface of the fruit (Foss and Antonelli 2003; Agnelo 2005; CABI 2007). The entrance holes may develop a brown sunken discoloration surrounding the entry point as well as rotting from the entry of decay fungi (Foss and Antonelli 2003; Agnelo 2005; CABI 2007). The entrance holes are generally more prevalent at the calyx and stem end. However, other areas of the fruit may be affected (Foss and Antonelli 2003; Agnelo 2005). Once inside the fruit, larvae may burrow several holes, often to the core, regardless of the number of larvae present, and usually hollow out a large pupal cell (Foss and Antonelli 2003; Agnelo 2005).

The risk posed by *Ametastegia glabrata* is that overwintering larvae or pupae may be found in imported apple fruit.

4.10.1 Probability of entry

Probability of importation

The likelihood that *Ametastegia glabrata* will arrive in Western Australia with the importation of the commodity: **VERY LOW**.

Supporting information for this assessment is provided below:

- *Ametastegia glabrata* is relatively common and widely distributed in the Northern Hemisphere, including North America (Naumann *et al*. 2002).
- The larvae feed on herbaceous hosts from the Chenopodiaceae and Polygonaceae families such as *Chenopodium*, *Fagopyrum*, *Polygonum*, *Rheum*, and *Rumex* spp. (Naumann *et al*. 2002; Carter 2004; Agnelo 2005) (see Appendix B). However, other hosts may serve as suitable pupation or overwintering sites, including the fruits of apples, raspberry canes and cherry twigs (Malipatil *et al*. 1995; Foss and Antonelli 2003).
- *Ametastegia glabrata* is usually only an apple pest where weed hosts grow in close proximity to orchards and weed control is poorly managed (Agnelo 2005; Irish-Brown 2008). Orchards with effective weed management practices in place are therefore unlikely to be affected (Carter 2004; Irish-Brown 2008).
- Most fruit with internally feeding larvae would show external symptoms of damage and fruit from trees displaying symptoms of infestation would likely be culled during the harvest process.
- *Ametastegia glabrata* pupae are initially green, turning dark brown or black, and the adult is a blue-black colour approximately 7 mm long (Beers and VanBuskirk 1993). Any contaminating *A. glabrata* would likely be detected during quality inspections.
- Fruit is typically picked into bags before being transferred into harvest bins kept on the ground in the orchard for transportation of fruit to the packing house. Like many small sawfly larvae, *A. glabrata* larvae have the ability to feign death when disturbed, by dropping to the ground (CABI 2007). Falling larvae from trees disturbed during the harvest process may contaminate picking bags.
- Sorting and grading is likely to detect and remove affected fruit, as infestation generally results in visible tunnel holes, brown sunken discolorations surrounding the entry point as well as rotting of the fruit (Foss and Antonelli 2003; Carter 2004; Agnelo 2005). However, some fruit with recent or minor infestations may go undetected, given the preference for tunnelling around the stem or calyx end (Foss and Antonelli 2003; Agnelo 2005).
- Post-harvest washing and brushing of fruit is likely to remove larvae on the external surface of the fruit. However, this is unlikely to affect the viability of any larvae within the fruit.
- After packing, fruit is stored at around 0ºC (Stebbins *et al*. 1997). Transport to Australia would be by air or sea freight, taking a minimum of 1–3 weeks.
- There is little information available specifically addressing cold tolerance of *A. glabrata*. However, the larvae can burrow into apples to overwinter in the last larval stage as pre-pupa (Carillo *et al*. 1990; Foss and Antonelli 2003). The cold winter temperatures in the PNW would suggest that larvae are likely to survive short-term cold transport conditions.

The incidental host status of apples, obvious symptoms of infestation, limited window of susceptibility of apple fruit to burrowing larvae, and the likely implementation of effective weed management practices in commercial orchards, support a risk rating for importation of ‘very low’.

Probability of distribution

The likelihood that *Ametastegia glabrata* will be distributed in Western Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **MODERATE**.

Supporting information for this assessment is provided below:

- Distribution of the commodity would be for wholesale or retail sale as the intended use of the commodity is human consumption. Larvae present within the fruit could potentially be distributed via wholesale and retail trade and waste material would be generated.
- *Ametastegia glabrata* 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 apples from retailers to households, or at the consumer's residence.
- The conditions in Australia may be suitable for *A. glabrata* to emerge immediately after they arrive.
- Apple fruit showing obvious symptoms would likely be unmarketable and disposed of before sale. Fruit without symptoms, or with only minor infestations, are likely to be consumed. Any waste material would need to be disposed of in the environment near suitable hosts given the limited dispersal capacity of larvae.
- Primary hosts of *A. glabrata* are polygonaceous and chenopodiacean species (Naumann *et al*. 2002; Agnelo 2005) (see Appendix B). Many of these hosts are widely distributed as weeds throughout Australia and perennial in nature. Secondary hosts, including the fruits of apples, raspberry canes and cherry twigs, may serve as suitable pupation or overwintering sites (Malipatil *et al.* 1995; Foss and Antonelli 2003).
- *Ametastegia glabrata* adults are recognised as weak fliers, and are therefore limited to short dispersal distances (Carter 2004; Agnelo 2005). Also, the larvae are incapable of dispersing to any significant distance (Agnelo 2005).
- In laboratory studies, *A. glabrata* adults lived for only three days without any food (Malipatil *et al*. 1995). Additionally, adults have a life span of approximately 13 days (Beers and VanBuskirk 1993). This would limit their ability to disperse to suitable hosts.
- Most discarded fruit are likely to end up in bins or composting systems. The colonisation by saprophytic fungi or bacteria would quickly rot such fruit.

The widely distributed host range, moderated by the limited dispersal capacity and narrow window of survival without a food source, support a risk rating for distribution of 'moderate'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that *Ametastegia glabrata* will enter Western Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **VERY LOW**.

4.10.2 Probability of establishment

The likelihood that *Ametastegia glabrata* will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **HIGH**.

Supporting information for this assessment is provided below:

- The larvae feed on herbaceous hosts from the Chenopodiaceae and Polygonaceae families such as *Chenopodium*, *Fagopyrum*, *Polygonum*, *Rheum*, and *Rumex* spp. (Naumann *et al*. 2002; Carter 2004; Agnelo 2005). The short dispersal range and limited capacity to endure periods of food deprivation may restrict the ability of *A. glabrata* to find suitable hosts in other regions. However, polygonaceous and chenopodiacean main hosts of *A. glabrata* such as dock as well as secondary hosts like apples, cherries or raspberries are widespread in temperate Australia as crops, amenity plantings, or weeds.
- Within months of the first Australian detection of *A. glabrata* on raspberries in Silvan, Victoria, it was detected in several sites throughout Victoria (Malipatil *et al*. 1995). The authors suggested that *A. glabrata* was prevalent in Victoria wherever dock was present. The successful establishment of *A. glabrata* in Victoria demonstrates the ability of the pest to establish in temperate Australia.

The previous detections in Australia, suitability of the environment, worldwide distribution, availability of hosts, and ability to reproduce without a mate support a risk rating for establishment of ‘high’.

4.10.3 Probability of spread

The likelihood that *Ametastegia glabrata* will spread based on a comparison of factors in the area of origin and in Western Australia that affect the expansion of the geographic distribution of the pest: **HIGH**.

Supporting information for this assessment is provided below:

- Within months of the first Australian detection of *A. glabrata* on raspberries in Silvan, Victoria, it was detected in several sites throughout Victoria (Malipatil *et al*. 1995). The authors suggested that *A. glabrata* was prevalent in Victoria wherever dock was present. The successful establishment of *A. glabrata* in Victoria demonstrates the ability of the pest to spread in temperate Australia.
- *Ametastegia glabrata* occurs in a wide range of environments in the Northern hemisphere (Europe, the Mediterranean, Siberia, North America), Chile and parts of Australia (Naumann *et al*. 2002). Some of these regions have similar climates to the mediterranean climate of southwestern Western Australia, suggesting that these environments would be suitable for the spread of this pest.
- Winged adults are considered weak flyers and would find it difficult to disperse unaided from one area to another (Agnelo 2005). Additionally, the potential for larvae to disperse is also very limited (Agnelo 2005). However, the prevalence of herbaceous hosts may allow for local spread from plant to plant, and slow spread between areas.
- The transportation of infested host material would aid the movement of this pest into new areas. Larvae that feed internally on fruit or nursery stock could be distributed through the wholesale or retail trade.

The previous detections in Australia, suitability of the environment, worldwide distribution, and availability of hosts support a risk rating for establishment of 'high'.

4.10.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *Ametastegia glabrata* will enter Western Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **VERY LOW**.

4.10.5 Consequences

The consequences of the establishment of *Ametastegia glabrata* in Western Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision rules described in Table 2.4 on page 12, that is, where the consequences of a pest with respect to one or more criteria are '**C**', the overall consequences are estimated to be **VERY LOW**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**C – Significant at the local level:** *Ametastegia glabrata* can cause direct damage to host plants through larval feeding and tunnelling, as well as from secondary rotting of affected fruits (Malipatil *et al*. 1995; Foss and Antonelli 2003; Carter 2004; Agnelo 2005; CABI 2007). Polygonaceous and chenopodian herbs are primary hosts (Malipatil *et al*. 1995; Naumann *et a*l. 2002; Carter 2004; Agnelo 2005). However, *A. glabrata* has been reported as a sporadic pest of apples, causing significant losses in some regions (Carillo *et al*. 1990; Malipatil *et al*. 1995; Foss and Antonelli 2003; CABI 2007). It is not known if any indigenous species of Chenopodiaceae and Polygonaceae or native *Rubus* species would be susceptible.
Other aspects of the environment	**B – Minor significance at the local level:** There are no known direct consequences of this pest on any other aspects of the environment but its introduction into a new environment may lead to competition for resources with native species.
Indirect	
Eradication, control etc.	**B – Minor significance at the local level:** There are no specific control measures in place to mitigate *A. glabrata* (Foss and Antonelli 2003; Irish-Brown 2008). However, weed hosts are necessary for the survival of this species (Carter 2004; Agnelo 2005). Therefore, selective herbicides used for weed control will likely provide protection against this pest for commercial growers (Foss and Antonelli 2003; Irish-Brown 2008).
Domestic trade	**B – Minor significance at the local level:** The establishment of *A. glabrata* in Western Australia may result in some intrastate quarantine restrictions.
International trade	**C – Significant at the local level:** The presence of *A. glabrata* in commercial production areas may result in some quarantine restrictions for produce sent to countries where this pest is not established.
Environmental and non-commercial	**B – Minor significance at the local level:** Additional and increased used of herbicides to control the weedy primary hosts of *A. glabrata* could affect other vegetation.

4.10.6 Unrestricted risk estimate

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 12.

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

As indicated, the unrestricted risk estimate for *Ametastegia glabrata* has been assessed as ‘negligible’, which achieves Australia’s ALOP. Therefore, no specific risk management measures are required for this pest.

4.11 Leafroller moths[8]

Archips argyrospila; Archips podana; Archips rosana; Argyrotaenia franciscana; Choristoneura rosaceana; Hedya nubiferana; Pandemis heparana; Pandemis pyrusana; Spilonota ocellana

The leafroller moth species listed above are recognised as pests that may be found associated with apples in the PNW 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 leafroller moths assessed cause similar damage to foliage and fruits, and it is difficult to differentiate between damage caused by different species. The leafroller moths most often found in mature apple orchards in Washington State are *Pandemis pyrusana* and *Choristoneura rosaceana* (Brunner 1993). Due to the recognised importance of *P. pyrusana* and *C. rosaceana* on many different host plants and increasingly common status as pests in apple orchards in eastern Washington (Brunner 1993), they have been used as the basis for the risk assessment.

Other closely related species of leafroller moths have been previously identified as of quarantine concern on Fuji apple from Aomori Prefecture in Japan (AQIS 1998a), Korean pear from the Republic of Korea (AQIS 1999) and on apple from New Zealand (Biosecurity Australia 2006a). The assessment of the leafroller moth species presented here builds on these existing pest risk assessments.

'Leafroller' refers to the caterpillar stage of a number of moth species in the family Tortricidae, which are a large family of over 5,000 described species that is more strongly represented in temperate and tropical upland regions throughout the world (Meijerman and Ulenberg 2000).

The larvae of leafroller moths feed on leaves and fruit and derive their common name from the habit of rolling or tying leaves together with silk to form a protective shelter (Caprile *et al*. 2006). This shelter may also be attached to fruit, between two touching fruits, or other feeding sites, so that feeding can occur without the caterpillar leaving the safety of the shelter.

Many leafroller moth species (eg. *Argyrotaenia franciscana*) quickly wriggle backwards when disturbed and drop to the ground or descend on a silken thread attached to the leaf or fruit surface, such as when fruit is being harvested (Caprile *et al*. 2006) making it less likely they will be associated with harvested apple fruit. However, they may contaminate picking bags.

The risk posed by leafroller moths is that larvae and any remaining eggs may be present on imported apple fruit.

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[8] In this section, the common name leafroller moths will be used to refer to all ten species. The scientific name will be used when the information is about a specific species.

4.11.1 Probability of entry

Probability of importation

The likelihood that exotic leafroller moths will arrive in Australia with the importation of the commodity: **MODERATE**.

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

- *Archips argyrospila*, *A. fuscocupreanus*, *A. podana*, *A. rosana*, *Argyrotaenia franciscana*, *Choristoneura rosaceana*, *Hedya nubiferana*, *Pandemis heparana*, *P. pyrusana*, and *Spilonota ocellana* are present in one or more states of the PNW.
- The leafroller moths most commonly found in mature apple orchards in Washington are *P. pyrusana* and *C. rosaceana* (Brunner 1993). Since the mid-1970s, *P. pyrusana* has become a common pest in apple and cherry orchards in eastern Washington (Brunner 1993).
- *Pandemis pyrusana* and *C. rosaceana* have two generations a year, while *A. argyrospila* and *A. rosana* have one generation a year throughout the PNW (Brunner 1993).
- *Pandemis pyrusana* and *C. rosaceana* overwinter as second or third instar larvae within a silken case known as a hibernaculum. Hibernacula are found in protected parts of the scaffold limbs, such as pruning scars or small crevices in the bark (Brunner 1993).
- Larvae of the overwintering generation become active in spring as fruit buds open and have left their hibernacula by the green stage of apple bud development. Larvae bore into opening buds and later feed on expanding leaves and flower clusters and are fully grown by mid-to-late May (Brunner 1993). Pupae are present from mid-May through to early June in a protected place, usually in a folded and webbed leaf surrounded with light silken webbing (Brunner 1993). Adults of the first overwintering generation appear from late May to early June (Brunner 1993).
- Summer generation egg hatch generally occurs from mid-to-late June with larvae maturing by late July or early August (Brunner 1993) prior to harvest. Eggs of the overwintering generation appear in mid-August and could be present on harvested apple fruit. Females deposit eggs in masses on smooth bark of 1–3 year-old wood. Hatching begins in late August and continues through September and into early October in some years. Newly hatched larvae feed for a short time on foliage and apple fruit surface before moving to scaffold limbs and building hibernacula in October (Brunner 1993).
- *Archips argyrospila* and *A. rosana* overwinter in the egg stage. Egg hatch begins at the green stage of flower bud development continuing through to bloom. Larvae feed on leaves, flower parts and young fruit maturing by mid-to-late May. Pupae are present from late May through early June with adult activity peaking in late June (Brunner 1993). Eggs are usually deposited in masses on the smooth bark of 1–3 year-old wood where they remain until the following spring (Brunner 1993).
- The overwintering generation of larvae of *P. pyrusana* and *C. rosaceana* may damage the external surface of apple fruit just before and during harvest by attaching leaves to fruit just after hatching in late August or early September (Brunner 1993). The damage is difficult to detect at harvest (Brunner 1993).

- Damage from the summer generation of *C. rosaceana* results in superficial skin tunnels or small holes near the stem end of apple fruit (Caprile *et al*. 2006).
- Apple harvest starts from mid-August and lasts until the end of October in Washington (Smith 2001), and it is likely that that some early instar larvae are still present on the apple fruit.
- Larvae and any eggs still remaining on the external fruit surface are likely to be removed by washing and waxing of fruit.
- Sorting and grading would remove some fruit that are contaminated with external larvae or webbing indicating infestation, particularly when webbing remains on the stem or calyx end of fruit where the brushes can not effectively reach.
- Larvae and eggs of leafroller moths are able to overwinter in Washington (Brunner 1993) and suggests that larvae and eggs are able to survive cold storage and transportation of apple fruit at low temperatures.

The information that larvae of leafroller moths can damage the external surface of the apple fruit sometimes causing tunnels or small holes near the stem end of apple fruit, presence of early instar larvae during late August to early September during the harvest period, moderated by packing house procedures and the removal of obvious, externally damaged fruit in the packing house, support a risk rating for importation of 'moderate'.

Probability of distribution

The likelihood that exotic leafroller moths will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **MODERATE**.

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

- Apple fruit is intended for human consumption and larvae may remain on the fruit during retail distribution. Disposal of fruit waste may further aid distribution of larvae. Disposal of infested fruit waste is likely to be via commercial or domestic rubbish systems and thus not near a suitable host.
- If the larvae were to survive cold storage and transport of apples to Australia they would then have to complete development and find a site to pupate. Any early instar larvae entering with the fruit would have to be within crawling distance of and be able to find a host plant randomly before it could successfully complete its development.
- *Choristoneura rosaceana*, *A. argyrospila* and *A. rosana* have been recorded from over 30 species of host plants in several families (Brunner 1993). Hosts include *Malus* (apple), *Pyrus* (pear), *Prunus* spp. (apricot, cherry, peach, plum), *Acer negundo* (box elder), *Crataegus* (hawthorn), *Fraxinus* (ash), *Juglans regia* (walnut), *Ligustrum* (privet), *Populus* (poplar), *Quercus* (oak), *Ribes uva-crispa* (gooseberry), *Rosa* (rose), *Rubus fruticosus* (blackberry), *Rubus idaeus* (raspberry), *Rubus loganobaccus* (loganberry), *Salix* (willow), and *Ulmus* (elm) (Brunner 1993; CABI 2007). All of these plants are grown as amenity or backyard garden plants in suburban and rural areas in Australia, some are grown commercially in orchards while some are widespread as weeds in southern Australia.

The association of the immature stages with apple fruit, ability of adults to fly to find a host plant, moderated by the need of larvae to find another host plant to finish their development, find a site to pupate, support a risk rating for distribution of ‘moderate’.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that exotic leafroller moths will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **LOW**.

4.11.2 Probability of establishment

The likelihood that the assessed leafroller moths will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **HIGH**.

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

- Caterpillars of *A. franciscana* have been recorded on more than 200 plant species in 71 families (Powell 1983; Miller and Hodges 1995; CABI 2007). Some of the more important and common leafroller moth hosts are: *Malus* (apple), *Camellia sinensis* (tea), *Citrus* varieties, *Gossypium* (cotton), *Hedera helix* (ivy), *Juglans regia* (walnut), *Laurus* (laurel), *Lupinus* (lupin), *Prunus avium* (cherry), *Prunus persica* (peach), *Pyrus* (pear), *Vitis vinifera* (grape), and berries (including *Rubus* hybrids) (Atkins *et al*. 1957; AliNiazee and Stafford 1972; Curtis *et al*. 1992; Brunner 1993; Yokoyama and Miller 1999; Caprile *et al*. 2006) (see Appendix B).
- Many of these leafroller moth host plant families and species are common and widely distributed throughout Australia. These include native and naturalized plants, household and garden plants and horticultural crops.
- The assessed leafroller moths are widespread throughout North America (US and Canada) including the PNW states (Brunner 1993) where climatic conditions are similar to those of temperate regions of Australia (Brunner 1993). Some of the leafroller moths examined, for example *A. rosana*, are also found in Europe from where they were introduced. In North America it colonised two separate areas – the Northeast and the Northwest (Brunner 1993). *Spilonota ocellana* is distributed from Europe to eastern Russia and Japan as well as Madeira and North America (Meijerman and Ulenberg 2000). This indicates that there are suitable climatic and ecological conditions for establishment across southern temperate Australia.
- The assessed leafroller moths 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 increase the number of generations per year (Solomon 1991). *Pandemis pyrusana* and *C. rosaceana* have two generations a year, whereas *A. argyrospila* and *A. rosana* only have one generation in Washington State (Brunner 1993).
- Sexual reproduction is essential for leafroller moths and requires the mating between male and female adults (Weires and Riedl 1991). Leafroller moths 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 m (Webster and Carde 1982, 1984; Shorey *et al*. 1996). After mating, eggs will be laid on a suitable host plant.

- Some leafroller moths are capable of mating several times (Webster and Carde 1982, 1984).
- Variation in fecundity (between 100–600 eggs per female) is determined by weather conditions, and the quality of host plants eaten by the larvae (Smirle 1993; Safonkin and Triseleva 2005).
- Populations can start from a single mated female. For example, *P. stultana* lay 100–600 eggs over five days (Kearns *et al*. 2004).
- Conventional insecticides may be successful in controlling leafroller moth populations but many of the leafroller moths assessed, including *A. argyrospila*, *C. rosaceana* and *P. pyrusana* have developed or are developing resistance to many different pesticides in some areas (Vakenti *et al*. 1984; Meagher and Hull 1986; Croft and Hull 1991; Smirle *et al*. 1998, 2002, 2003a, b; Dunley *et al*. 2006).
- Biological control using parasitic wasps, including species of *Macrocentrus*, *Apanteles*, *Enytus*, *Exochus* and a tachinid fly *Actia* sp., which attack leafroller moth larvae (Caprile *et al*. 2006) is used in the US. However, the impact of potential natural enemies in Australia is not known, nor their impact on native leafrollers.
- In the US, organic control is achieved using *Bacillus thuringiensis* and the Entrust formulation of spinosad sprays and pheromone traps (McLaren *et al*. 1999; Caprile *et al*. 2006). There is no way of knowing whether the existing use of these procedures in Australia would be efficacious in eliminating or containing a potential incursion of an exotic leafroller moth in Australia.
- 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 the assessed leafroller moths would not be reduced in most of these pests' potential geographic range in Australia.

The ready availability and wide host range of the assessed leafroller moths, their widespread distribution across many climatic zones in North America with similarities to Australia, high fecundity, ability to produce several generations per year where climatic conditions are conducive and the development of increasing pesticide resistance to several conventional insecticides, support a risk rating for establishment of 'high'.

4.11.3 Probability of spread

The likelihood that the assessed leafroller moths will spread based on a comparison of factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pest: **HIGH**.

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

- The leafroller moths in this assessment are found throughout California and the PNW states and across North America (Canada and US) where climatic conditions are similar to those of southern Australia. Some of the leafroller moths assessed here, e.g. *A. rosana*, are also found in Europe.

- *Pandemis pyrusana* occurs throughout the PNW states (Brunner 1993), *C. rosaceana* is found across Canada and is widespread throughout the US except for the arid areas of the south west (Chapman and Lienk 1971).
- Adult leafroller moths are capable of independent flight, thus allowing for unassisted movement between areas. Adults have been recorded flying up to a lateral distance of 400 m (HortResearch 1999).
- 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 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 fruit production areas. This may allow these species to spread between growing areas.
- A mixture of adult flight and the legal transportation of infested apple, citrus, cherry, peach and pear trees or fruit, and grapes would aid the movement of these exotic leafroller moths 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 the assessed leafroller moths.

The wide host ranges and ready availability of many host plants both cultivated and wild, and the ability of adult moths to fly as well as the larva's ability to balloon to disperse to find host plants, support a risk rating for spread of 'high'.

4.11.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that the assessed leafroller moths will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **LOW**.

4.11.5 Consequences

The consequences of the establishment of exotic leafroller moths in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision rules described in Table 2.4 on page 12, that is, where the consequences of a pest with respect to one or more criteria are '**E**', the overall consequences are estimated to be **MODERATE**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**E – Significant at the regional level:** Leafroller moths can cause direct harm affecting fruit quality and plant health of numerous fruit crops including apple, apricot, blackberry, cherry, gooseberry, loganberry, peach, pear, plum, raspberry and walnut (Brunner 1993; CABI 2007). Many of these plants are significant economic crops in all southern Australia states. Some of these leafroller moths are rated as primary economic pests in North America where they damage the leaves, buds and fruit of their hosts (Weires and Riedl 1991). It is likely that the effect on native plants could be significant, given the polyphagous nature of these leafrollers.
Other aspects of the environment	**B – Minor significance at the local level:** There are no known direct consequences of the assessed species on any other aspects of the environment but their introduction into a new environment may lead to competition for resources with native species.
Indirect	
Eradication, control etc.	**E – Significant at the regional level:** Additional programs to eradicate or minimise the impact of these pests on their host plants may be necessary. Existing control programs may be effective for some hosts (e.g. broad spectrum pesticide applications) but not all hosts (e.g. *Malus* (apples) and *Pyrus* (pears) where specific integrated pest management programs are used) (APAL 2009). However, several leafroller moths in the PNW have developed resistance to organophosphate pesticides (Dunley *et al.* 2006). *Pandemis pyrusana* and *C. rosaceana* have developed resistance to organophosphates such as azinphosmethyl and cross-resistance to insect growth regulators tebufenozide and methoxyfenozide in Washington State with some populations also displaying cross-resistance to spinosad and indoxacarb (Dunley *et al*. 2006). This cross resistance would make it difficult to eradicate or control these exotic leafroller moths if the resistant strains were introduced into Australia. These pests may potentially result in an increase in the cost of production by triggering specific control stategies. 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 the cost of production. Additionally, costs for crop monitoring and consultant's advice to manage these pests may be incurred by the producer.
Domestic trade	**D – Significant at the district level:** The presence of these pests in commercial production areas of commodities, such as pome fruit and stone fruit, may have a significant effect at the local level due to resulting trade restrictions on the sale or movement of a wide range of commodities between states/territories. These restrictions may lead to a loss of markets.
International trade	**D – Significant at the district level:** The presence of these leafroller moths in commercial production areas of a range of commodities (e.g. apples, pears, apricots, nectarines, peaches, plums) would have a significant effect at the regional level due to limitations of accessing international markets where these pests are absent. *Choristoneura rosaceana* is listed as an A1 quarantine pest by EPPO (EPPO 2008) and is also of quarantine significance for Comité de Sanidad Vegetal Del Cono Sur (COSAVE 2009).
Environmental and non-commercial	**B – Minor significance at the local level:** Insecticides such as synthetic pyrethroids are already registered for and used in Australian orchards to control other leafroller moth species. Additional pesticide applications or other control activities would be required to control exotic leafroller moths on susceptible host plants. Any additional insecticide usage may affect the environment.

4.11.6 Unrestricted risk estimate

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 12.

Unrestricted risk estimate for the assessed leafroller moth species	
Overall probability of entry, establishment and spread	Low
Consequences	Moderate
Unrestricted risk	Low

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

4.12 Apple fruit moth

Argyresthia conjugella

Argyresthia conjugella (apple fruit moth) belongs to the family Yponomeutidae which contains around 600 species, some of which are minor pests in agriculture, forestry, and horticulture. *Argyresthia conjugella* is an economic pest of apple, and it is mainly distributed in temperate climatic zones of Europe (Russell IPM 2009), North America, Japan, Middle East, Central Asia, Siberia and the Far East (Ovsyannikova and Grichanov 2008e).

The principal hosts of the larva *A. conjugella* are rowan (*Sorbus aucuparia*) and apple (*Malus* spp.) (Nazari 2003).

In Europe, the adults appear in the early summer from May/June (Russell IPM 2009) to August/September (Furenhed 2006) and lay their eggs on the fruit (Carter 1984). Larvae of *A. conjugella* are present from July to August (Carter 1984) and are known to make tunnels in the apple in search for the seeds (Furenhed 2006), resulting in secondary infections that lead to fruit rotting (Carter 1984). The pupa is enclosed in a closely spun silken cocoon in a loosely woven net spun amongst dead leaves on the ground or under bark (Carter 1984).

The risk posed by *Argyresthia conjugella* is that larvae may be present in imported apple fruit.

Argyresthia conjugella was included in the existing import policy for Fuji apple from Japan (AQIS 1998a). The assessment of *A. conjugella* presented in this PRA builds on this existing pest risk assessment.

4.12.1 Probability of entry

Probability of importation

The likelihood that *Argyresthia conjugella* will arrive in Australia with the importation of the commodity: **MODERATE**.

Supporting information for this assessment is provided below:

- *Argyresthia conjugella* is an economic pest of apple (Russell IPM 2009).
- *Argyresthia conjugella* has established in Washington State since 1985 (LaGasa 2008).
- *Argyresthia conjugella* lays its eggs on the surface of apple fruit in June-July, hatching in 12–13 days time in Britain (Carter 1984). The larva of *A. conjugella* bores tunnels in apple fruit in search of the seeds (Furenhed 2006). Larval development lasts 40–50 days (Ovsyannikova and Grichanov 2008e).
- Sometimes the larva pupates in the cavity with the seeds, but generally it leaves the fruit for pupation (Petersen pers. comm. in Furenhed 2006), hibernating on the ground as a larva or a pupa for 6–8 months (Ahlberg 1927 in Furenhed 2006).
- *Argyresthia conjugella* is a specialist seed predator of rowan (*Sorbus aucuparia*). Large scale synchronous fluctuation of seed production in rowan drives *A. conjugella* to seek alternative host plants such as apple during years when rowan berries are not available for egg laying (Knudsen *et al.* 2008).

- Some studies show that *A. conjugella* develops with difficulty in apples (Ahlberg 1927 in Furenhed 2006; Edland 1979 in Furenhed 2006; Kobro *et al.* 2003). However, Krämer (1960), Kobro (1995) and Ovsyannikova and Grichanov (2008e) report that *A. conjugella* can successfully complete development in apple fruit.
- Adults that have emerged from apple fruit are often bigger than those that have developed in rowan berries (Petersen pers. comm. in Furenhed 2006).
- *Argyresthia conjugella* emerges as an adult in late May/June in northern Europe (Furenhed 2006).
- In Europe, the larva does not leave the fruit until August/September (Furenhed 2006), and since the apple harvest in Washington State starts from mid August and lasts until the end of October (Smith 2001), it is likely that that some larvae would still be present in the apple fruit.
- *Argyresthia conjugella* overwinters in northern Europe as larvae or pupae (Furenhed 2006), suggesting that larvae and pupae are able to survive cold storage and transportation of apple fruit at low temperatures.

The fact that *Argyresthia conjugella* is a known pest of apple, bores inside the apple fruit in search of seeds and sometimes pupates inside the apple fruit, moderated by the fact that apple is not the preferred host, supports a risk rating for importation of 'moderate'.

Probability of distribution

The likelihood that *Argyresthia conjugella* will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **LOW**.

Supporting information for this assessment is provided below:

- Apple fruit is intended for human consumption and the larvae may remain in the fruit during retail distribution. Disposal of fruit waste may further aid distribution of viable insects. Disposal of infested fruit waste is likely to be via commercial or domestic rubbish systems.
- If the larvae were to survive cold storage and transport to Australia, they would then have to complete development and find a site to pupate. *Argyresthia conjugella* pupates in a dense silken cocoon within a second open-network cocoon beneath the surface of the ground among fallen leaves, or under bark (Nazari 2003; Furenhed 2006; Ovsyannikova and Grichanov 2008e).
- *Argyresthia conjugella* reaches hosts through flight of adults that would emerge from pupae developed from larvae. The ability for flight increases the dispersal of *A. conjugella* and a chance to find a host. Adults are winged and highly mobile (Furenhed 2006).
- Reproduction requires the mating between male and female adults.
- *Argyresthia conjugella* only feeds on rowan (*Sorbus aucuparia*) and apple (*Malus* spp.) (Nazari 2003). Both these plants are grown as amenity or garden plants in suburban and rural areas in Australia.

The limited host range of *Argyresthia conjugella* and the association of the larvae with apple fruit, moderated by the need to find a place to pupate and complete development, support a risk rating for distribution of 'low'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that *Argyresthia conjugella* will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **LOW**.

4.12.2 Probability of establishment

The likelihood that *Argyresthia conjugella* will establish based on the comparison of factors in the source and destination areas that affect pest survival and reproduction: **MODERATE**.

Supporting information for this assessment is provided below:

- The only hosts of *Argyresthia conjugella* are rowan (*Sorbus aucuparia*) and apple (*Malus* spp.) (Nazari 2003).
- Both rowan (*Sorbus aucuparia*) and apple (*Malus* spp.) are common and widely grown household and garden plants throughout temperate Australia.
- *Argyresthia conjugella* is widespread throughout Europe (especially Scandinavia), Asia and North America (Nazari 2003). It is also recorded across all of Russia, central Asia, as well as Japan (Ovsyannikova and Grichanov 2008e). It has been introduced and established in North America (Carter 1984). In Canada, it is recorded from British Columbia, Alberta, and Saskatchewan, while in the US, it is recorded from New York State and California (Nazari 2003) as well as Washington State (LaGasa 2008), where climatic conditions are similar to those of temperate regions of Australia.
- Sexual reproduction is essential for *A. conjugella*. After mating, eggs are laid on a suitable host plant.
- *Argyresthia conjugella* has one generation per year. In Europe, the adults emerge in late May/June, with the female laying its eggs in June/July on the unripe fruit of rowan (*Sorbus aucuparia*) or apple (*Malus* spp.) shortly after petal fall (Kobro *et al.* 2003). After two weeks, the larva hatches and immediately eats its way into the fruit. The larva does not leave the fruit until August/September, when it lowers itself down to the ground on a silken thread. It then hibernates in the leaf litter as a larva or pupa for 6–8 months (Ahlberg 1927 in Furenhed 2006). It is expected that *A. conjugella* will have a similar life cycle if introduced to Australia.
- *Argyresthia conjugella* undergoes obligatory diapause (Knudsen *et al.* 2008). In a study conducted in southern Norway, most *A. conjugella* moths (97%) emerged after the first winter. However, 3% emerged after 2–4 years (Kobro *et al.* 2003). This life cycle strategy ensures that there will at least be a few moths emerging when rowan is actually fruiting.
- *Argyresthia conjugella* males and females are attracted to secondary plant metabolites of rowan and apple. It is especially attracted to apple during times when rowan is not available for egg-laying (Jaastad *et al.* 2004; Bengtsson *et al*. 2006; Knudsen *et al.* 2008).
- *Argyresthia conjugella* females attract males by pheromones. Males respond to synthetic pheromone from 03:00 to 10:00 hours and pheromone release in females peaked between 05:00 and 07:00 hours (Jaastad *et al.* 2002), confirming that this moth mates during the period at the first light of day (Jaastad *et al.* 2005).

- The larvae of *A. conjugella* are parasitised by the braconid wasp, *Microgaster politus* (Kobro *et al*. 2003) while predatory ground beetles such as *Pterostichus* spp., *Harpalus latus* and staphylinid beetles are major predators of the apple fruit moth in the pupal stage during spring and autumn (Furenhed 2006). The microsporidia of *Thelohanla argyresthiae* and a nuclear polyhedrosis virus also attack the pupae of *A. conjugella* (Ovsyannikova and Grichanov 2008e). However, the impact on establishment of *A. conjugella* by potential natural enemies in Australia is not known.
- While pest control activities in commercial orchards may limit or prevent the establishment of *A. conjugella*, such controls are unlikely to be applied in urban and suburban areas. Thus, the potential for establishment of *A. conjugella* would not be reduced in most of the potential geographic range of *A. conjugella* in Australia.

The ready availability of the two known host plants, rowan (*Sorbus aucuparia*) and apple (*Malus* spp.) of *A. conjugella*, the moth's wide distribution across many climatic zones with similarities to areas of temperate Australia and its ability to diapause and emerge successively over 1–4 years, support a risk rating for establishment of 'moderate'.

4.12.3 Probability of spread

The likelihood that *Argyresthia conjugella* will spread based on a comparison of factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pest: **MODERATE**.

Supporting information for this assessment is provided below:

- *Argyresthia conjugella* is widespread throughout Europe, European Russia, Urals, central Asia, Siberia and the Far East to Japan and it has been introduced to North America (Canada and US) where climatic conditions are similar to those in temperate parts of Australia.
- Both of its known host plants, rowan (*Sorbus aucuparia*) and apple (*Malus* spp.), are widely grown across southern Australia in commercial orchards as well as suburban gardens and amenity plantings. This would aid the spread of *A. conjugella*.
- *Argyresthia conjugella* is capable of independent flight (Jaastad *et al.* 2005), thus allowing for short distance dispersal from tree to tree. However, due to its small size, long distance dispersal between areas unaided may prove to be difficult.
- 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.
- 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. Nursery stock for which there are no restrictions in the eastern states could be an important pathway for long distance spread.
- Interstate restrictions on the movement of nursery stock may also limit the human-assisted spread of *A. conjugella* to Western Australia.

The widespread distribution of the host plants (rowan and apple) of *Argyresthia conjugella* and its ability to fly, and find a mate by the use of pheromone and strong attraction to the secondary plant metabolites of rowan and apple, support a risk rating for spread of ‘moderate’.

4.12.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of ‘rules’ for combining descriptive probabilities shown in Table 2.2 on page 9.

The likelihood that *Argyresthia conjugella* will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **LOW**.

4.12.5 Consequences

The consequences of the establishment of *Argyresthia conjugella* in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision rules described in Table 2.4 on page 12, 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**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D – Significant at the district level:** *Argyresthia conjugella* can cause direct harm to the fruit of rowan and apple and is a serious pest of apple in Fennoscandia (Ahlberg 1927 in Jaastad *et al*. 2004). The yield losses in Russia have been reported to exceed those caused by codling moth (Ovsyannikova and Grichanov 2008e).
Other aspects of the environment	**B – Minor significance at the local level:** There are no known direct consequences of this pest on any other aspects of the environment but its introduction into a new environment may lead to competition for resources with native species.
Indirect	
Eradication, control etc.	**D – Significant at the district level:** Additional programs to eradicate or minimise the impact of *A. conjugella* on its host plants may be necessary. Existing control programs may be effective for some hosts (e.g. broad spectrum pesticide applications) but not all hosts (e.g. *Malus* (apples) where specific integrated pest management programs are used) (APAL 2009). This pest may potentially result in an increase in the cost of production by triggering specific control strategies. 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 the cost of production. Additionally, costs for crop monitoring and consultant's advice to manage these pests may be incurred by the producer.
Domestic trade	**C – Significant at the local level:** The presence of *A. conjugella* in commercial production areas of apples may have a significant effect at the local level due to resulting trade restrictions on the sale or movement of apples between states/territories. These restrictions may lead to a loss of markets.
International trade	**C – Significant at the local level:** The presence of *A. conjugella* in commercial apple production areas would have a significant effect at the local level due to limitations of accessing the very few international markets where these pests are absent.
Environmental and non-commercial	**B – Minor significance at the local level:** Insecticides such as synthetic pyrethroids are already registered for and used in Australian orchards to control other moth species. Additional pesticide applications or other control activities would be required to control *A. conjugella* only on two susceptible host plants (rowan and apple). Any additional insecticide usage may affect the environment.

4.12.6 Unrestricted risk estimate

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 12.

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

As indicated, the unrestricted risk for *Argyresthia conjugella* has been assessed as 'very low', which achieves Australia's ALOP. Therefore, no specific risk management measures are required for this pest.

4.13 Codling moth

Cydia pomonella

Cydia pomonella (codling moth) is not present in Western Australia and is a pest of regional quarantine concern for this state.

Cydia pomonella belongs to the family Tortricidae, which is an economically important group with many representatives causing major economic damage to agricultural, horticultural and forestry industries (Meijerman and Ulenberg 2000). *Cydia pomonella* is one of the most damaging pests of apple and pear worldwide (CABI 2007).

Cydia pomonella overwinters as full grown larvae within thick, silken cocoons under loose scale of bark and in soil or debris around the base of the tree. The moths are only active a few hours before and after sunset. Each female lays 30–70 tiny disc shaped eggs on fruit, walnuts, leaves, or spurs. After the eggs hatch, young larvae seek out and bore into fruit or developing walnuts. After completing development, they leave the fruit and drop from the trees to search out pupation sites and continue the life cycle in the soil or on debris under the tree. Some crawl back up the tree to pupate in bark crevices. Depending on the climate, codling moths could have 2–4 generations per year. The adults are about 15–19 mm long with mottled grey wings held tentlike over their bodies. Their appearance blends well with most tree bark, making them difficult to detect (Caprile and Vossen 2005).

The risk posed by *C. pomonella* is the presence of larvae inside imported apple fruit.

Cydia pomonella was assessed in the Final Import Risk Analysis Report for Apples from New Zealand (Biosecurity Australia 2006a). The assessment of *C. pomonella* presented here builds on the previous assessment.

The probability of importation for *C. pomonella* was rated as 'moderate' in the assessments in the Final Import Risk Analysis Report for Apples from New Zealand (Biosecurity Australia 2006a).

The probability of distribution after arrival in Australia of *C. pomonella* will not differ for the same commodity (here: apples). The probability of establishment and of spread in Australia, and the consequences it may cause will be the same for any commodity with which the species is imported into Australia. Accordingly, there is no need to re-assess these components. However, differences in horticultural practices, climatic conditions and the prevalence of the pest between previous export areas (New Zealand) and the US make it necessary to re-assess the likelihood that *C. pomonella* will be imported to Australia with apples from the US.

4.13.1 Probability of entry

Probability of importation

The likelihood that *Cydia pomonella* will arrive in Western Australia with the importation of the commodity: **MODERATE**.

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

- *Cydia pomonella* is the key pest of apple in the PNW (Brunner *et al.* 2002). It is widely distributed throughout all apple and pear growing areas of North America (Hollingsworth 2008).
- *Cydia pomonella* is essentially a pest of pome fruit (Hely *et al*. 1982), and apple is one of its main host plants (Hely *et al*. 1982).
- Live codling moth larvae have been detected in a shipment of Washington apples being exported to Taiwan in 2007 (USDA/FAS 2007).
- On pome fruit, the larvae often enter through the calyx and bore down to the core of the fruit. Entrance hole and sawdust-like frass are normally present in infested fruit. *Cydia pomonella* feeding can cause premature fall of infested fruit (CABI 2007).
- As the larvae of *C. pomonella* feed internally within apple fruit, grading and packing processes may not effectively detect and remove all infested fruits. However, quality inspection in the packing house is likely to remove at least some infested fruit, as the entrance hole and frass deposited by developing larvae can easily be detected (CABI 2007).
- Diapausing *C. pomonella* larvae are resistant to cold temperature and can survive exposure to -20ºC for 3 days (Neven 1999). Larvae inside apple fruit would be able to survive cold storage before and during transportation.

The presence of larvae inside the fruit, its wide distribution throughout North America, including the PNW, and its ability to survive cold storage temperature, moderated by the possibility for infested fruit to drop prematurely or be rejected during sorting and packing processes, support a risk rating for importation of 'moderate'.

4.13.2 Probability of distribution, of establishment and of spread

As indicated above, the probability of distribution, of establishment and of spread for *Cydia pomonella* will be the same as those assessed for apples from New Zealand (Biosecurity Australia 2006a). The ratings from the previous assessment are presented below:

Probability of distribution:	**MODERATE**
Probability of establishment:	**HIGH**
Probability of spread:	**HIGH**

4.13.3 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *Cydia pomonella* will enter Western Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **LOW**.

4.13.4 Consequences

The consequences of the establishment of *Cydia pomonella* in Western Australia have been estimated previously for apples from New Zealand (Biosecurity Australia 2006a). This estimate of impact is provided below:

Plant life or health	**D**
Any other aspects of the environment	**A**
Eradication, control, etc.	**E**
Domestic trade	**B**
International trade	**D**
Environment	**B**

Based on the decision rules described in Table 2.4 on page 12, that is, where the consequences of a pest with respect to one or more criteria are '**E**', the overall consequences are estimated to be **MODERATE**.

4.13.5 Unrestricted risk estimate

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 12.

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

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

4.14 Grapholita moths[9]

Grapholita molesta; Grapholita packardi; Grapholita prunivora

The three Grapholita moths assessed here 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 the species assessed here.

Grapholita molesta (oriental fruit moth), *G. packardi* (cherry fruitworm) and *G. prunivora* (lesser appleworm) are pests on a range of hosts, including apples.

Grapholita molesta is not present in Western Australia and is a pest of regional quarantine concern for that state. It is a widespread pest throughout the eastern states of Australia. This species is assessed for Western Australia only. *Grapholita packardi* and *G. prunivora* are not present in Australia.

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

The risk posed by the assessed Grapholita moths is the presence of larvae inside imported apple fruit.

Grapholita molesta was assessed in the Final Import Risk Analysis Report for Apples from New Zealand (Biosecurity Australia 2006a) and the Pest Risk Analysis for Stone Fruit from New Zealand into Western Australia (Biosecurity Australia 2006b). The assessment of Grapholita moths presented here builds on these existing pest risk assessments.

The probability of importation for *Grapholita molesta* was rated ‘very low’ and ‘moderate’ in the assessments in the New Zealand apple IRA (Biosecurity Australia 2006a) and the Pest Risk Analysis for Stone Fruit from New Zealand into Western Australia (Biosecurity Australia 2006b), respectively.

While the host range of *G. packardi* and *G. prunivora* somewhat differs from that of *G. molesta* (see Appendix B), the overlap of host range and the similar biology of the three species (CABI 2007) warrant an assessment modelled on that for *G. molesta*. The probability of distribution after arrival in Australia of all assessed Grapholita moths will not differ for the same commodity (here: apples). The probability of establishment and of spread in Australia, and the consequences they may cause will be the same for any commodity with which the species is imported into Australia. Accordingly, there is no need to re-assess these components. The risk ratings for distribution, establishment, spread, and consequences as set out for *Grapholita molesta* in the New Zealand Apple Import Risk Analysis (Biosecurity Australia 2006a) will be adopted for this assessment and extended to include the other two species assessed here. However, differences in horticultural practices, climatic conditions and

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[9] In this section, the common name Grapholita moths will be used to refer to all three species. The scientific name will be used when the information is about a specific species.

the prevalence of the pest between the US and other countries make it necessary to re-assess the likelihood that the assessed Grapholita moth species will be imported to Australia (or Western Australia in the case of *Grapholita molesta*) with apples from the US.

4.14.1 Probability of entry

Probability of importation

The likelihood that the Grapholita moths assessed will arrive in Australia with the importation of the commodity: **MODERATE**.

- *Grapholita molesta* is widespread in North America (Rothschild and Vickers 1991; Brunner and Rice 1993). It is predominantly a pest of stone fruit, but also affects apples and other pome fruit (Rothschild and Vickers 1991), where apples are grown adjacent to peach orchards. Apples serve as potential late season post-peach harvest hosts (Myers *et al.* 2006a, b). In the eastern US, where historically, *G. molesta* had little commercial importance, it has recently emerged as a significant pest on apples (Myers *et al.* 2006a, b).

- *Grapholita packardi* is present in Washington and Oregon (CABI 2007) and recorded from apple, blueberry, cherry, hawthorn, peach and plum fruit and rose (Chapman and Lienk 1971). However, on apple, it is primarily associated with actively growing shoots, with few accounts of feeding on apple fruit (Chapman and Lienk 1971).

- *Grapholita prunivora*, a native of the northeastern US, is widely distributed in Washington and Oregon (Moffitt and Willett 1993). While its natural host range included American native *Crataegus*, *Malus* (crabapple) and *Prunus* species, this range has expanded to apples, cherries and plums since their introduction to North America (Moffitt and Willett 1993). It is currently not considered an economic pest in orchards, probably because it is controlled by insecticide applications for other pests, such as *Cydia pomonella* (Moffitt and Willett 1993). However, it may emerge as a more important pest if the control of *C. pomonella* shifts to more species-specific techniques such as the use of sex pheromones (Neven and Mantey 2004).

- Damage to apple fruit by *Grapholita* spp. is similar to that of *Cydia pomonella*. Entrance holes are usually near the calyx and sometimes inconspicuous. Grading and packing processes may not effectively detect and remove all infested fruits. However, quality inspection in the packing house is likely to remove at least some infested fruit, as the entrance hole and frass deposited by the developing larvae can be detected (CABI 2007).

- After packing, fruit is stored at around 0ºC (Stebbins *et al.* 1997). Transport to Australia would be by either air freight or sea freight taking a minimum of 1–3 weeks.

- *Grapholita prunivora* appears to be more cold tolerant than *G. molesta* (Neven 2004), though a direct comparison has not been made. At 2°C, some late stage (blackhead) eggs of *G. prunivora* survived for 49 days (Neven 2004). Larvae are more cold tolerant, and fourth instar larvae have been found to survive 2°C for more than 175 days (Neven 2004). It is feasible that significant numbers of *Grapholita* spp. survive cold storage and transport.

The presence of larvae inside the fruit, their distribution in North America including the PNW, their ability to survive cold storage temperatures, moderated by the possibility for infested fruit to be rejected during sorting and packing processes, support a risk rating for importation of ‘moderate’.

4.14.2 Probability of distribution, of establishment and of spread

As indicated above, the probability of distribution, of establishment and of spread for *Grapholita* moths will be the same as those assessed for *Grapholita molesta* in apples from New Zealand (Biosecurity Australia 2006a). The ratings from the previous assessment are presented below:

Probability of distribution:	**MODERATE**
Probability of establishment:	**HIGH**
Probability of spread:	**HIGH**

4.14.3 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that Grapholita moths will enter Australia (or Western Australia in the case of *G. molesta*) as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia or Western Australia: **LOW**.

4.14.4 Consequences

The consequences of the establishment of *Grapholita molesta* in Western Australia have been estimated previously for apples from New Zealand (Biosecurity Australia 2006a). This estimate of impact is provided below:

	G. molesta	*G. packardi & G. prunivora*
Plant life or health	**E**	**E**
Any other aspects of the environment	**A**	**A**
Eradication, control, etc.	**E**	**E**
Domestic trade[10]	**B**	**D**
International trade[11]	**D**	**E**
Environmental and non-commercial	**B**	**B**

Based on the decision rules described in Table 2.4 on page 12, that is, where the consequences of a pest with respect to one or more criteria are '**E**', the overall consequences are estimated to be **MODERATE**.

[10] The rating of 'B' was given for *G. molesta* as it is found in all eastern states of Australia, but not in Western Australia. *Grapholita packardi* and *G. prunivora* are not present in Australia. Establishment of these pests in any part of Australia would likely be significant for domestic trade at the district scale, effecting a rating of 'D'.

[11] The rating of 'D' was given for *G. molesta* as it is present in many parts of the world. *Grapholita packardi* and *G. prunivora* are restricted to North America and included in the EPPO A1 list of pest recommended for regulation. Establishment of these pests in any part of Australia would likely be of major significance for international trade at the district scale, effecting a rating of 'E'.

4.14.5 Unrestricted risk estimate

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 12.

Unrestricted risk estimate for the assessed Grapholita moth species	
Overall probability of entry, establishment and spread	Low
Consequences	Moderate
Unrestricted risk	Low

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

4.15 Lacanobia fruitworm

Lacanobia subjuncta

Lacanobia subjuncta is recognised as a pest of apple and it is present in the PNW states.

Lacanobia subjuncta belongs to the family Noctuidae, which is one of the largest families in the order Lepidoptera. *Lacanobia subjuncta* is widely distributed in North America (McCabe 1980) and has been present in irrigated areas of eastern Washington since the 1970s when it was collected in light traps in Yakima County, Washington state (Landolt 2002). In the late 1990s, it was recognised as a significant pest of apple orchards causing considerable crop loss in the Columbia Basin region of Washington State and northeast Oregon (Brunner *et al*. 2000; Doerr *et al*. 2004).

Apple is the primary host of *L. subjuncta* (Landolt 1998, 2002; Doerr and Brunner 2007). However, larvae have been found feeding on a number of other commercial crops, ground cover plants and weeds, indicating a potential high degree of polyphagy (Brunner *et al*. 2000; Landolt 1998, 2002). Larvae primarily feed on leaf tissue with fruit damage being incidental to foliage feeding, generally at high population densities (Doerr and Brunner 2007). In some apple orchards, significant fruit injury has occurred caused by late instar larvae (Doerr *et al*. 2002).

Lacanobia subjuncta has two generations per year (Landolt 1998). Larvae overwinter and pupate in the soil near host plants (Doerr and Brunner 2007). First adult flight occurs in North America from late April through June with a second adult flight from July to September (Brunner *et al*. 2000; Doerr *et al*. 2005). Adult *L. subjuncta* has a distinctive light brown to black colour pattern of scales on its wings, which are approximately 25 mm long and 50 mm between the wing tips (Doerr and Brunner 2007). Mated females lay their eggs in loose clusters of approximately 100 eggs on the underside of fruit tree leaves (Doerr and Brunner 2007). There are six larval instar development stages for *L. subjuncta*, and the last larval instar grows to approximately 50 mm in length (Landolt 2002; Doerr and Brunner 2007).

The risk posed by *Lacanobia subjuncta* is that larvae may be found within imported apple fruit.

4.15.1 Probability of entry

Probability of importation

The likelihood that *Lacanobia subjuncta* will arrive in Australia with the importation of the commodity: **VERY LOW**.

Supporting information for this assessment is provided below:

- *Lacanobia subjuncta* was first reported infesting apple orchards in the Columbia Basin of Washington State during the mid 1990s (Doerr and Brunner 2007) and has since become a significant pest of apple in central Washington, northeast Oregon (Doerr *et al*. 2005) and Idaho (Colt *et al*. 2001).
- Mated females lay up to 100 eggs on the underside of fruit tree leaves or on weed hosts (Doerr and Brunner 2007), allowing for the potential rapid establishment of this pest in commercial regions.

- There are two generations of *L. subjuncta* per year (Landolt 1998). The first generation of larvae occurs from early June through to July with the second generation from mid August through to October (Brunner *et al*. 2000; Doerr *et al*. 2005; Doerr and Brunner 2007). Depending on the apple variety, all six larval instars could potentially be present in apple orchards during the harvest period (Doerr and Brunner 2002).
- Apple is the primary host of *L. subjuncta* (Landolt 1998; Doerr and Brunner 2007). Larvae will also feed on ground cover plants including *Amaranthus retroflexus* (redroot pigweed), *Chenopodium berlandieri* (lambsquarters), *Convolvulus arvensis* (bindweed), *Malva neglecta* (mallow), *Medicago lupulina* (black medic), *Sonchus oleraceus* (sow thistle), and *Taraxacum officinale* (dandelion) (Landolt 1998). Many of these weed hosts are commonly found adjacent to commercial orchards allowing for the establishment and dispersal of this pest to commercial crops.
- The majority of noctuid pests of apples leave the trees in favour of feeding on ground cover plants. However, *L. subjuncta* can remain on the tree to complete larval development (Doerr and Brunner 2007). Larvae tend to be found in the tops of trees and on the outer branches (Warner 1998) and are likely to be present in apple trees during the harvest period.
- Larvae are primarily foliage feeders and can defoliate entire growing shoots (Doerr *et al*. 2002; Landolt 2002). Fruit feeding is considered incidental to foliage feeding but can be quite severe in orchards where population densities are high (Brunner *et al*. 2000; Doerr and Brunner 2007).
- Late instar larvae may cause significant levels of fruit injury, when present in high numbers, by feeding on the surface of the fruit (Landolt 2002; Doerr and Brunner 2007). Late instar larvae are large, up to 50 mm in length (Doerr and Brunner 2007), and are likely to be visually detected and removed during harvest and packing house procedures. Post-harvest washing and brushing of fruit are likely to remove any larvae present on the external surface of the fruit (Warner 1998).
- Sorting and grading is likely to detect and remove affected fruit, as infestation caused by larvae feeding generally results in a visible hollowed out 'scoop', approximately the size of a fingertip, on the surface of the apple fruit (Landolt 2002; Doerr and Brunner 2007). It is possible for the presence of secondary rots to follow after the initial damage caused by surface feeding, and affected fruit are likely to be detected and removed during harvest and packing house operations.
- After packing, fruit is stored at around 0ºC (Stebbins *et al*. 1997). Transport to Australia would be by either air freight or sea freight taking a minimum of 1–3 weeks. The temperature range for *L. subjuncta* larvae to complete development is 10ºC to 31ºC (Brunner *et al*. 2000; Doerr *et al*. 2002). Doerr *et al*. (2002) reported high larvae mortality at 10ºC (92.3%), suggesting larvae present on the fruit may not be able to survive cold storage and low temperature transportation.
- Doerr *et al*. (2002) estimated the lower developmental threshold for pupae to be 4.9ºC. However, there have been insufficient studies investigating cold tolerance development and survival of pupae at lower temperatures. *Lacanobia subjuncta* overwinters in the soil (Doerr *et al*. 2005; Doerr and Brunner 2007) of the cold climatic regions of North America (McCabe 1980) and Canada (McCabe 1980; Scott 2006), suggesting limited cold tolerance and capacity to survive cold conditions.

Despite the wide distribution of *L. subjuncta* in apple orchards in the PNW and its association with apple fruit at harvest, the obvious symptoms of infestation, large size of larvae and incapability to survive low temperatures, support a risk rating for importation of 'very low'.

Probability of distribution

The likelihood that *Lacanobia subjuncta* will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **LOW**.

Supporting information for this assessment is provided below:

- *Lacanobia subjuncta* has a wide range of host plants, including tree crops, shrubs, weeds and ground cover plants (Doerr and Brunner 2007). Apple is the primary host (Landolt 1998). Larvae have also been collected from apricot, cherry, pear, plum, prune trees (Brunner *et al*. 2000; Landolt 2002). Landolt (2002) has also recorded *L. subjuncta* on ground crops such as alfalfa (*Medicago sativa*), peas (*Pisum sativum*), and potato (*Solanum tuberosum*). Many of these host plants are widely distributed throughout Australia in domestic, commercial and wild environments, allowing for the potential distribution of this pest.
- Distribution of the commodity would be for retail sale as the intended use of the commodity is human consumption. Larvae could potentially remain on the fruit and emerge at unpacking and repacking facilities, retailer outlets or consumer residences. Any infested fruit would likely be discarded in bins, composting systems or landfills. The colonisation of fruit by saprophytic fungi or bacteria on discarded fruit would quickly rot the fruit, depleting the food source potentially needed for larvae to complete development.
- Late instar larvae reported feeding on the fruit are large, up to 50 mm in length (Doerr and Brunner 2007). Any larvae feeding on the fruit are likely to be easily detected. Furthermore, larval feeding causes a hollowed out scoop on the surface of the fruit, often as large as a fingertip (Landolt 2002; Doerr and Brunner 2007). The obvious symptoms of infestation and their large size, suggests a favourable potential for detection and removal of infested fruit at unpacking and repacking facilities or retailer distribution outlets.
- Larvae pupate in the soil (Doerr and Brunner 2007) and fruit infested by late instar larvae could potentially be discarded near suitable pupation sites. Following pupation, emerging adults are capable of finding a suitable host or mate through independent flight allowing for the potential distribution of this pest.

The wide host range and capacity for independent flight, moderated by large larval size and obvious symptoms of infested fruit, support a risk rating for distribution of 'low'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that *Lacanobia subjuncta* will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **VERY LOW**.

4.15.2 Probability of establishment

The likelihood that *Lacanobia subjuncta* will establish based on the comparison of factors in the source and destination areas that affect pest survival and reproduction: **MODERATE**.

Supporting information for this assessment is provided below:

- The primary host plant of *L. subjuncta* is apple (*Malus pumila*) (Landolt 1998). However, larvae have also been recorded on a variety of stone fruit crops (Landolt 1998; Brunner *et al*. 2000) and many common weed species found in commercial orchards or in the wild (Landolt 1998). Many of these hosts are found throughout Australia allowing for the potential establishment of this pest.
- *Lacanobia subjuncta* is found from coast to coast across temperate climatic regions of North America (McCabe 1980; Landolt 1997; Doerr and Brunner 2007). Many of these regions have similar climatic conditions to temperate southeastern and southwestern Australia, suggesting potential establishment of this pest. However, *L. subjuncta* is only present in North America (McCabe 1980), suggesting a limited ability to establish itself in new regions.
- Sexual reproduction is essential for *L. subjuncta*. After successful pupation, adults would need to disperse from the pupation site and locate a mate to establish a viable population.
- One mated female is capable of laying up to 100 eggs (Doerr and Brunner 2007). The potential fecundity of this species allows for the establishment of persistent populations.
- There are two generations of *L. subjuncta* per year (Landolt 1998). The first generation larvae appear from June to July and the second from mid August to October (Doerr and Brunner 2007; Brunner *et al*. 2000). The temperatures in many parts of temperate southeastern and southwestern Australia are similar to those experienced in the PNW for August to October (National Weather Service 2008). It is therefore likely that the Australian climate would be suitable for the second generation larvae and therefore the establishment of this pest.
- Eggs, larvae and pupae develop between a temperature range of 10°C–32.5°C, and the optimal temperature for development is between 25°C and 30°C (Brunner *et al.* 2000; Doerr *et al*. 2002). Research by Doerr *et al*. (2002) reported third and fourth larval instars are able to complete development at higher temperatures of 37.5°C and 32.5°C, respectively. It is therefore likely that the climate throughout much of Australia would be well suited for the establishment of this species.
- *Lacanobia subjuncta* adults are capable of independent flight. Adult males are considered strong fliers (Doerr and Brunner 2002), enabling them to move directly to a suitable host or viable mate, aiding in the potential establishment of this pest.
- Conventional insecticides may be successful in controlling *L. subjuncta*, but resistance is developing to some chemicals in some areas (Brunner *et al*. 2000; Colt *et al*. 2001).
- While pest control activities in commercial orchards may limit or prevent the establishment of this pest, such controls are unlikely to be applied in urban and suburban areas. Thus, the potential for establishment of *L. subjuncta* in these areas would not be reduced.
- Doerr and Brunner (2007) reported several hymenopterous and tachinid species as potential parasitoids of *L. subjuncta*. Eggs of these parasites have been found attached to the head of the *L. subjuncta* larvae (Doerr and Brunner 2007). There are many species of Tachinidae present in Australia (APPD 2009) which could potentially reduce population numbers. However, their effectiveness in controlling fruitworm numbers in America has not yet been assessed.

The potential availability of suitable hosts, high fecundity, capacity of independent flight, potential favourable climatic conditions for development and increasing pesticide resistance, moderated by the need to find a mate for reproduction and limited ability to adapt and potentially establish in new regions, support a risk rating for establishment of 'moderate'.

4.15.3 Probability of spread

The likelihood that *Lacanobia subjuncta* will spread based on a comparison of those factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pest: **MODERATE**.

Supporting information for this assessment is provided below:

- *Lacanobia subjuncta* occurs in the temperate regions of North America (McCabe 1980; Landolt 1998). Many of these regions have similar environments to Australia and if introduced, the Australian environment would likely be suitable for the spread of this pest. Even though temperatures may be favourable throughout parts of Australia, *L. subjuncta* has only established in North America (McCabe 1980) suggesting a limited ability to effectively adapt to different climatic regions or survive transportation conditions and spread to new continents.
- Apple is the primary host of *L. subjuncta*, and commercial apple fruit crops are grown in all states of Australia. However, the presence of natural barriers such as arid areas, the climatic differentials and long distances between these areas may limit the capacity of this species to spread unaided.
- Other minor hosts such as tree crops, shrubs, weeds and ground cover plants (Landolt 1998; Brunner e*t al*. 2000) are distributed widely throughout Australia. The prevalence of other suitable hosts may allow for local spread between areas.
- *Lacanobia subjuncta* adults are capable of independent flight. Adult males are considered strong fliers (Doerr and Brunner 2002) and this may increase the potential for males to locate females to reproduce, aiding in the spread of this pest.
- There are two generations of *L. subjuncta* per year (Landolt 1998) and each female is capable of laying approximately 100 eggs (Doerr and Brunner 2007). The high fecundity of these species suggests a favourable potential for spread.
- Apple fruit is intended for human consumption and infested fruit may be distributed through wholesale and retail trade. However, the presence of larvae on apple fruit is incidental except at high population densities of the late instar larvae (Doerr and Brunner 2007), reducing the likelihood of *L. subjuncta* being present on the fruit and spreading to new areas through facilitated transport.
- Late instar larvae may also feed on apple fruit (Doerr *et al.* 2000). Infested fruit are likely to be discarded prior to transportation given the large size of the larvae and obvious symptoms of infestation.

The wide host range, high fecundity and capacity for flight, moderated by visible symptoms of infestation and limited distribution range, support a risk rating for spread of 'moderate'.

4.15.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *Lacanobia subjuncta* will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **VERY LOW**.

4.15.5 Consequences

The consequences of the establishment of *Lacanobia subjuncta* in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision rules described in Table 2.4 on page 12, 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**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D – Significant at district level:** *Lacanobia subjuncta* has a wide host range, including *Amaranthus retroflexus* (redroot pigweed), *Chenopodium berlandieri* (lambsquarters), *Convolvulus arvensis* (bindweed), *Malva neglecta* (mallow), *Medicago lupulina* (black medic), *Sonchus oleraceus* (sow thistle) and, *Taraxacum officinale* (dandelion) (Landolt 1998). However, the main host of *L. subjuncta* is apple. It has also been recorded on apricots, cherry, pears, plums and prunes, whether planted as commercial crops or amenity trees (Landolt 1998). This pest is capable of causing direct damage to host plants more commonly through defoliation and subsequent reduction on host vigour and growth (Doerr and Brunner 2007). Damage caused by larval feeding is indicated by a hollowed out scoop on the surface of the fruit (Doerr and Brunner 2007), lowering fruit marketability. During the late 1990s, *L. subjuncta* was the main cause of crop loss in apple orchards in the Columbia Basin region of Washington State and northeast Oregon, with losses of approximately $US30 000 recorded (Brunner *et al*. 2000; Doerr *et al.* 2004). It is not known if any native plant species would be susceptible.
Other aspects of the environment	**B – Minor significance at the local level:** There are no known direct consequences of this pest on any other aspects of the environment but its introduction into a new environment may lead to competition for resources with native species.
Indirect	
Eradication, control etc.	**D – Significant at district level:** Programs in America to contain, eradicate, and/or minimise the impact of *L. subjuncta* on host plants include visual inspection, population monitoring, pheromone trapping, larvae sampling, and pesticide application (Doerr and Brunner 2007).These control programs are likely to be costly and may disrupt existing integrated pest management (IPM) programs for other pests in Australia because of the need to re-introduce or increase the use of organophosphate insecticides for the control of *L. subjuncta*. In Washington State, *L. subjuncta* has developed resistance to organophosphate pesticides (Brunner *et al.* 2000; Colt *et al.* 2001). The resistance to chemicals would make it difficult to eradicate or control this pest if the resistant strain were introduced to Australia.
Domestic trade	**C – Significant at local level:** Apples, pears and stone fruit are grown in all Australian states. If *L. subjuncta* becomes established in commercial production areas, this may result in interstate trade restrictions.
International trade	**C – Significant at local level:** The presence of *L. subjuncta* in commercial production areas of a range of commodities (apples, pears and stone fruit) may limit access to international markets where this pest has not established.
Environmental and non-commercial	**B – Minor significance at local level:** Pesticide applications and other control activities would be required to control this pest on susceptible crops, which could have minor indirect impact on the environment.

4.15.6 Unrestricted risk estimate

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 12.

Unrestricted risk estimate for *Lacanobia subjuncta*	
Overall probability of entry, establishment and spread	Very low
Consequences	Low
Unrestricted risk	Negligible

As indicated, the unrestricted risk estimate for *Lacanobia subjuncta* has been assessed as ‘very low’, which achieves Australia’s ALOP. Therefore, no specific risk management measures are required for this pest.

4.16 Thrips[12]

Frankliniella occidentalis; Frankliniella tritici

The thrips species assessed here 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 both species.

Frankliniella occidentalis (western flower thrips) and *F. tritici* (eastern flower thrips) are serious agricultural pests, damaging flowers, leaves and fruit through their feeding activities (CABI 2007). Their mouthparts are used to rupture and imbibe fluids from plant cells, causing scarring that can reduce crop yield, productivity and marketability.

Frankliniella occidentalis is also a vector of several tospoviruses, including *Tomato spotted wilt virus* (TSWV) and *Impatiens necrotic spot virus* (INSV) (Morse and Hoddle 2006). Tospoviruses are persistently transmitted by *F. occidentalis*, i.e. once the thrips has acquired the virus, it remains infective for life. Tospoviruses are not passed on to the next generation.

Thrips are easily overlooked because of their small size. Eggs are usually laid within host plant tissue. Larval, pupal and adult thrips are mobile and easily dispersed on clothing and packing materials. Adult thrips are winged and can travel considerable distances on the wind (CABI 2007). They are opportunistic species well adapted to surviving harsh climatic conditions and are known to survive temperatures below freezing over extended periods (McDonald *et al.* 1997).

Frankliniella tritici is absent from Australia. *Frankliniella occidentalis* is absent from the Northern Territory (DRDPIFR NT 2009), and interstate restrictions on the movement of host material exist in Australia (DPIW 2008a; DRDPIFR NT 2008). In Tasmania, *F. occidentalis* is an ‘A List Pest’ under the Plant Quarantine Act 1997. There are controls on host produce entering Tasmania, and there are active monitoring and control practices in the state.

Of the viruses vectored by *F. occidentalis* and present in the US, TSWV is absent from the Northern Territory and Tasmania, and INSV is not reported from Australia.

This assessment considers two risks: 1) the risk associated with *F. tritici* (for all of Australia) and *F. occidentalis* (for the Northern Territory and Tasmania); and 2) the risk of INSV being introduced by *F. occidentalis* on imported apple fruit. This is assessed for all of Australia.

The risk posed by thrips is the presence of eggs, larvae or adult stages on imported apple fruit.

The risk posed by INSV is its presence in *F. occidentalis* on imported apple fruit. Apple is not a host for INSV, but *F. occidentalis* that has acquired INSV from a virus host may subsequently have moved to apples. The introduction of INSV would depend on the entry of *F. occidentalis*. Establishment and spread of INSV in Australia may rely on the existing population of *F. occidentalis* in Australia, and the probability for this is rated ‘high’, given the widespread distribution of the vector and a related virus, TSWV.

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[12] In this section, the common name thrips will be used to refer to both species assessed. The scientific name will be used when the information is about a specific species.

4.16.1 Probability of entry

Probability of importation

The likelihood that *Frankliniella occidentalis* or *F. tritici* will arrive in Australia, including the Northern Territory or Tasmania, with the importation of the commodity: **HIGH**.

Supporting information for this assessment is provided below:

- *Frankliniella occidentalis* is widespread across North America, including the PNW (Nakahara 1997; Baker 2002; CABI 2007).
- *Frankliniella tritici* is widespread across eastern North America and some western states, including Idaho (CABI 2007).
- *Frankliniella occidentalis* and *F. tritici* infest a wide range of host plants including herbaceous ornamentals, weeds, shrubs, herbs, vegetable and fruit crops (Nakahara 1997; CABI 2007; Dreistadt and Phillips 2007; Frantz and Fasulo 2008). *Frankliniella occidentalis* is considered an economic pest of apples in orchards of Washington State (Smith 2001; CABI 2007).
- Adult thrips are extremely small, less than 2 mm long (Baker 2002; Antonelli 2003; Dreistadt and Phillips 2007). Their body colour can range from translucent white or yellow to black or brown in adults, and pale cream to translucent green in larvae (CABI 2007; Dreistadt and Phillips 2007). Any thrips present on apple fruit may be difficult to detect during harvest. Adults and immature forms may hide in crevices such as the calyx or stem end of the fruit (Terry *et al.* 2007).
- Thrips are primarily leaf and flower feeders (Hubscher 1988; Morse and Hoddle 2006). They may also feed on apple fruit, and feeding damage is usually only one cell deep, indicated by fruit russeting or scarring at harvest (Hubscher 1988; Dreistadt and Phillips 2007; Terry *et al.* 2007). Sorting and grading are likely to detect and remove affected fruit. However, thrips may feed within enclosed plant parts, which makes them difficult to detect (Dreistadt and Phillips 2007).
- Eggs are typically deposited onto leaves or buds (Dreistadt and Phillips 2007), but may also be found in other plant parts such as the fruit (Terry *et al*. 2007). Damage on apple fruit from oviposition is a result of the egg laying punctures that cause a condition known as 'pansy spot', a whitish discoloured area surrounding the small scar where the egg was laid (Hubscher 1988; Miliczky *et al*. 2007; Terry *et al*. 2007). Fruit with large or numerous 'pansy spots' are likely to be detected and removed during packing house procedures.
- Feeding and oviposition typically results in visible morphological changes in affected tissues. Post-harvest grading, washing, brushing and packing procedures are therefore likely to cull symptomatic fruit and leaf material. Damage to the fruit may be obvious but would not be a reliable indicator of infestation. It is likely that packing house processing will reduce the numbers of adults, larvae and eggs present on the commodity. However, their small size, large numbers, cryptic behaviour, inconspicuous colouring and egg deposition, suggest that some thrips may survive fruit processing operations (Morse and Hoddle 2006).
- Sexually mature females of thrips overwinter in the soil, in curled leaves, under bark and in evergreen plants of cold climatic regions of North America and Canada (Hubscher

1988). Thus, thrips are likely to be capable of tolerating cold conditions and potentially survive cold storage and transportation.

- After packing, fruit is stored at around 0ºC (Stebbins *et al.* 1997). Transport to Australia would be by either air freight or sea freight taking a minimum of 1–3 weeks. McDonald *et al.* (1997) demonstrated that thrips larvae are potentially cold tolerant, and are capable of surviving sub-zero temperatures and still reproduce effectively afterwards at higher temperatures.
- Thrips have been recorded on produce entering the Netherlands from 30 different countries over a thirteen-year period (1980-1993), and approximately 1000 thrips specimens are intercepted by US border inspectors annually (Morse and Hoddle 2006). Therefore, thrips appear to be capable of surviving packing house procedures, cold storage and transport conditions.

The cold tolerance of *F. occidentalis* and *F. tritici*, their ability to adapt to varying environments, their small size, cryptic nature, association with apple fruit, and prevalence in the exporting country, support a risk rating for importation of 'high'.

Probability of distribution

The likelihood that the thrips assessed will be distributed in Australia, including the Northern Territory or Tasmania, in a viable state, as a result of the processing sale or disposal of the commodity: **MODERATE**.

Supporting information for this assessment is provided 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.
- The conditions in Australia, including the Northern Territory or Tasmania, may be suitable for larvae to emerge immediately after they arrive.
- Adult thrips are winged, but are generally recognised as poor fliers (Dreistadt and Phillips 2007). However, they can potentially be distributed to a suitable host plant by floating on the wind or with the movement of nursery stock or other commodities.
- The small size, inconspicuous body colouring, cryptic behaviour, oviposition in protected plant parts and tendency to infiltrate tight spaces, allows for a favourable potential for distribution of thrips from the port of entry (Morse and Hoddle 2006; Dreistadt and Phillips 2007).
- Although the mobility and reproductive capacity of thrips may be temporarily subdued by prolonged cold treatment, it is likely that they would survive and reproduce after transportation with the commodity (McDonald *et al.* 1997; McDonald *et al.* 2000).
- Thrips are highly polyphagous with over 250 plant species from more than 65 families recorded as host plants (CABI 2007) (see Appendix B). Many of these host plants are widely distributed in Australia, including the Northern Territory and Tasmania, allowing for the potential distribution of this pest.

The small size of thrips, their inconspicuous body colouring, cryptic behaviour, oviposition in protected plant parts, tendency to infiltrate tight spaces, wide host range, ability to adapt to varying environment, moderated by its weak directional flying ability, support a risk rating for distribution of 'moderate'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that *F. occidentalis* or *F. tritici* will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **MODERATE**.

4.16.2 Probability of establishment

The likelihood that the assessed thrips will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **HIGH**.

Sporting information for this assessment is provided below:

- Thrips are highly polyphagous with over 250 plant species from more than 65 families recorded as host plants (CABI 2007). The broad host range of thrips suggest many environments in Australia, including the Northern Territory and Tasmania would be amenable to the establishment of new thrips species. Many weed, crop and native hosts are commonly found in Australia (see Appendix B), allowing for the potential establishment of these pests.
- *Frankliniella occidentalis* has already established in most areas of Australia (DAWA 2006; Mound 2008), indicating that Australian environments, including those of the Northern Territory and Tasmania, would be suitable for the establishment of thrips species.
- *Frankliniella occidentalis* and *F. tritici* feed in a variety of habitats from lowland to subalpine and from humid to arid (Kirk and Terry 2003; Morse and Hoddle 2006; CABI 2007). The prevalence and spread of these species in diverse regions worldwide shows their capacity to adapt to a wide range of environmental conditions. Many of these regions have tropical, subtropical, warm or cool-temperate environments similar to many Australian environments, suggesting environmental conditions are potentially amenable to the establishment or expansion of the geographic range of *F. occidentalis* and *F. tritici*.
- Female thrips do not require a male to reproduce. Male thrips are haploid, produced from unfertilised eggs whereas females are diploid and derived from fertilised eggs (Funderburk and Stavisky 2004). Thrips population could potentially establish from a single female (Morse and Hoddle 2006).
- Female thrips lay their eggs under bud scales, in petals and sepals, on stems, within the calyx or on fruit (Dreistadt and Phillips 2007; Terry *et al*. 2007). Eggs are laid soon after an appropriate host is located, and depending on environmental conditions and nutrient levels, as many as 150–300 eggs may be laid by each female (Smith 2003). The high fecundity of these species suggests a favourable potential for their establishment in new regions of Australia.
- 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). A mean life span of *F. occidentalis* adults was reported to be 20.5 days (Rijn *et al.* 1995 in Kumm 2002). Breeding may be continuous with as many as 8–15 generations annually (Kumm 2002; Dreistadt and Phillips 2007). The short generation times favour the establishment of populations.

- The use and timing of chemicals is difficult because of the small size of thrips, their rapid reproduction, widespread resistance to pesticides and preference for secluded habitats (McDonald *et al.* 1998). Repeat applications are usually required to ensure newly hatched thrips, recently emerged adults and thrips blown in from adjacent areas are exposed (Dreistadt and Phillips 2007).
- Chemical control is only partially effective and must be combined with appropriate cultural practices and conservation of natural enemies to prevent the establishment of this pest (Dreistadt and Phillips 2007).

The wide host range of thrips, worldwide distribution, adaptability, high fecundity, short generation time and capacity to reproduce by parthenogenesis, support a risk rating for establishment of 'high'.

4.16.3 Probability of spread

The likelihood that the assessed thrips will spread based on a comparison of factors in the area of origin and in the Northern Territory and Tasmania that affect the expansion of the geographic distribution of the pest: **HIGH**.

Supporting information for this assessment is provided below:

- *Frankliniella occidentalis* is near-cosmopolitan (Nakahara 1997; Baker 2002), and *F. tritici* is widespread in the Northern Hemisphere (CABI 2007). They inhabit regions from tropical to cool-temperate climates, such as those of the Northern Territory and Tasmania, respectively, suggesting they could spread in Australia.
- The broad host range of these thrips suggests the environment of Australia, including the Northern Territory and Tasmania, would be potentially amenable to their spread, with many weed, crop and native host species in these regions being potentially susceptible to thrips infestations.
- Facilitated transport of thrips with infested commodities is likely to aid in their spread over long distances. The small sizes of eggs, immature larvae and adult thrips, inconspicuous body colouring, cryptic behaviour, and tendency to infiltrate tight spaces increases the potential for thrips to spread undetected via the movement of infested fruit.
- Thrips can reproduce parthenogenetically (Funderburk and Stavisky 2004). A mean life span of *F. occidentalis* adults was reported to be 20.5 days (Rijn *et al.* 1995 in Kumm 2002). Under favourable conditions, females are able to lay approximately 150–300 eggs in their lifetime and breeding may be continuous with as many as 8–15 generations annually (Kumm 2002; Dreistadt and Phillips 2007). The potential high fecundity of these species suggests a favourable potential for spread.

The small size of thrips, inconspicuous body colouring, cryptic behaviour, oviposition in protected plant parts, tendency to infiltrate tight spaces, wide host range, worldwide distribution, capacity for independent flight, capacity for parthenogenesis and high fecundity, support a risk rating for spread of 'high'.

4.16.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive probabilities shown in Table 2.2 on page 9.

The likelihood that *F. occidentalis* or *F. tritici* will enter Australia, including the Northern Territory and Tasmania, as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia, including the Northern Territory and Tasmania: **MODERATE**.

4.16.5 Consequences

The consequences of the establishment of the assessed thrips in Australia, including the Northern Territory and Tasmania, have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision rules described in Table 2.4 on page 12, 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**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D – Significant at the district level:** Thrips are capable of causing direct harm to their hosts through feeding and oviposition (Antonelli 2003; Terry *et al*. 2007). Both adults and larvae feed on the cell contents of soft plant tissue. On apple fruit, feeding damage results in surface scarring. Adult females lay their eggs by puncturing the fruit with their serrated ovipositors (Terry *et al.* 2007), causing an irregularly shaped blemish known as a 'pansy spot' (Hubscher 1988; Terry *et al.* 2007). Damage can range from an inoffensive cosmetic blemish to a significant downgrading of fruit. *Frankliniella occidentalis* can also cause indirect damage by vectoring tospoviruses (Morse and Hoddle 2006). Both the thrips and vectored agents have a wide host range and can cause significant damage to susceptible hosts. In particular, establishment of *F. occidentalis* in the Northern Territory or Tasmania may aid the establishment and spread of TSWV, which is present in other parts of the country. INSV may be introduced by *F. occidentalis* in Australia. It is a major viral pathogen in greenhouse flower production in the US and Europe (Nameth 1996; Windham *et al*. 2009). It is increasingly found in outdoor vegetable crops (Morris 2004). Flower crop losses due to INSV can be up to 100% (EPPO 2000). It is not known if any native plant species and communities would be susceptible.
Other aspects of the environment	**B – Minor significance at the local level:** There are no known direct consequences of thrips on any other aspects of the environment but their introduction into a new environment may lead to competition for resources with native species.
Indirect	
Eradication, control etc.	**C – Significant at the local level:** Additional programs to minimise the impact of thrips on host pants may be necessary. Existing control programs, such as broad spectrum insecticide applications, may be effective for some species and hosts 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. Efforts to eradicate incursions of other thrips have been unsuccessful so control of *F. occidentalis* and *F. tritici* will be an ongoing issue. Increased costs for crop monitoring and consultant's advice to the producer may be incurred. The extremely wide range of host species for these thrips would also make it difficult and costly to completely eradicate them from the natural environment.
Domestic trade	**D – Significant at the district level:** If *F. tritici* becomes established in Australia, it is likely to result in interstate trade restrictions. If *F. occidentalis* becomes established in the Northern Territory or Tasmania, it is likely to result in interstate trade restrictions only between these two areas, as the thrips is present in the other states and territories of Australia. INSV, if introduced in one region of Australia may result in interstate trade restriction, especially for nursery stock of a wide range of plant species.
International trade	**D – Significant at the district level:** The presence of *F. occidentalis* and *F. tritici* in commercial production areas of a range of commodities (ornamentals, vegetables and fruit crops including apples, pears and stone fruit) may limit access to international markets where it has not established. While *F. occidentalis* is widespread worldwide, it is still absent from many Asian countries such as Taiwan, Thailand or India, as is *F. tritici*. INSV, if introduced in Australia, may limit access to international markets where it has not established. Currently, it is absent from Asia, Africa and South America.
Environmental and non-commercial	**B – Minor significance at local level:** Pesticide applications and other control activities would be required to control these pests on susceptible crops, which could have minor indirect impact on the environment.

4.16.6 Unrestricted risk estimate

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 12.

Unrestricted risk estimate for *Frankliniella tritici*, *F. occidentalis* and/or *Impatiens necrotic spot virus*	
Overall probability of entry, establishment and spread	Moderate
Consequences	Low
Unrestricted risk	Low

As indicated, the unrestricted risk estimate for *F. occidentalis* and *F. tritici* has been assessed as ‘low’, which is above Australia’s ALOP. Therefore, specific risk management measures are required for these pests per se, and in the case of *F. occidentalis*, as a potential vector for INSV for all of Australia.

4.17 Coprinus rot

Coprinopsis psychromorbida

Coprinus rot is a fungal post-harvest disease of apple and pear caused by the low-temperature basidiomycete *Coprinopsis psychromorbida* (Traquair 1987; Spotts 1990c). The disease occurs most frequently in apple and pear fruit that have been stored for extended periods (Spotts 1990c).

Coprinopsis psychromorbida is a heterothallic basidiomycete with two mating types (Traquair 1980; Redhead and Traquair 1981). Conspecific monokaryotic and dikaryotic strains of *C. psychromorbida* that cause fruit rot have been isolated, indicating that a sexual fruiting stage may be involved in the dissemination of the fruit rot pathogen. No basidiocarps have been found on apple fruit (Gaudet and Sholberg 1990) but they probably occur on orchard litter (Sholberg and Gaudet 1992). Pome fruit, lucerne and grass isolates are infertile (Gaudet and Sholberg 1990). Isolates from these kinds of hosts can infect pome fruit (Traquair 1987; Gaudet and Sholberg 1990). The pathogen can also infect wooden packing cases (Traquair 1987).

Severe decay of apples caused by *C. psychromorbida* was reported from British Columbia, Canada, in 1986, after seven months in controlled-atmosphere storage (Sholberg and Gaudet 1992). Serious losses of d'Anjou pears stored at -1.1ºC for nine months due to Coprinus rot occurred in Oregon in 1979 (Spotts *et al.* 1981).

Susceptible apple cultivars include McIntosh, Golden Delicious and Red Delicious, while Spartan, Newtown, Jonathan and Jonagold are less susceptible (Gaudet and Sholberg 1990; Spotts 1990c).

Coprinus rot symptoms are similar to those of fisheye rot caused by *Butlerelfia eustacei* (Traquair 1987). *Coprinopsis psychromorbida* causes sunken fruit lesions, 0.5–25 mm in diameter, with dark brown borders and lighter centres. The decayed tissue is firm and dry (Spotts 1990c). In the advanced stages of the disease, extensive white, raised mycelium often covers the fruit, fruit wraps and storage trays (Spotts *et al.* 1981).

Coprinopsis psychromorbida is capable of producing fruit decay at 2ºC (Gaudet and Sholberg 1990) and was observed on apples and pears that were held under controlled-atmosphere conditions at temperatures of -1.1–2ºC (Spotts *et al.* 1981; Meheriuk and McPhee 1984). Penetration of fruit occurs exclusively through lenticels (Gaudet *et al.* 1990).

Under experimental conditions, fruit lesions are clearly visible after 55 days at 2ºC (Gaudet and Sholberg 1990). Infection of healthy apples was evident 2–4 weeks after they were placed with an extensively decayed apple at 5ºC and after 4–10 weeks, individual lesions merged (Gaudet *et al.* 1990). Optimum temperature for pathogenicity in Golden Delicious apples is 15ºC (Gaudet and Sholberg 1990). Under experimental conditions, no radial growth of *C. psychromorbida* cultures occurs at 25ºC (Spotts *et al.* 1981).

Infection of apple and pear fruit probably occurs in the orchard during the last month before harvest (Willett *et al.* 1989; Spotts 1990c). The source of inoculum for fruit infection is unknown but is probably basidiospores from basidiocarps found on litter. However, Sholberg and Gaudet (1992) show that orchard litter/grass infected with *C. psychromorbidus* can serve as a source of inoculum for rot in stored apples (Sholberg and Gaudet 1992). In storage, fungal infection spreads to healthy fruit via growth of mycelia from fruit to fruit (Gaudet *et al.* 1990).

Coprinopsis psychromorbida also causes snow mould on overwintering cereals, grasses and legumes (Gaudet and Sholberg 1990; Spotts 1990c). On these hosts, it develops a cottony mycelium under a blanket of snow. Some strains of the fungus produce sclerotia which aid in survival during summer (Spotts 1990c). Basidiocarps usually develop in autumn under very moist conditions and quickly autolyze, when mature, to release basidiospores (Spotts 1990c).

Coprinopsis psychromorbida has been isolated from *Agrostis stolonifera*, *Dianthus* sp., *Elymus piperi*, *Medicago sativa*, *Triticum aestivum*, *Urtica dioica*, horse manure (Redhead and Traquair 1981), *Poa pratensis*, *Triticum aestivum*, (Gaudet and Sholberg 1990), *Festuca rubra*, *Trifolium repens* and orchard litter (Sholberg and Gaudet 1992).

Coprinopsis psychromorbida has been identified throughout the PNW as a postharvest pathogen of apple and pear (Willett *et al.* 1989), but has not been recorded in Australia.

The risk posed by *Coprinopsis psychromorbida* is that symptomless infected fruit may be exported and result in the establishment of this pathogen in Australia.

4.17.1 Probability of entry

Probability of importation

The likelihood that *Coprinopsis psychromorbida* will arrive in Australia with the importation of the commodity: **HIGH**.

Supporting information for this assessment is provided below:

- Coprinus rot symptoms occur most frequently in apple and pear fruit that have been stored for extended periods (Spotts 1990c).
- Coprinus rot has been identified throughout the PNW as a postharvest disease of apple and pear (Willett *et al.* 1989).
- The fungus readily grows at temperatures used for cold storage of apples and can cause post-harvest fruit decay at 2ºC (Gaudet and Sholberg 1990). Coprinus rot was observed on apples and pears that were held under controlled-atmosphere conditions at temperatures of -1.1–2ºC (Spotts *et al.* 1981; Meheriuk and McPhee 1984). Serious losses of d'Anjou pears in controlled-atmosphere storage due to Coprinus rot occurred in Oregon in 1979 (Spotts *et al.* 1981).
- Infection of apple fruit by basidiospores of *C. psychromorbida* probably occurs in the orchard during the last month before harvest (Willett *et al.* 1989; Spotts 1990c). Basidiocarps are formed on senescent plant tissues in autumn and spring (Redhead and Traquair 1981). Sholberg and Gaudet (1992) show that orchard litter/grass infected with *C. psychromorbidus* can serve as a source of inoculum for rot in stored apples (Sholberg and Gaudet 1992).
- Symptoms of the disease only show after some time in storage. The severity of decay will depend on the virulence of the *C. psychromorbida* strain and on the storage temperature (Gaudet and Sholberg 1990).

- When apple fruit are infected with *C. psychromorbida* under experimental conditions by inserting a plug of inoculum into the flesh, fruit lesions are clearly visible after 55 days at 2ºC (Gaudet and Sholberg 1990). Infection of healthy apples was evident 2–4 weeks after they were placed with an extensively decayed apple at 5ºC and after 4–10 weeks, individual lesions merged (Gaudet *et al.* 1990).
- In storage, *C. psychromorbida* infection spreads to healthy fruit via growth of mycelia from fruit to fruit (Gaudet *et al.* 1990).

The wide distribution of this fungus in the PNW, its ability to grow at temperatures used for cold storage and the potential for infection occurring before harvest with symptoms only developing in storage, support a risk rating for importation of 'high'.

Probability of distribution

The likelihood that *Coprinopsis psychromorbida* will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **HIGH**.

Supporting information for this assessment is provided below:

- Imported apple fruit is intended for human consumption in Australia. It is expected that once the apple fruit has arrived in Australia, it will be distributed throughout Australia for wholesale or retail sale. Any infected fruit present may be distributed during these procedures. However, infected fruit with obvious signs of rot are expected to be disposed of rather than distributed further.
- Conditions during transport of fruit to Australia will be favourable for survival of the pathogen.
- If fruit purchased by consumers are found to have decay, they will be disposed of into garden compost bins, possibly near host plants, or into landfills. Individual consumers will distribute small quantities of apples to a variety of urban, rural and wild environments, where they will be consumed, or disposed of, in close proximity to a suitable host plant.
- Coprinus rot occurs most frequently in apple and pear fruit that have been stored for extended periods (Spotts 1990c). The severity of decay will depend on the virulence of the *C. psychromorbida* strain and on the storage temperature (Gaudet and Sholberg 1990). The shorter the storage time the less likely that symptoms will be expressed on infected fruit.
- Many people peel apples before eating them. Infected peel could serve as substrate for saprophytic growth of *C. psychromorbida* when disposed of to landfills or domestic compost.
- The fungus can be dispersed via movement of storage trays and other packing materials. Black sclerotia were observed on the wood of storage crates of pears infested with *C. psychromorbida* in Oregon (Spotts *et al.* 1981). Sclerotia are likely to be significant survival propagules and sources of infection of this fungus.
- Allocyst-like structures are formed in the mycelium (Traquair 1987). These may function as resting or dispersal structures.
- Microsclerotia of *C. psychromorbida* have been observed in infected wheat leaves (Gaudet and Kokko 1985). These microsclerotia may serve as survival structures.

- *Coprinopsis psychromorbida* occurs in western Canada (including Alberta and British Columbia) and the US (including Alaska and the PNW) (Traquair 1980, 1987; Smith 1981; Willett *et al.* 1989; Farr and Rossman 2009). Environments with climates similar to these areas exist in parts of temperate southeastern and southwestern Australia, suggesting that the climate in these parts of Australia is likely to be suitable for the survival of *C. psychromorbida*.

The potential distribution of infected fruit throughout Australia, the disposal of fruit waste in the environment and the pathogen's ability to grow at temperatures used for cold storage, support a risk rating for distribution of 'high'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that *Coprinopsis psychromorbida* will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **HIGH**.

4.17.2 Probability of establishment

The likelihood that *Coprinopsis psychromorbida* will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **HIGH**.

Supporting information for this assessment is provided below:

- *Coprinopsis psychromorbida* has a wide host range, including apples, pears, overwintering cereals, grasses and legumes (Gaudet and Sholberg 1990). Suitable hosts are widely present in Australia. *Coprinopsis psychromorbida* has also been isolated from orchard litter and horse manure (Redhead and Traquair 1981; Sholberg and Gaudet 1992).
- Infected fruit disposed near suitable hosts or substrates may serve as a source of inoculum.
- *Coprinopsis psychromorbida* occurs in western Canada (including Alberta and British Columbia) and the US (including Alaska and the PNW) (Traquair 1980, 1987; Smith 1981; Willett *et al.* 1989; Farr and Rossman 2009). Environments with climates similar to these areas exist in parts of temperate southeastern and southwestern Australia, suggesting that the climate in these parts of Australia is likely to be suitable for the survival of *C. psychromorbida*.
- Microsclerotia of *C. psychromorbida* have been observed in infected wheat leaves (Gaudet and Kokko 1985). These microsclerotia may serve as survival structures.
- The fungus requires temperate climate conditions for growth (Gaudet and Sholberg 1990). Under experimental conditions, no radial growth of *C. psychromorbida* cultures occurs at 25ºC (Spotts *et al.* 1981).
- *Coprinopsis psychromorbida* is able to form sclerotia (Spotts *et al.* 1981; Gaudet and Kokko 1985; Spotts 1990c) which may serve as survival propagules at higher temperatures.

The wide distribution of hosts and the occurrence of suitable climatic conditions for survival and infection in some parts of Australia, support a risk rating for establishment of 'high'.

4.17.3 Probability of spread

The likelihood that *Coprinopsis psychromorbida* will spread based on a comparison of those factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pest: **HIGH**.

Supporting information for this assessment is provided below:

- Hosts and substrates of *C. psychromorbida* include apple, pear, overwintering cereals, grasses, legumes, orchard litter and horse manure (Redhead and Traquair 1981; Gaudet and Sholberg 1990; Sholberg and Gaudet 1992). These hosts and substrates are present in Australia in commercial orchard districts, suburban and rural areas.
- In storage, infection with *C. psychromorbida* spreads to healthy fruit via growth of mycelia from fruit to fruit (Gaudet *et al.* 1990).
- *Coprinopsis psychromorbida* occurs in western Canada (including Alberta and British Columbia) and the US (including Alaska and the PNW) (Traquair 1980, 1987; Smith 1981; Willett *et al.* 1989; Farr and Rossman 2009). Environments with climates similar to these areas exist in parts of temperate southeastern and southwestern Australia, suggesting that the climate in these parts of Australia is likely to be suitable for the survival of *C. psychromorbida*.
- Basidiocarps are formed in autumn and spring (Readhead and Traquair 1981) on senescent plant material.
- *C. psychromorbida* is able to form sclerotia (Spotts *et al.* 1981; Gaudet and Kokko 1985; Spotts 1990c) which may serve as survival propagules at higher temperatures.

The dispersal of the fungus via infected fruit, orchard litter/grass, horse manure and packing material and its ability to form sclerotia as survival propagules support a risk rating for spread of ‘high’.

4.17.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of ‘rules’ for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *Coprinopsis psychromorbida* will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to a suitable host, establish in the area and subsequently spread within Australia: **HIGH**.

4.17.5 Consequences

The consequences of the establishment of *Coprinopsis psychromorbida* in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision rules described in Table 2.4 on page 12, 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**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D – Significant at the district level:** Coprinus rot is a post harvest disease of apple and pear (Spotts 1990c). *Coprinopsis psychromorbida* causes sunken fruit lesions, 0.5–25 mm in diameter, with dark brown borders and lighter centres. The decayed tissue is firm and dry (Spotts 1990c). In the advanced stages of the disease, extensive white, raised mycelium often covers the fruit, fruit wraps and storage trays (Spotts 1990c). Serious losses (estimated at $US 115 000) of stored d'Anjou pears due to Coprinus rot have occurred in Oregon in 1979 (Spotts *et al.* 1981). Severe economic losses due to decay of apples in controlled atmosphere storage have been reported from British Columbia, Canada, in 1986. After seven months in controlled-atmosphere storage, around 180 000 kg of Spartan apples were lost due to decay by *C. psychromorbida* (Sholberg and Gaudet 1992). *Coprinopsis psychromorbida* also causes snow mold on cereals, grasses and legumes (Spotts 1990c). It is not known what effect the pathogen would have on native grasses and other plants growing at high altitudes or in cool temperate regions in Australia.
Other aspects of the environment	**A – Indiscernible at the local level:** There are no known direct consequences of these species on other aspects of the environment.
Indirect	
Eradication, control etc.	**D – Significant at the district level:** Recommended measures for the control of *Coprinopsis psychromorbida* include an application of fungicide (e.g. Ziram) 10 days before harvest and the use of chlorine and sodium *o*-phenylphenate in the dump tank water in the packing house (Spotts *et al.* 1981; Spotts 1990c). Implementation of control measures would result in an increase in the cost of production. Additionally, costs for crop monitoring and consultant's advice to manage this pest may be incurred by the producer.
Domestic trade	**D – Significant at the district level:** Coprinus rot is a post harvest disease of apple and pear (Willett *et al.* 1989; Spotts 1990c). Serious losses due to this disease have occurred in the US and Canada (Spotts *et al.* 1981; Sholberg and Gaudet 1992). *Coprinopsis psychromorbida* also causes snow mold on cereals, grasses and legumes (Spotts 1990c). *Coprinopsis psychromorbida* has not been recorded in Australia. The introduction of *C. psychromorbida* 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 (apple, pear, cereals, grasses and legumes).
International trade	**D – Significant at the district level:** The presence of *C. psychromorbida* in commercial production areas of a range of commodities, including apple and pear, would have a significant effect at the district level due to potential limitations of accessing international markets where this pest is absent. For example, New Zealand lists *C. psychromorbida* as one of the regulated pests for pears from Oregon, US (MAFNZ 1999). *Coprinopsis psychromorbida* is already present in the US and Canada (Traquair 1980, 1987; Smith 1981; Willett *et al.* 1989; Farr and Rossman 2009).
Environmental and non-commercial	**B – Minor significance at the local level:** Additional fungicide applications or other control activities would be required to control this disease on susceptible crops and these may have minor impact on the environment.

4.17.6 Unrestricted risk estimate

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 12.

Unrestricted risk estimate for *Coprinopsis psychromorbida*	
Overall probability of entry, establishment and spread	High
Consequences	Low
Unrestricted risk	Low

As indicated, the unrestricted risk estimate for *Coprinopsis psychromorbida* has been assessed as ‘low’, which is above Australia’s ALOP. Therefore, specific risk management measures are required for these pests.

4.18 Apple blotch

Phyllosticta arbutifolia

Apple blotch is a fungal disease caused by *Phyllosticta arbutifolia* (syn. *Phyllosticta solitaria*), which is native to North America. The pathogen is present in Washington (Farr and Rossman 2009). Apple blotch used to be a major disease in the southeastern US. However, it is now described as rare in most commercial apple orchards (Yoder 1990a), possibly due to a regular fungicide program in commercial orchards against other diseases and the preference for more resistant cultivars.

Apple blotch can cause damage to fruit, leaves, buds and stems. In warm and wet weather, infection can occur throughout the growing season (Pierson *et al*. 1971), with primary infection usually occurring about 2–3 weeks after blossom fall (CABI/EPPO 1997d).

Phyllosticta arbutifolia can overwinter as pycnosclerotia in cankers and as dormant mycelium in stem cankers or infected dormant buds (Yoder 1990a). Overwinter cankers are likely the main source of primary inoculum.

Fruits are more susceptible to infection early in the season, but symptoms usually appear by mid summer (Pierson *et al*. 1971). Early symptoms on young fruit appear as small, isolated, dark-coloured, lesions. These gradually enlarge and develop fringed margins (Yoder 1990a; CABI/EPPO 1997d). The fringed margins usually disappear when lesions merge. As the fruit enlarges, lesions may crack (Yoder 1990a). The fungus grows superficially and there is no rotting of the fruit tissues. However, blotch lesions and cracks provide sites for secondary infections, commonly by *Penicillium* spp. and *Botryosphaeria obtusa* (Pierson *et al.* 1971).

Pycnidia developed in the primary lesions on fruits and leaves can produce conidia which are important inoculum sources for secondary infections in late summer through to early autumn (Yoder 1990a). In autumn, pycnidia on shoots, fruits and leaves may become typical pycnosclerotia. Overwintering pycnosclerotia can give rise to pycnidiospores in the spring. However, many overwintering pycnosclerotia become sterile. Their role as inoculum sources is probably minor (CABI/EPPO 1997d).

Apple blotch incidence and severity is increased by heavy rains and extended wet periods, which promote the exudation, dissemination and germination of conidia (Yoder 1990a). The fungus is dispersed as rain-splashed conidia. Spores can germinate at a wide temperature range, 5–39°C, with an optimum germination temperature range of 21–27°C (CABI/EPPO 1997d). *Phyllosticta arbutifolia* can survive at 1–2°C for at least nine months (McClintock 1930).

The risk posed by *Phyllosticta arbutifolia* is that infected fruit with viable inoculum may be imported and may result in the establishment of this pathogen in Australia.

Phyllosticta arbutifolia (as *P. solitaria*) was included in the existing import policy for Fuji apples from Japan (AQIS 1998a). The assessment of *P. arbutifolia* presented here builds on the existing pest risk assessment.

4.18.1 Probability of entry

Probability of importation

The likelihood that *Phyllosticta arbutifolia* will arrive in Australia with the importation of the commodity: **LOW**.

Supporting information for this assessment is provided below:

- *Phyllosticta arbutifolia* is present in Washington State and in many eastern states (Farr and Rossman 2009; Glawe 2009). Although apple blotch caused by *P. arbutifolia* used to be a major disease in the eastern US, it is now described as rare in most commercial apple orchards (Yoder 1990a).
- Infections on fruit usually occur early in the season and symptoms usually appear by mid-summer. Infected fruit with obvious symptoms are likely to be rejected during hand harvesting and during sorting and packing processes. However, infected fruit with mild symptoms may escape detection.
- *Phyllosticta arbutifolia* can survive for long period at the low temperatures used in cold storage and transportation. It can survive at 1–2°C for at least nine months (McClintock 1930). Spores can germinate at a wide temperature range of 5–39°C with an optimum germination temperature range of 21–27°C (CABI/EPPO 1997d).

The presence of *Phyllosticta arbutifolia* in Washington State and its strong capacity to survive cold storage and transportation, moderated by the rare occurrence of this fungus in most commercial apple orchards and a limited potential of infected fruit passing through harvesting and packing house processes, support a risk rating for importation of ‘low’.

Probability of distribution

The likelihood that *Phyllosticta arbutifolia* will be distributed in Australia in a viable state, as a result of processing, sale or disposal of the commodity: **MODERATE**.

Supporting information for this assessment is provided below:

- Imported apple fruit is intended for human consumption in Australia. It is expected that once the apple fruit has arrived in Australia it will be distributed throughout Australia for wholesale or retail sale. Any infected fruit present may be distributed during these processes. Infected fruit with obvious symptoms are likely to be disposed of rather than distributed further. Disposal of infected fruit near susceptible hosts may aid distribution of the pathogen. Infected fruit with mild symptoms may go unnoticed and be distributed.
- Individual consumers will distribute small quantities of apples to a variety of urban, rural and wild environments, where they will be consumed, or disposed of in close proximity to a suitable host plant.
- Known hosts of *P. arbutifolia* are species of *Malus*, *Pyrus*, *Crataegus* and *Aronia* (Yoder 1990a; Farr and Rossman 2009). These hosts are available and widespread in Australia, in commercial orchard districts, as well as suburban and rural areas.
- *Phyllosticta arbutifolia* is able to survive at least nine months of cold storage at 1–2°C (McClintock 1930).

- Conidia produced from primary lesions on fruit are an important inoculum source for summer infections (Yoder 1990a). *Phyllosticta arbutifolia* can be dispersed by its rain-splashed conidia.

The ability of the fungus to survive cold storage and transportation, the disposal of fruit waste in the environment and the ability of wind blown water droplets to transfer spores from the fruit waste to a suitable host, moderated by a limited potential of infected fruit passing through wholesale and retail sale processes and a limited range of hosts, support a risk rating for distribution of 'moderate'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that *Phyllosticta arbutifolia* will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **LOW**.

4.18.2 Probability of establishment

The likelihood that *Phyllosticta arbutifolia* will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **MODERATE**.

Supporting information for this assessment is provided below:

- Known hosts of *P. arbutifolia* are species of *Malus*, *Pyrus*, *Aronia* and *Crataegus* (Yoder 1990a; Farr and Rossman 2009). These hosts are widely planted in Australia, in commercial orchard districts, as well as in suburban and rural areas.
- *Phyllosticta arbutifolia* has been reported in many areas of the US as well as in Brazil, Canada, China, India, Japan and South Africa (Farr and Rossman 2009). Environments with climates similar to these areas exist in various parts of Australia, suggesting that *P. arbutifolia* has the potential to establish in Australia, particularly in some warm-temperate, subtropical and tropical regions of Australia.
- Apple blotch is a disease found in regions that are warm and wet (Yoder 1990a). However, spores of *P. arbutifolia* can germinate at a wide temperature range (CABI/EPPO 1997d). *Phyllosticta arbutifolia* can be dispersed by rain-splashed conidia, and the disease incidence and severity is reported to be positively correlated with rainfall (CABI/EPPO 1997d). Temperature and humidity conditions in some warm-temperate, subtropical and tropical regions of Australia would be suitable for this pathogen's establishment.
- While pest control activities may limit or prevent the establishment of this pest in commercial orchards, such controls are unlikely to be applied to naturalised populations of *Malus*, *Pyrus*, *Crataegus* and *Aronia*. Such controls are also unlikely to be applied to *Malus* and *Pyrus* in backyard gardens or organic production.

The occurrence of suitable temperature and moisture conditions for the fungus in some parts of Australia, moderated by the limited range of hosts, support a risk rating for establishment of 'moderate'.

4.18.3 Probability of spread

The likelihood that *Phyllosticta arbutifolia* will spread based on a comparison of factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pest: **MODERATE**.

Supporting information for this assessment is provided below:

- *Phyllosticta arbutifolia* has been reported in many areas of the US as well as in Brazil, Canada, China, India, Japan and South Africa (Farr and Rossman 2009). Environments with climates similar to these areas exist in various parts of Australia, suggesting that the fungus can establish and spread in Australia, particularly in some warm-temperate, subtropical and tropical regions of Australia.
- Known hosts of *P. arbutifolia* are species of *Malus*, *Pyrus*, *Aronia* and *Crataegus* (Yoder 1990a; Farr and Rossman 2009). These hosts are available and widely distributed in Australia, in commercial orchard districts, as well as in suburban and rural areas.
- Disposal of infected fruit via commercial or domestic rubbish systems may aid the spread of the pathogen.
- *Phyllosticta arbutifolia* is only known to be dispersed by rain-splashed conidia. The radius of infection in wind-blown rain from a 10 m tree was estimated to be 80 m, with 100% infection occurring within 12 m from the infected trees (CABI/EPPO 1997d).
- Transport of infected plant seedlings and other planting materials with cankers may aid the long distance movement of *P. arbutifolia* (CABI/EPPO 1997d).

The ability of *Phyllosticta arbutifolia* to tolerate a wide range of climate, moderated by the restricted host range and the requirement of rain to disperse the fungus, support a risk rating for spread of 'moderate'.

4.18.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *Phyllosticta arbutifolia* will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **LOW**.

4.18.5 Consequences

The consequences of the establishment of *Phyllosticta arbutifolia* in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision rules described in Table 2.4 on page 12, that is, where the consequences of a pest with respect to one or more criteria are '**E**', the overall consequences are estimated to be **MODERATE**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D – Significant at the district level:** Apples are the principal host of *Phyllosticta arbutifolia* (CABI/EPPO 1997d). *Phyllosticta arbutifolia* affects apple trees at both the vegetative growth and fruiting stages. The fungus can cause damage on fruit, leaves, buds, twigs, and branches of susceptible apple and pear cultivars (Yoder 1990a). Lesions may girdle leaf petioles, twigs and small branches (Yoder 1990a). Significant defoliation will reduce yield. Infected fruit will be rejected or have reduced market value. In the US, losses caused by *P. arbutifolia* were reported in the past to vary between 5 and 10% (CABI/EPPO 1997d). However, the economic importance of *P. arbutifolia* has declined, probably due to the regular fungicide treatment of apple and pear orchards against diseases such as apple scab (caused by *Venturia inaequalis*). *Phyllosticta arbutifolia* also infects species of *Aronia* and *Crataegus* (Farr and Rossman 2009). This would have impacts on amenity/nursery industries.
Other aspects of the environment	**A – Indiscernible at the local level:** There are no known direct consequences of this pathogen on other aspects of the environment.
Indirect	
Eradication, control etc.	**D – Significant at the district level:** Programs to monitor and eradicate *P. arbutifolia*, should it reach Australia, would be costly. The disease is usually controlled by planting disease-free nursery stock or using resistant cultivars and following a regular fungicide program for summer disease control (Yoder 1990a). Eradication of cankers formed on branches and twigs by using fungicides can be costly (Yoder 1990a). Existing IDM programs may be disrupted due to possible increases in the use of fungicides. Costs for crop monitoring and consultant's advice regarding management of the pest may be incurred by the producer.
Domestic trade	**D – Significant at the district level:** Presence of *P. arbutifolia* in apple or pear commercial production areas would result in the implementation of interstate quarantine measures, causing loss of market and subsequent significant industry adjustment at district level.
International trade	**E – Significant at the regional level:** *Phyllosticta arbutifolia* has been listed as an A1 quarantine pathogen by EPPO (CABI/EPPO 1997d) and is also of quarantine significance for Comité de Sanidad Vegetal Del Cono Sur (COSAVE 2009). Its presence in apple production areas of Australia would make it more difficult for Australia to access these markets.
Environmental and non-commercial	**B – Minor significance at the local level:** Additional fungicide applications or other control activities would be required to control this disease on susceptible crops and these may have minor impact on the environment.

4.18.6 Unrestricted risk estimate

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 12.

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

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

4.19 Sphaeropsis rot

Sphaeropsis pyriputrescens

Sphaeropsis rot is a recently reported major post-harvest disease of apple and pear fruit. It is a fungal disease caused by *Sphaeropsis pyriputrescens* (Xiao and Rogers 2004).

On apple fruit, *S. pyriputrescens* causes decayed brown and firm areas originating at the stem or calyx end of the fruit. Infection originating from the fruit skin or from fruit-to-fruit spread in storage has also been observed. The preferred site of infection varies for different cultivars. On Golden Delicious, stem infection is more common than calyx infection and on Fuji, calyx infection is more common than stem infection. On Red Delicious, both stem and calyx infections are common (Kim and Xiao 2008).

The internal decayed flesh appears yellowish brown (Xiao *et al.* 2004). Decay in the fruit flesh develops along the vascular tissue (Washington State University 2005a). As the disease advances, pycnidia (fruiting bodies) can form on the stems, sepals or the surface of decayed fruit (Xiao *et al*. 2004).

Conidia formed in pycnidia are apparently the main type of inoculum for fruit infection. Infection of fruit occurs in the orchard and symptoms develop after some time in storage (Washington State University 2005a).

Sphaeropsis pyriputrescens also causes twig dieback and cankers on apple and crabapple trees. Infection occurs on dead or dying fruit spurs and pruning wounds. Cankered areas are slightly sunken, brown and the canker margins often develop cracks in the cortical tissue. Pycnidia are often observed in older areas of these lesions (Xiao and Boal 2005a).

Sphaeropsis pyriputrescens is widely distributed in Washington State. The disease was detected in fruit from all seven counties of central Washington State surveyed over a three year period (2003 to 2005). *Sphaeropsis pyriputrescens* accounted for 16.9% of decayed fruit sampled in commercial packing houses. The percentage of orchards with Sphaeropsis-infected fruit ranged from 32–100% with an average of 73% (Kim and Xiao 2008).

Under experimental conditions, mycelium of *S. pyriputrescens* grows at temperatures between -3–25ºC. Optimum growth was observed at 20ºC. The fungus does not grow, but can survive, at 30ºC (Kim *et al.* 2005). Conidia of *S. pyriputrescens* germinate at 0–30ºC and a minimum of 5–6 hours of wetness is required for germination at the optimum temperature (Washington State University 2005a).

The risk posed by *Sphaeropsis pyriputrescens* is that symptomless infected fruit may be exported and result in the establishment of this pathogen in Australia.

4.19.1 Probability of entry

Probability of importation

The likelihood that *Sphaeropsis pyriputrescens* will arrive in Australia with the importation of the commodity: **HIGH**.

Supporting information for this assessment is provided below:

- Sphaeropsis rot caused by *S. pyriputrescens* is one of the important post-harvest diseases of apple in Washington State (Kim and Xiao 2008; Xiao and Kim 2008).
- *Sphaeropsis pyriputrescens* is widely distributed in all major apple-growing counties in Washington State. The disease was detected in fruit from all seven counties of central Washington State surveyed over a three year period 2003–2005 (Kim and Xiao 2008). It accounted for 16.9% of decayed fruit sampled in commercial packing houses. The percentage of orchards with Sphaeropsis-infected fruit ranged from 32–100% with an average of 73%. Some varieties, such as Red Delicious, seem to be more susceptible to the disease than others (Kim and Xiao 2008).
- In one grower lot in Washington State in 2003, 24% of the Red Delicious apples had Sphaeropsis rot after nine months of storage in controlled atmosphere. About 15–20% of fruit were infected after ten months of storage in another grower lot (Kim and Xiao 2008).
- In 2006, 60–100% of sampled apple trees and over 90% of sampled crabapple trees were infected by *S. pyriputrescens* in a commercial Fuji orchard in Washington State (Xiao 2007). Approximately 20–40% and 0–50% of sampled trees were infected in 2005 and 2006, respectively, in a commercial Red Delicious orchard (Xiao 2007).
- Sphaeropsis rot is an orchard-related post-harvest disease. Infection of fruit occurs in the orchard and symptoms develop after some time in storage (Washington State University 2005a). When conditions are suitable for the fungus, it can colonize the fruit early in the season and remain latent throughout the growing season (Xiao 2007).
- Infection of woody parts of the tree occurs through dying or dead fruit spurs, or through pruning wounds and causes canker and dieback (Xiao and Boal 2005a). Cankered areas produce pycnidia (Xiao and Boal 2005a).
- When stem and calyx of pear fruit were inoculated with spore suspensions of *S. pyriputrescens*, it took 2–4 months at 0°C for the fungus to move to the flesh of the fruit and cause decay (Xiao and Rogers 2004).
- *Sphaeropsis pyriputrescens* can grow at temperatures of -1–4ºC which are used for commercial storage of apple fruit (Kim *et al.* 2005).

The wide distribution of *S. pyriputrescens* in Washington State, its ability to grow at temperatures used for cold storage and transportation, and the potential for infection to occur in the orchard while symptoms only develop after some time in storage, support a risk rating for importation of ‘high’.

Probability of distribution

The likelihood that *Sphaeropsis pyriputrescens* will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **HIGH**.

Supporting information for this assessment is provided below:

- Imported apple fruit is intended for human consumption in Australia. It is expected that once the apple fruit has arrived in Australia, it will be distributed throughout Australia for wholesale or retail sale. Any infected fruit present may be distributed during these procedures. However, infected fruit with obvious signs of rot are likely to be disposed of rather than distributed further. Disposal of the infected fruit is likely to be via commercial or domestic rubbish systems.

- If fruit purchased by consumers are found to be rotten, they will be disposed of into garden compost bins, possibly near host plants, or into landfills.
- Infected fruit disposed near suitable hosts may aid distribution of the pathogen. Individual consumers will distribute small quantities of apples to a variety of urban, rural and wild environments, where they will be consumed, or disposed of, in close proximity to a suitable host plant.
- Symptoms of infection by *S. pyriputrescens* develop after some time in storage (Washington State University 2005a). Some of the fruit might go into long term storage facilities in Australia before distribution. Some of the fruit infected with *S. pyriputrescens* may not develop symptoms while in storage and will be distributed to retail outlets.
- Pycnidia can form on the surface of decayed fruit (Xiao *et al*. 2004). Pycnidia are apparently the main source of inoculum for fruit infection in the orchard (Washington State University 2005a).
- *Sphaeropsis pyriputrescens* can grow at temperatures of -1–4ºC which are used for commercial storage and transportation of apple fruit (Kim *et al.* 2005).

The potential distribution of infected fruit throughout Australia, the disposal of fruit waste in the environment and the ability of the fungus to grow at temperatures used for commercial storage and transportation of apple fruit, support a risk rating for distribution of 'high'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that of *Sphaeropsis pyriputrescens* will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **HIGH**.

4.19.2 Probability of establishment

The likelihood that *Sphaeropsis pyriputrescens* will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **MODERATE**.

Supporting information for this assessment is provided below:

- Known host plants of *S. pyriputrescens* include species of *Malus* and *Pyrus* (Xiao and Rogers 2004; Xiao and Boal 2005a; Xiao 2006; Kim and Xiao 2008).
- Suitable hosts are widespread in Australia, both in production orchards and in amenity plantings.
- *Sphaeropsis pyriputrescens* can survive and grow over a wide range of temperatures. Under experimental conditions, mycelium of the fungus grows at temperatures -3–25ºC. Optimum growth was observed at 20ºC. The fungus does not grow, but can survive, at 30ºC (Kim *et al.* 2005). Conidia of *S. pyriputrescens* germinate at 0–30ºC (Washington State University 2005a).
- A minimum of 5–6 hours of wetness is required for conidia of *S. pyriputrescens* to germinate at the optimum temperature (Washington State University 2005a).

- Pycnidia can form on the stems, sepals or the surface of decayed apple or pear fruit (Xiao *et al.* 2004) and on woody parts with twig dieback or canker symptoms (Xiao and Boal 2005a). Pycnidiospores are apparently the main type of inoculum for fruit infection which occurs in the orchard (Washington State University 2005a).
- Dead tissues on fruit spurs and twigs with dieback symptoms or cankers of both apple and crabapple trees are important sources of inoculum responsible for infection of apple fruit in the orchard (Xiao 2007).
- During the dormant period, apple trees seem to be most susceptible to infection leading to the formation of cankers (Xiao 2007).

The ability of the fungus to survive on both live and dead tissues of its hosts and over a wide range of temperatures, moderated by its limited range of hosts and its requirement of wetness for conidia germination, support a risk rating for establishment of 'moderate'.

4.19.3 Probability of spread

The likelihood that *Sphaeropsis pyriputrescens* will spread based on a comparison of factors in the area of origin and in Australia that affect the expansion of geographic distribution of the pest: **MODERATE**.

Supporting information for this assessment is provided below:

- Host plants of *S. pyriputrescens* include apple, crabapple and pear (Xiao and Rogers 2004; Xiao and Boal 2005a; Xiao 2006; Kim and Xiao 2008).
- Hosts of *S. pyriputrescens* are present in Australia in commercial orchard districts, suburban and rural areas.
- Similar climates to those the PNW, where *S. pyriputrescens* is present, are found in some parts of Australia.
- Sphaeropsis rot is an orchard-related post-harvest disease. Infection of fruit occurs in the orchard and symptoms develop after some time in storage (Washington State University 2005a). When conditions are suitable for the fungus, it can colonize the fruit early in the season and remain latent throughout the growing season (Xiao 2007).
- Spread by humans may occur by transporting infected fruit or plants.
- *Sphaeropsis pyriputrescens* can survive and grow over a wide range of temperatures. Under experimental conditions, mycelium of the fungus grows at temperatures -3–25ºC. Optimum growth was observed at 20ºC. The fungus does not grow, but can survive, at 30ºC (Kim *et al.* 2005). Conidia of *S. pyriputrescens* germinate at 0–30ºC (Washington State University 2005a).
- A minimum of 5–6 hours of wetness is required for conidia of *S. pyriputrescens* to germinate at the optimum temperature (Washington State University 2005a).

The ability of the fungus to be dispersed with infected fruit and plant material, and its ability to survive over a wide range of temperatures, moderated by its limited range of hosts, support a risk rating for spread of 'moderate'.

4.19.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *Sphaeropsis pyriputrescens* will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **LOW**.

4.19.5 Consequences

The consequences of the establishment of *Sphaeropsis pyriputrescens* in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision described in Table 2.4 on page 12, that is, where the consequences of a pest with respect to one or more criteria are '**E**', the overall consequences are estimated to be **MODERATE**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**E - Significant at the regional level:** *Sphaeropsis pyriputrescens* causes fruit decay of apple and pear in storage (Xiao and Rogers 2004; Xiao *et al.* 2004). It also causes twig dieback and cankers on apple and crabapple trees (Xiao and Boal 2005a). *Sphaeropsis* pyriputrescens has the potential to cause significant economic losses due to decay of fruit in storage. It accounted for 16.9% of decayed apple fruit sampled in commercial packing houses surveyed over a three year period (2003–2005) in central Washington State (Kim and Xiao 2008). In one grower lot in Washington State in 2003, 24% of the Red Delicious apples had Sphaeropsis rot after 9 months of storage in controlled atmosphere. About 15–20% of fruit were infected after 10 months of storage in another grower lot (Kim and Xiao 2008). Very little is known of the host range of this recently described species. The phylogenetic relationships have not been investigated (Crous *et al*. 2006; Phillips *et al*. 2008). It is likely the host range will include hosts other than species of Maloideae (Slippers *et al*. 2007).
Other aspects of the environment	**A - Indiscernible at the local level:** There are no known direct consequences of this pathogen on other aspects of the environment.
Indirect	
Eradication, control etc.	**D - Significant at the district level:** Recommended measures for the control of *S. pyriputrescens* include removal of cankers and twigs with dieback symptoms (Washington State University 2005a). Research on the effectiveness of various fungicides in controlling *S. pyriputrescens* is in progress (Xiao 2007). Implementation of these control measures would result in an increase in the cost of production. Additionally, costs for crop monitoring and consultant's advice to manage these pests may be incurred by the producer.
Domestic trade	**D - Significant at the district level:** The presence of *S. pyriputrescens* in commercial production areas could result in the implementation of interstate quarantine measures, causing loss of market and subsequent industry adjustment.
International trade	**E - Significant at the regional level:** The presence of *S. pyriputrescens* in commercial production areas of apple and pear would have a significant effect at the regional level due to potential limitations of accessing international markets where this pathogen is absent. To date, *S. pyriputrescens* has only been recorded from the US and Canada (Xiao and Rogers 2004; Xiao *et al.* 2004; Stokes *et al*. 2007).
Environmental and non-commercial	**B - Minor significance at the local level:** Additional fungicide applications or other control activities would be required to control this disease on susceptible crops. Any additional fungicide usage may affect the environment.

4.19.6 Unrestricted risk estimate

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 12.

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

As indicated, the unrestricted risk exstimate for *Sphaeropsis pyriputrescens* has been assessed as ‘low’, which is above Australia’s ALOP. Therefore, specific risk management measures are required for this pest.

4.20 Hawthorn powdery mildew

Podosphaera clandestina

Podosphaera species are fungal pathogens that cause powdery mildew on foliage, stems and fruits of many types of plants. Different powdery mildew fungi can cause similar diseases on different hosts and some plants are susceptible to more than one species. Hawthorn powdery mildew (caused by *P. clandestina*) is one of the most serious diseases of cherry in Washington State (Grove and Boal 1991a).

Podosphaera clandestina infects a wide range of plants, including *Alnus* sp., *Amelanchier* spp., *Crataegus* spp., *Holodiscus* sp., *Malus* spp., *Prunus* spp., *Spiraea* spp., *Symphoricarpos albus*, and *Vaccinium* spp. (Farr and Rossman 2009). In the PNW, the fungus has been associated with *Holodiscus* sp., *Malus* spp., *Prunus* spp., *Rosa* spp., *Spiraea* spp. and *Symphoricarpos albus* (Farr and Rossman 2009; Glawe 2009).

Although *P. clandestina* occurs on apple, apple appears not to be a major host (CABI 2007). There is limited information available on its association with apple fruit.

In cherry orchards, *P. clandestina* overwinters as cleistothecia on the orchard floor, in tree crotches, and in bark crevices. On hawthorn, *P. clandestina* overwinters in buds (Xu and Robinson 2000). Rain water promotes ascospore release which causes primary infection (Grove and Boal 1991b).

Podosphaera clandestina is widespread in the US, including the PNW region (Farr and Rossman 2009). In Australia, it is reported in NSW, Tasmania and Victoria (APPD 2009), but not in Western Australia. The Australian strain of *P. clandestina* differs from the North American strain; it is associated with hawthorn only. Therefore, the North American strain is considered a quarantine pest for the whole of Australia.

The risk posed by *Podosphaera clandestina* is that infected or contaminated apple fruit may be imported into Australia and may result in the establishment of this pathogen.

4.20.1 Probability of entry

Probability of importation

The likelihood that *Podosphaera clandestina* will arrive in Australia with the importation of the commodity: **VERY LOW**.

Supporting information for this assessment is provided below:

- *Podosphaera clandestina* is present on *Malus* spp. in the PNW (Farr and Rossman 2009; Glawe 2009). Apple is not a major host (CABI 2007) and it is not certain if this pathogen is present on apple fruit in the PNW.
- In cherries, foliage infection is more common than fruit infection (Grove and Boal 1991b). This may also be the case for apples.
- This pathogen has been assessed for cherries from the PNW and it was rarely seen there even though cherries are a major host.

- In cherries, there is little fruit-to-fruit transmission of the fungus in storage and transit (Washington State University 2009). This may also be the case for apples.
- Powdery mildew produces characteristic web-like white powdery growths or brown/black spots on affected tissues. Symtomatic host material is likely to be removed during routine harvesting and grading operations due to obvious symptoms.
- The post-harvest brushing and washing is likely to reduce the presence of contaminant fungal mycelium, conidiospores and cleistothecia on the fruit surface.

The occurrence of *P. clandestina* in the PNW, moderated by the minor host status of apple, the likelihood of the pest to be removed during post-harvest procedures and low rates of fruit-to-fruit transmission support a risk rating for importation of 'very low'.

Probability of distribution

The likelihood that *Podosphaera clandestina* will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **LOW**.

Supporting information for this assessment is provided below:

- Imported apple is intended for human consumption in Australia. It is expected that once the apple fruit has arrived in Australia, it will be distributed throughout Australia for wholesale or retail sale. Fruit showing symptoms of disease are unmarketable. However, infected fruit with little symptoms may be distributed during these procedures.
- Infected fruit disposed near suitable hosts may aid distribution of the pathogen. Individual consumers can distribute small quantities of apples to a variety of urban, rural and wild environments, where they will be consumed, or disposed of, in close proximity to a suitable host plant.
- *Podosphaera clandestina* has a wide host range with susceptible hosts in the genera *Amelanchier*, *Crataegus*, *Cydonia*, *Diospyros*, *Holodiscus*, *Malus*, *Prunus*, *Pyracantha*, *Pyrus*, *Sanguisorba*, *Spiraea*, *Symphoricarpos* and *Vaccinium* (Farr and Rossman 2009), many of which are widely distributed in Australia.
- The fungus requires living plant tissue to grow (Teviotdale *et al*. 2001). Fruit-borne conidia are short lived and any fungus present on infected fruit would have limited time for growth and sporulation (Silverside 2001).
- The ripe fruit may be less susceptible to *P. clandestina*. For example, susceptibility of cherries decreases above soluble solids content of 12–13°Brix (Grove 1995).

The wide range of hosts, moderated by the specific environment required for the survival and growth of the fungus, the unmarketability of symptomatic fruit and the short-lived nature of conidia, support a risk rating for distribution of 'low'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that *Podosphaera clandestina* will enter Australia as a result of trade in the commodity: **VERY LOW**.

4.20.2 Probability of establishment

The likelihood that *Podosphaera clandestina* will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **HIGH**.

Supporting information for this assessment is provided below:

- *Podosphaera clandestina* has been reported on *Crataegus* (hawthorn) in New South Wales, Tasmania and Victoria, with no records of infection on other genera (APPD 2009). Other strains are likely to establish in the same area if introduced.
- *Podosphaera clandestina* has a wide host range with susceptible hosts in the genera *Amelanchier*, *Crataegus*, *Cydonia*, *Diospyros*, *Holodiscus*, *Malus*, *Prunus*, *Pyracantha*, *Pyrus*, *Sanguisorba*, *Spiraea*, *Symphoricarpos* and *Vaccinium* (Farr and Rossman 2009), some of which are widely distributed in Australia. Cherries are known to be particularly susceptible to the North American strain of *P. clandestina*.
- Powdery mildews generally do well in warmer climates (Teviotdale *et al*. 2001). Germination of conidia can occur in temperature ranges of 5-25°C and down to 50% relative humidity, with the rate increasing as relative humidity rises (Xu and Robinson 2000). Warm-temperate Australian environment are 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.
- Powdery mildews can overwinter as mycelium in buds and leaves and infect newly emerging leaves in spring (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; Xu and Robinson 2000).
- 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 number of spores from overwintered cleistothecia on infected plant material. It takes 24–48 hours from germination to formation of new conidia (Xu and Robinson 2000).

The climatic suitability of Australia, the wide range and distribution of hosts for *P. clandestina*, and its ability to overwinter in buds and leaves, support a risk rating for establishment of ‘high’.

4.20.3 Probability of spread

The likelihood that *Podosphaera clandestina* will spread based on a comparison of factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pest: **HIGH**.

Supporting information for this assessment is provided below:

- *Podosphaera clandestina* has been reported on *Crataegus* (hawthorn) in New South Wales, Tasmania and Victoria, with no records of infection on other genera (APPD 2009). Other strains are likely to spread in the same area if introduced.

- *Podosphaera clandestina* has a wide host range with susceptible hosts in the genera *Amelanchier*, *Crataegus*, *Cydonia*, *Diospyros*, *Holodiscus*, *Malus*, *Prunus*, *Pyracantha*, *Pyrus*, *Sanguisorba*, *Spiraea*, *Symphoricarpos* and *Vaccinium* (Farr and Rossman 2009), some of which are widely distributed in Australia including urban, rural and wild environments.
- The spores are wind- and water-dispersed, causing infection on new leaves, fruit and shoots (Grove 1998).
- Facilitated distribution of *P. clandestina* is required for long distance spread. This may occur through the movement of infected fruit or nursery stock. Interstate quarantine controls may limit the rate of spread. However, intrastate transportation would be a potential pathway for spread.

The climatic suitability of Australia, the wide range and distribution of hosts for *P. clandestina*, dispersal of spores by wind and water, rapid infection process, and the potential movement of infected planting materials support a risk rating for spread of 'high'.

4.20.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *P. clandestina* will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **VERY LOW**.

4.20.5 Consequences

The consequences of the establishment of *Podosphaera clandestina* have been estimated using the decision rules described in Table 2.3 on page 11.

Based on the decision rules described in Table 2.4 on page 12, 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**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D – Significant at the district level:** *Podosphaera clandestina* is capable of causing direct harm to its 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. Introduction of this pathogen would have a significant impact on the apple, cherry and pear industries in Australia. The pathogen could make some cultivars of susceptible rosaceous amenity trees unsightly and lead to replacement of these cultivars. It is unlikely there would be an effect on native plant species. Control measures, where implemented, may reduce the impact of this pathogen. However, control may not be implemented to non-commercial crops and amenity plantings. Any impact of this fungus is likely to be tempered by current fungal control programs in commercial orchards.
Other aspects of the environment	**A – Indiscernible at the local level:** There are no known direct consequences of this pathogen on other aspects of the environment.
Indirect	
Eradication, control etc.	**C – Minor significant at the regional level:** Programs to minimise the impact of this disease on host plants are unlikely to be required as existing management measures in place to control other powdery mildew pathogens are likely to be effective in controlling this fungus. Fungicide applications are specific to powdery mildew infections and thus additional spray programs may be necessary in orchards where powdery mildews do not occur, especially in cherry orchards.
Domestic trade	**B – Minor significance at the local level:** The establishment of *P. clandestina* in parts 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 (see Appendix B), so the impacts may be restricted in magnitude.
Environmental and non-commercial	**B – Indiscernible at the local level:** Additional fungicide applications or other control activities would be required to control these diseases on susceptible crops. Any additional fungicide usage may affect the environment.

4.20.6 Unrestricted risk estimate

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 12.

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

As indicated, the unrestricted risk estimate for *Podosphaera clandestina* has been assessed as ‘negligible’, which achieves Australia’s ALOP. Therefore, no specific risk management measures are required for this pest.

4.21 Bull's eye rot[13]

Cryptosporiopsis curvispora; Cryptosporiopsis perennans

Cryptosporiopsis curvispora and *C. perennans* are the anamorphs of the ascomycetes *Neofabraea malicorticis* and *N. perennans*, respectively (Landcare Research 2009). These two species have been grouped together because of their related biology and taxonomy. They are predicted to pose similar risk and to require similar mitigation measures. Unless explicitly stated, the information presented is considered as applicable to both species assessed.

On apple fruit, the fungi express as a fruit rot called bull's eye rot. On trees, they cause tree cankers. The canker caused by *C. curvispora* is known as anthracnose canker, while *C. perennans* causes perennial canker (Dugan *et al.* 1993).

These pathogens have traditionally been considered separate species in the US and Canada (Kienholz 1939), while in Europe, *C. perennans* has been considered a synonym of *C. curvispora* (de Jong *et al.* 2001). Morphological studies (Dugan *et al.* 1993) as well as recent molecular phylogenetic studies (de Jong *et al.* 2001; Gariépy *et al.* 2003) have established that *C. curvispora* and *C. perennans* are two distinct species. While both fungi were thought to be present in Australia, a recent molecular analysis of herbarium specimens has revealed that *C. curvispora* is absent from Australia, while *C. perennans* is only reported from Victoria (Cunnington 2004).

In the PNW, *C. curvispora* is very common in the humid areas west of the Cascades range, while *C. perennans* commonly occurs in the drier areas east of the Cascades (Kienholz 1939; Grove 1990a; Dugan *et al.* 1993).

Both species economically affect apple and pear orchards (Grove 1990a; Spotts 1990a; Gariepy *et al.* 2005). They also occur on a number of other rosaceous hosts (Grove 1990a).

While the cankers may reduce the growth and bearing capacity (Andrews *et al.* 2008), they rarely kill trees or branches (Grove 1990a). Cankers serve as a source of conidial inoculum for the infection of fruit. Conidia are dispersed by rain or irrigation and can infect lenticels or wounds at any time between petal fall and harvest (Spotts 1990a), with infection becoming more likely closer to harvest (Henriquez *et al.* 2008). Fruit mummies on the orchard floor may provide an alternative source of inoculum (Grove *et al.* 1992). Symptoms on fruit usually do not appear in the field, but show after several months of storage (Spotts 1990a). Symptoms present as brown, depressed, round spots. Acervuli, fruiting bodies containing conidia, develop in concentric rings, causing a 'bull's eye' pattern to form (Spotts 1990a; Andrews *et al.* 2008). Cold storage does not eliminate the fungi, but can delay the onset of symptoms (Edney 1956).

Bull's eye rot may open the way for secondary decay fungi to complete the rotting process (Ogawa and English 1991).

In orchards, conidia are the infectious and dispersal agents (Grove 1990a). Conidia of *C. curvispora* can affect sound wood, while those of *C. perennans* infect branches through

[13] In this section, the common name Bull's eye rot will be used to refer to both species. The scientific name will be used when the information is about a specific species.

wounds, usually pruning scars (Kienholz 1939; Henriquez *et al*. 2006). The role of ascospores in dispersal is unclear.

The risk posed by *Cryptosporiopsis curvispora* and *C. perennans* is that apple fruit may be infected yet show no symptoms of disease at the time of importation.

This assessment considers *C. curvispora* as a quarantine pest for Australia, and *C. perennans* as a quarantine pest for Western Australia.

4.21.1 Probability of entry

Probability of importation

The likelihood that *Cryptosporiopsis curvispora* or *C. perennans* will arrive in Australia with the importation of the commodity: **HIGH**.

Supporting information for this assessment is provided below:

- Both *C. curvispora* and *C. perennans* are prevalent in the PNW. In Washington State, *C. curvispora* is very common in the moist areas west of the Cascades, and *C. perennans* in the drier areas east of the Cascades (Kienholz 1939; Dugan *et al.* 1993; Gariepy *et al.* 2005).
- Cankers produce conidia which serve as inoculum for apple fruit. Fruit infection can occur any time between petal fall and harvest (Spotts 1990a).
- While Spotts (1990a) suggested that fruit-to-fruit spread does not occur in storage, Grove *et al.* (1992) demonstrated fruit-to-fruit transfer for *C. perennans*.
- Usually, symptoms only develop after several months in storage (Pierson *et al.* 1971; Spotts 1990a).
- Many of the most important apple cultivars of the PNW, such as Gala, Golden Delicious and Granny Smith, are susceptible to anthracnose, perennial canker, or both (Grove 1990a; MAL 2007a; Andrews *et al.* 2008).
- Post-harvest fungicide application may provide partial control for bull's eye rot, but may not reach fungal cells deep inside the lenticels of the apple (Spotts 1990a).
- Cold temperatures, such as in cold storage, delay the onset of symptoms of bull's eye rot (Edney 1956; Pierson *et al.* 1971; Spotts 1990a).

The wide spread of the pathogens in the PNW, the asymptomatic nature of fruit at harvest, development of the disease in storage and the ability of the pathogens to survive cold storage, support a risk rating for importation of 'high'.

Probability of distribution

The likelihood that *Cryptosporiopsis curvispora* or *C. perennans* will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **HIGH**.

Supporting information for this assessment is provided below:

- Imported apple is intended for human consumption in Australia. It is expected that once the apple fruit has arrived in Australia, it will be distributed throughout Australia for wholesale or retail sale. Any infected fruit present may be distributed during these procedures.

- Apple waste disposed of as litter may be deposited into urban, peri-urban and agricultural situations, as well as areas of natural vegetations, throughout Australia.
- Some of the fruits might go into long term storage facilities before distribution. Infected fruit can remain for several months in storage before development of symptoms (Spotts 1990a). The asymptomatic fruit will be distributed to retail outlets and may finally reach areas where host plants are grown.
- If bull's eye rot develops after purchase by the consumer, rotten fruit may be disposed of into the environment.
- Both *C. curvispora* and *C. perennans* have a variety of rosaceous hosts, including *Amelanchier pallida*, *Chaenomeles* sp., *Crataegus* spp., *Cydonia oblonga*, *Malus* spp., *Prunus* spp., *Pyrus* spp., *Rosa* spp. and *Sorbus* spp. (Kienholz 1939; de Jong *et al.* 2001). However, apple and pear appear to be the preferred hosts.

The ready availability of the hosts and spore and symptom development during or after storage, support a risk rating for distribution of 'high'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that *Cryptosporiopsis curviformis* or *C. perennans* will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **HIGH**.

4.21.2 Probability of establishment

The likelihood that *Cryptosporiopsis curviformis* or *C. perennans* will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **MODERATE**.

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

- Both *C. curvispora* and *C. perennans* have a variety of rosaceous hosts, including *Amelanchier pallida*, *Chaenomeles* sp., *Crataegus* spp., *Cydonia oblonga*, *Malus* spp., *Prunus* spp., *Pyrus* spp., *Rosa* spp. and *Sorbus* spp. (Kienholz 1939; de Jong *et al.* 2001). Many of these are planted as commercial fruit trees, or as ornamentals in home gardens or amenity plantings, or have become naturalised in the wild in many areas of Australia.
- Both *C. curvispora* and *C. perennans* occur in the US, Canada, the UK and continental Europe (Grove 1990a; de Jong *et al.* 2001). *Cryptosporiopsis curvispora* also occurs in New Zealand (Grove 1990a). Similar climates in cool-temperate Australia, such as Tasmania, and parts of NSW and Victoria, would be climatically suitable for the establishment of these fungi.
- *Cryptosporiopsis perennans* has already established in Victoria (Cunnington 2004). A closely related species, *Neofabraea alba*, has established in Tasmania and Western Australia (Cunnington 2004).

- Conidia of both *C. curvispora* and *C. perennans* are dispersed by the impact of water droplets, from rain or irrigation (Grove 1990a; Spotts 1990a).
- Usually, cankers, rather than fruit, provide the inoculum for fruit infection (Grove 1990a). However, apple fruit producing conidia of *C. perennans* have been shown to infect other apples (Grove *et al.* 1992). There are no records of fruit-borne conidia infecting wood and producing canker growths.
- The susceptibility of branches to infection with *C. perennans* varies with season. Apple branches are most susceptible during autumn and winter (Grove *et al.* 1992).

The wide distribution of hosts and the susceptibility of apples to bull's eye rot, moderated by the limited opportunity for host infection, support a risk rating for establishment of 'low'.

4.21.3 Probability of spread

The likelihood that that *Cryptosporiopsis curviformis* or *C. perennans* will spread based on a comparison of factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pests: **MODERATE**.

- Both *C. curvispora* and *C. perennans* have a variety of rosaceous hosts, including *Amelanchier pallida*, *Chaenomeles* sp., *Crataegus* spp., *Cydonia oblonga*, *Malus* spp., *Prunus* spp., *Pyrus* spp., *Rosa* spp. and *Sorbus* spp. (Kienholz 1939; de Jong *et al.* 2001). Many of these are planted as commercial fruit trees, or as ornamentals in home gardens or amenity plantings, or have become naturalised in the wild in many areas of Australia.
- Both *C. curvispora* and *C. perennans* occur in the US, Canada, the UK and continental Europe (de Jong *et al.* 2001; Grove 1990a). *Cryptosporiopsis curvispora* also occurs in New Zealand (Grove 1990a). Similar climates in cool-temperate Australia, such as Tasmania, and parts of NSW and Victoria, would be climatically suitable for the establishment of these fungi.
- On apple and pear trees, *C. curviformis* or *C. perennans* produce cankers on branches and twigs and develop saprophytically on dead wood, from which spores are produced and distributed (Grove *et al.* 1992; Henriquez *et al.* 2006).
- Conidia produced on cankers caused by *C. curvispora* and *C. perennans* are dispersed by the impact of water droplets, from rain or irrigation (Grove 1990a; Spotts 1990a). This limits the potential of long-distance spread of conidia.
- In the US, woolly aphids (*Eriosoma lanigerum*) feed on the tissue of canker margins and produce galls. *Eriosoma lanigerum* is present in Australia. The rupture of these galls below -18°C assists the dispersion of conidia (Kienholz 1939; Grove 1990a). Such low temperatures are unlikely to occur in Australia where rosaceous hosts of *C. curvispora* and *C. perennans* grow. However, the spread of conidia will not entirely depend on this mechanism.
- While Grove (1990a) considered the sexual stage of *C. curvispora* and *C. perennans* insignificant for the spread of the disease, it is possible that wind-dispersed ascospores produced by the sexual stage plays a role in long-distance spread (Ogawa and English 1991).

The range of hosts, and the ability of pathogen to infect fruit, branches, twigs and dead wood, to survive in dead cankers and to survive in stored apple fruit, moderated by the limited distance of spread for conidia and the limited opportunity for host infection, support a risk rating for spread of 'moderate'.

4.21.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *Cryptosporiopsis curvispora* or *C. perennans* will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **LOW**.

4.21.5 Consequences

The consequences of the establishment of *Cryptosporiopsis curvispora* or *C. perennans* in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision described in Table 2.4 on page 12, 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**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D - Significant at the district level:** Bull's eye rot caused by *C. curvispora* or *C. perennans* is one of the significant post-harvest diseases in apples and pears in the PNW and British Columbia (Grove *et al.* 1992; Sholberg and Haag 1996; Gariepy *et al.* 2005). Edney (1956) reported storage losses of upto 50% in Cox's Orange Pippin apples. During the two-year study (1996–1997), Lennox (2004) reported, for d' Anjou pear, a wide range (1%–80%) of losses after eight months of storage, depending on year and orchard provenance. However, in a more recent study, Xiao and Boal (2004a) reported mean loss, after four to eight months of storage, of 0.8% and 2.2% for d' Anjou pear in 2001 and 2002, respectively. Cankers produced by the two fungi rarely kill trees, but serve as a source of inoculum (Grove 1990a).
Other aspects of the environment	**A - Indiscernible at the local level:** There are no known direct consequences of these species on other aspects of the environment.
Indirect	
Eradication, control etc.	**C - Significant at the local level:** Programs to minimise the impact of these pathogens on host plants may be costly and may include additional pesticide applications and crop monitoring. Control of the disease involves increased orchard hygiene including removal of cankers (Grove 1990a; Spotts 1990a; Andrews *et al.* 2008). Fungicide treatments of trees and post-harvest fungicide applications for fruit may be necessary (Spotts 1990a; Andrews *et al*. 2008). Change of irrigation methods to reduce spread of conidia may result in a subsequent increase in the cost of production.
Domestic trade	**B - Minor significance at the local level:** If *C. curvispora* or *C. perennans* established in parts of Australia, it may result in some interstate trade restriction on commodities such as apples and pears. The movement and trade of nursery stock could be affected in areas of bull's eye rot outbreak.
International trade	**D - Significant at the district level:** The presence of *C. curvispora* or *C. perennans* in commercial production areas of apples and pears may limit access to overseas markets which are free from these pests. Korea listed *C. curvispora* as a quarantine pest.
Environmental and non-commercial	**B - Minor significance at the local level:** Pesticide applications or other control activities would be required to control this pest on susceptible crops, which could have minor indirect impact on the environment.

4.21.6 Unrestricted risk estimate

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 12.

Unrestricted risk estimate for *Cryptosporiopsis curvispora* and *Cryptosporiopsis perennans*	
Overall probability of entry, establishment and spread	Low
Consequences	Low
Unrestricted risk	Very low

As indicated, the unrestricted risk estimate for *Cryptosporiopsis curvispora* and *C. perennans* has been assessed as 'very low', which achieves Australia's ALOP. Therefore, no specific risk management measures are required for these pests.

4.22 Phacidiopycnis rot and speck rot

Phacidiopycnis piri; Phacidiopycnis washingtonensis

Phacidiopycnis rot is a recently recognised fungal post-harvest disease of pome fruit in the US caused by *Phacidiopycnis piri* (Xiao and Boal 2002). It is one of the major post-harvest fruit rots in d'Anjou pears in Washington State (Xiao and Boal 2004a). The pathogen also causes fruit rot in apples, but in Washington State it is much less common than in pears (Xiao *et al.* 2005; Kim and Xiao 2006).

Speck rot is one of the post-harvest diseases of apple (Kim and Xiao 2006). It was discovered in Washington State during a survey of post-harvest diseases in Red Delicious apples in the 2002 and 2003 storage seasons. The causal agent of the disease was described as a new fungal species, *Phacidiopycnis washingtonensis* (Xiao *et al.* 2005; Kim and Xiao 2006).

Phacidiopycnis piri and *P. washingtonensis* have been grouped together because of their related biology and taxonomy, and are predicted to require similar mitigation measures. Unless explicitly stated, the information presented is considered as applicable to both species assessed.

Phacidiopycnis piri also causes canker on branches and dieback of twigs and fruit spurs of pear trees (Xiao and Boal 2005b) and canker and dieback of apple trees (DiCosmo *et al.* 1984). Pycnidia, and less frequently apothecia, of the fungus are formed on dead or dying bark tissues (Xiao and Boal 2005b).

Symptoms on pear fruit infected with *P. piri* are stem-end rot, calyx-end rot and wound-associated rot. The decayed area is spongy and its colour varies with age. At later stages of decay, it appears brown to black with water-soaked margins. Under humid conditions, the fungus also forms white mycelium. At advanced stages of infection, the fungus forms pycnidia and conidia on the decayed area of the fruit (Xiao and Boal 2004a; Xiao 2006).

Phacidiopycnis washingtonensis is also associated with a canker and twig dieback disease of crabapple trees (Xiao *et al.* 2005) and apple trees (Kim and Xiao 2006). Infected crabapple is suspected as one of the sources of inoculum leading to storage rot of apples (Xiao *et al.* 2005).

Symptoms of apple fruit infected with *P. washingtonensis* are primarily stem-end rot and calyx-end rot and occasionally also occur at lenticels on fruit skin. The decayed area is light brown to brown and is spongy to firm. On diseased Red Delicious apples lesions may cover a part of or the entire fruit. Symptoms advance along vascular tissues and the internal decayed areas of the fruit are usually of V- or U-shape. The skin colour of aged decayed areas often turns dark brown or black. The fungus forms pycnidia and conidia on the surface of decayed fruit in storage (Kim and Xiao 2006).

The risk posed by *Phacidiopycnis piri* and *P. washingtonensis* is that symptomless infected fruit may be exported and result in the establishment of these pathogens in Australia.

4.22.1 Probability of entry

Probability of importation

The likelihood that *Phacidiopycnis piri* or *P. washingtonensis* will arrive in Australia with the importation of the commodity: **HIGH**.

Supporting information for this assessment is provided below:

- *Phacidiopycnis piri* is widespread on pear in the PNW (Xiao and Boal 2003; Xiao and Boal 2005b) and is also found on apples, but much less common than on pears (Xiao *et al.* 2005; Kim and Xiao 2006).
- Speck rot, caused by *P. washingtonensis*, is a post-harvest disease of apple in Washington State (Kim and Xiao 2006). The percentage of fruit affected by this disease has been increasing following the first detections in the 2002 and 2003 storage seasons (Kim and Xiao 2006). Speck rot was detected in 6 of 26 orchards (23%), accounting for 1% of the total decayed fruit in 2003; 19 of 72 orchards (26%), accounting for 4% of the total decayed fruit in 2004; and 14 of 81 orchards (17%), accounting for 3% of the total decayed fruit in 2005 (Kim and Xiao 2006).
- The assessed fungi can survive and grow at a wide temperature range, -3–25˚C, with optimum growth occurring at 15–20˚C (Xiao and Sitton 2004; Xiao *et al.* 2005).
- Conidia of *P. piri* germinate at 0–30˚C with an optimal temperature for germination of 20–25˚C (Liu and Xiao 2005).
- Infection of the stem- and calyx-end with the assessed fungi usually takes place in the orchard and symptoms develop during storage (Xiao and Boal 2004a; Kim and Xiao 2006). Symptoms of stem- and calyx-end infections with *P. piri* are first observed after approximately three months in storage and increase with time in storage (Xiao and Boal 2004a; Washington State University 2005c). Phacidiopycnis rot originating from wound infections shows after about two months (Xiao and Boal 2004a; Washington State University 2005c). Infected fruit with *P. washingtonensis* could develop symptoms up to six months after storage (Xiao *et al.* 2005).
- Infection with *Phacidiopycnis piri* can spread from fruit to fruit in storage (Xiao and Boal 2004a; Xiao 2006).
- Symptomless infected fruit and infected fruit with mild symptoms that escaped detection during harvesting, sorting and packing processes may be exported to Australia.

The ability of *Phacidiopycnis piri* or *P. washingtonensis* to survive cold storage and transportation and the possibility of infected fruit escaping detection, support a risk rating for importation of 'high'.

Probability of distribution

The likelihood that *Phacidiopycnis piri* or *P. washingtonensis* will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **MODERATE**.

Supporting information for this assessment is provided below:

- Imported apple fruit is intended for human consumption in Australia. It is expected that once the apple fruit has arrived, it will be distributed throughout Australia for wholesale or retail sale. Any infected fruit present may be distributed during these processes.
- Individual consumers will distribute small quantities of apples to a variety of urban, rural and wild environments.

- Fruit waste infected with the assessed fungimay be disposed of in close proximity to a suitable host plant.
- Known hosts of *P. piri* are *Malus* spp. (apple), *Pyrus* spp. (pear) and *Cydonia vulgaris* (quince) (DiCosmo *et al.* 1984; Farr and Rossman 2009). These hosts are widespread in Australia, in commercial orchard districts, as well as suburban and rural areas.
- As *Phacidiopycnis piri* is also associated with canker on branches and dieback of twigs and fruit spurs of pear trees (Xiao and Boal 2005b) and canker and dieback of apple trees (DiCosmo *et al.* 1984), and can survive as mycelium in diseased twigs all year around (Xiao and Boal 2004b).
- Although growth of the assessed fungi slows down at low temperatures, the fungi can survive at temperatures commonly used in storage and transportation of apples (Xiao and Sitton 2004; Xiao *et al*. 2005). Therefore, the fungi will be distributed in a viable state.

The potential distribution of infected fruit throughout Australia, the disposal of fruit waste in the environment and the ability of the assessed fungi to survive cold storage and transportation, moderated by their limited known hosts range, support a risk rating for distribution of 'moderate'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that *Phacidiopycnis piri* or *P. washingtonensis* will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **MODERATE**.

4.22.2 Probability of establishment

The likelihood that *Phacidiopycnis piri* or *P. washingtonensis* will establish based on the comparison of factors in the source and destination areas that affect pest survival and reproduction: **MODERATE**.

Supporting information for this assessment is provided below:

- The assessed fungi have a limited range of hosts in the family Rosaceae. Known hosts of *P. piri* include *Malus* spp. (apple), *Pyrus* spp. (pear) and *Cydonia vulgaris* (quince) (DiCosmo *et al.* 1984; Farr and Rossman 2009). Known hosts of *P. washingtonensis* include *Malus* spp. and *Pyrus communis* (Xiao *et al.* 2005). However, these hosts are widely distributed in Australia in commercial orchards districts, as well as suburban and rural areas.
- Fruit waste infected with the assessed fungi may be disposed of in close proximity to a suitable host plant and may serve as a source of inoculum.
- The commercial apple cultivars Fuji, Golden Delicious and Red Delicious are known to be susceptible to *P. washingtonensis* (Kim and Xiao 2006).
- *Phacidiopycnis piri* produces pycnidia on the decayed area of the fruit (Xiao and Boal 2004a; Xiao 2006) and on dead or dying bark tissues (Xiao and Boal 2005b). Pycnidia produced on dead bark and spurs of pear trees throughout the growing season are

considered the main source of inoculum for fruit infection with *Phacidiopycnis piri* (Xiao and Boal 2004b; Xiao and Boal 2005b).

- *Phacidiopycnis piri* can survive as mycelium in diseased twigs all year around (Xiao and Boal 2004b).
- *Phacidiopycnis washingtonensis* has the ability to survive on both live and dead tissues of its hosts (Xiao *et al.* 2005; Kim and Xiao 2006).
- *Phacidiopycnis piri* occurs in Austria, Canada (British Columbia), Germany, India, the United Kingdom and the US (Oregon and Washington State) (DiCosmo *et al.* 1984; Xiao and Boal 2005b; Farr and Rossman 2009). *Phacidiopycnis washingtonensis* is only known to occur in Washington State (Xiao *et al.* 2005; Kim and Xiao 2006; Kim and Xiao 2008). Environments with climates similar to these areas exist in many parts of temperate southeastern and southwestern Australia, suggesting that the climate in these parts of Australia is likely to be suitable for the establishment of the assessed fungi.
- The assessed fungi can grow at a wide temperature range of -3–25˚C (Xiao and Sitton 2004; Xiao *et al.* 2005) and if introduced to an area in close proximity to a suitable host could establish a viable population in Australia.

The ability of the assessed fungi to survive on both live and dead tissues of their hosts and over a wide range of temperatures, moderated by their limited known hosts range, support a risk rating for establishment of 'moderate'.

4.22.3 Probability of spread

The likelihood that *Phacidiopycnis piri* or *P. washingtonensis* will spread based on a comparison of those factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pathogen: **MODERATE**.

Supporting information for this assessment is provided below:

- The assessed fungi can survive and grow at a wide temperature range of -3–25˚C (Xiao and Sitton 2004; Xiao *et al.* 2005).
- Although the fungi have few known hosts (*Malus* spp., *Pyrus* spp. and *Cydonia vulgaris* for *P. piri*; and *Malus* spp. and *Pyrus communis* for *P. washingtonensis*), these hosts are widely distributed in Australia, in commercial orchard districts, as well as suburban and rural areas.
- *Phacidiopycnis piri* occurs in Austria, Canada (British Columbia), Germany, India, the United Kingdom and the US (Oregon and Washington State) (DiCosmo *et al.* 1984; Xiao and Boal 2005b; Farr and Rossman 2009). *Phacidiopycnis washingtonensis* is only known to occur in Washington State (Xiao *et al.* 2005; Kim and Xiao 2006; Kim and Xiao 2008). Environments with climates similar to these areas exist in many parts of temperate southeastern and southwestern Australia, where host plants are present, suggesting that the climate in these parts of Australia is likely to be suitable for the survival of these fungi.
- The distribution of infected fruit or nursery stock via commercial or domestic trade may aid the spread of these pathogens.

- Conidia of *P. piri* are found in pycnidia on fruit (Xiao and Boal 2004a; Xiao 2006) and on dead or dying bark tissues (Xiao and Boal 2005b). Conidia of *P. washingtonensis* are found in pycnidia on fruit, diseased twigs or branches (Xiao *et al*. 2005).
- Conidia of *P. piri* are dispersed by water (DiCosmo *et al.* 1984). Conidia of *P. washingtonensis* are probably splash dispersed (Xiao *et al*. 2005).
- Conidia of the assessed fungi germinate either by budding, forming one to several secondary conidia, or by developing germ tubes (Liu and Xiao 2005; Xiao *et al.* 2005). Formation of secondary conidia provides a survival strategy under unfavourable conditions (Hanlin 1994).
- *Phacidiopycnis piri* is associated with canker on branches and dieback of twigs and fruit spurs of pear trees (Xiao and Boal 2005b) and canker and dieback of apple trees (DiCosmo *et al.* 1984), and can survive as mycelium in diseased twigs all year around (Xiao and Boal 2004b). *Phacidiopycnis washingtonensis* is associated with a canker and twig dieback disease of crabapple trees. It has been found on the dead tissues of infected crabapple trees (Xiao *et al.* 2005) and apple trees (Kim and Xiao 2006).
- Pycnidia produced on dead bark and spurs of pear trees throughout the growing season are considered the main source of inoculum for fruit infection with *P. piri* (Xiao and Boal 2004b; Xiao and Boal 2005b). The epidemiology of *P. washingtonensis* is not clearly known. However, crabapple is suspected as one of the sources of infection leading to storage rot of apples (Xiao *et al.* 2005).
- *Phacidiopycnis piri* can survive as mycelium in diseased twigs all year around (Xiao and Boal 2004b). *Phacidiopycnis washingtonensis* has been found on dead tissues of crabapple (Xiao *et al.* 2005) and apple (Kim and Xiao 2006) trees in orchards.
- Infection with *P. piri* can spread from fruit to fruit in storage (Xiao and Boal 2004a; Xiao 2006).
- Symptoms of speck rot and early symptoms of Phacidiopycnis rot are similar to those of gray mould (Xiao 2006; Xiao and Kim 2008). The misdiagnosis of symptoms with gray mould would make an early detection of the disease in Australia difficult.
- Geographical areas such as arid regions between western and eastern parts of Australia could be natural barriers for the spread of the assessed fungi. However, movement of infected fruit or nursery stock can facilitate the spread of the fungi between these regions.

The ability of *Phacidiopycnis piri* and *P. washingtonensis* to survive and grow at a wide temperature range and their ability to survive on both live and dead tissues of their hosts, moderated by the limited known hosts range, support a risk rating for spread of 'moderate'.

4.22.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of ‘rules’ for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *Phacidiopycnis piri* or *P. washingtonensis* will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **LOW**.

4.22.5 Consequences

The consequences of the establishment of *Phacidiopycnis piri* or *P. washingtonensis* in Australia have been estimated using the decision rules described in Table 2.3 on page 11.

Based on the decision rules described in Table 2.4 on page 12, that is, where the consequences of a pest with respect to one or more criteria are '**E**', the overall consequences are estimated to be **MODERATE**.

Reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**E - Significant at regional level:** Phacidiopycnis rot is a fungal post-harvest disease of apple and pear caused by *Phacidiopycnis piri* (Xiao and Boal 2002; Xiao *et al.* 2005; Kim and Xiao 2006). It is one of the major post-harvest fruit rots in d'Anjou pears in Washington State (Xiao and Boal 2004a) but it is much less common in apple (Xiao *et al.* 2005; Kim and Xiao 2006). Over a 2–year survey of pear orchards in Washington State, Phacidiopycnis rot occurred in approximately 90% of the sampled orchards and accounted for an average of 30% of the decayed fruit after 6–8 months in storage (Xiao and Boal 2004a). Incidence of Phacidiopycnis rot varied greatly among orchards sampled (Xiao and Boal 2004a). *Phacidiopycnis piri* also causes canker on branches and dieback of twigs and fruit spurs of pear trees (Xiao and Boal 2005b) and canker and dieback of apple trees (DiCosmo *et al.* 1984). *Phacidiopycnis washingtonensis* is associated with both healthy and diseased tissues of its host species of *Malus* and *Pyrus* (Xiao *et al*. 2005). The fungus infects fruit and vegetative tissues (Xiao *et al*. 2005). In Washington State, *P. washingtonensis* occurred in 23, 26 and 27% of total apple growers lots surveyed, accounting for 1, 4 and 3% of the total decay in 2003, 2004 and 2005, respectively (Kim and Xiao 2006). In 2004 and 2005, Red Delicious fruit losses observed were as high as 24% in three growers' lots in Washington State (Kim and Xiao 2006). *Phacidiopycnis washingtonensis* is also associated with dieback twigs of crabapple and pear and canker disease of crabapple (Xiao *et al.* 2005). It is not known if the assessed fungi would have any effects on native plants. Species of *Phacidiopycnis* are usually associated with canker diseases of conifers (Xiao *et al.* 2005). It is not known whether *P. piri* or *P. washingtonensis* cause disease of conifers.
Other aspects of the environment	**A - Indiscernible at the local level:** There are no known direct consequences of these pathogens on other aspects of the environment.
Indirect	
Eradication, control etc.	**D - Significant at the district level:** Application of the fungicide Ziram within two weeks before harvest provides some control of stem- and calyx-end rot caused by *P. piri* (Washington State University 2005c). More research is needed to develop effective management measures for controlling stem- and calyx-end rot. A drench with thiabendazole applied before storage controls infection originating from wounds on the fruit skin (Washington State University 2005c). Speck rot caused by *P. washingtonensis* is a relatively new disease and more research is needed to develop effective management measures for the disease in commercial orchards. Existing integrated pest management programs may be disrupted due to possible increases in the use of fungicides. Costs for crop monitoring, orchard sanitation, pruning, and fungicides may be incurred by the producer.
Domestic trade	**D - Significant at the district level:** The presence of *P. piri* or *P. washingtonensis* in commercial apple and pear production areas could result in the implementation of interstate quarantine measures, causing loss of market and subsequent industry adjustment.
International trade	**E – Significant at the regional level:** The presence *of P. piri* or *P. washingtonensis* in commercial production areas of apple and pear would have a significant effect at the regional level due to potential limitations of accessing international markets where these pathogens are absent. To date, *Phacidiopycnis piri* has been recorded from Austria, Canada, Germany, India, the United Kingdom and the US (DiCosmo *et al.* 1984; Xiao and Boal 2005b; Farr and Rossman 2009). Some countries, e.g. Israel and Korea, have listed *P. piri* as a quarantine pest. A number of pear consignments from the US have been rejected entry to Israel due to the presence of this pathogen (Northwest Horticultural Council 2006). *Phacidiopycnis washingtonensis* has only been recorded from the US (Xiao *et al*. 2004; Xiao and Boal 2005a; Kim and Xiao 2006, 2008).
Environmental and non-commercial	**B - Minor significant at the local level:** Additional fungicide applications or other control activities would be required to control these diseases on susceptible crops. Any additional fungicide usage may affect the environment.

4.22.6 Unrestricted risk estimate

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 12.

Unrestricted risk estimate for *Phacidiopycnis piri* and *P. washingtonensis*	
Overall probability of entry, establishment and spread	Low
Consequences	Moderate
Unrestricted risk	Low

The unrestricted risk for *Phacidiopycnis piri* and *P. washingtonensis* has been assessed as ‘low’, which exceeds Australia’s ALOP. Therefore, specific risk management measures are required for these pests.

4.23 European canker

Neonectria ditissima

European canker, caused by the fungus *Neonectria ditissima*, is an important disease affecting apples, pears and many species of hardwood forest trees (Swinburne 1975; Castlebury *et al.* 2006). The disease mostly affects branches and trunks of trees, causing cankers. Infection is initiated through leaf and bud scars, bark disruptions such as pruning cuts and wounds, or woolly aphid galls (Swinburne 1975). In apples and pears, the fruit is also infected and develops rot. Foliage is not affected (Butler 1949). Typically, infection of fruit occurs at the blossom end, through either open calyx, lenticels, scab lesions or wounds caused by insects (Swinburne 1964, 1975; McCartney 1967). Sometimes the rot can develop at the stem-end (Bondoux and Bulit 1959; Swinburne 1964) or rarely on the surface of the fruit when the skin is damaged (Bondoux and Bulit 1959). Apple varieties vary greatly in their susceptibility to the disease, but no variety is immune (McKay 1947).

The fungus produces two types of spores: conidia in spring and summer, and ascospores in autumn and winter. Spores are dispersed by rain splash and wind, and possibly by insects and birds (Butler 1949). Spores germinate over a temperature range of 2–30°C, the optimum being 20–25°C (Munson 1939).

The risk scenario of particular relevance to *N. ditissima* is primarily any latent infection in fruit that would not have been detected during harvesting or during sorting and packing processes.

Neonectria ditissima (as *Nectria galligena*) was assessed in the Final Import Risk Analysis Report for Apples from New Zealand (Biosecurity Australia 2006a). In that assessment, the overall probability of entry, establishment and spread was assessed to be ‘low’ using a semi-quantitative method and the consequences assessed to be ‘moderate’. As a result the unrestricted risk was assessed to be ‘low’ and specific risk management measures were determined to be necessary.

Neonectria ditissima is present in western Washington and Oregon states, including the Willamette Valley (Grove 1990b). It has not been reported in Idaho and eastern Washington state. The likelihood of *N. ditissima* occurring on apple fruit from western Washington and Oregon is comparable to that from New Zealand. Pest management procedures for *N. ditissima* (including sorting, packing and shipping procedures) are similar for both countries. Transport of apple fruit from the US will normally take longer than from New Zealand. However, *N. ditissima* can readily survive extended cold storage (Biosecurity Australia 2006a). For these reasons, Biosecurity Australia considers that the probability of importation of *N. ditissima* on apple fruit from the PNW would be in the same range as that for apple fruit from New Zealand. Factors affecting the distribution of the commodity (and with it the pathogen) in Australia are similar for both countries. The probability of establishment and of spread of *N. ditissima* in Australia, and the consequences it may cause will be the same for any commodity with which the species is imported into Australia. Therefore, the existing pest risk assessment for *N. ditissima* is proposed for the importation of apple fruit from the PNW as the unrestricted risk estimate is considered to be in the same range.

4.23.1 Unrestricted risk estimate

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 12.

Biosecurity Australia considers the unrestricted risk of *N. ditissima* through the importation of apple fruit from the PNW is the same as the risk of this pathogen through the importation of apple fruit from New Zealand. Therefore, the existing pest risk assessment for *N. ditissima* has been adopted for the importation of apple fruit from the PNW.

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

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

4.24 Mucor rot[14]

Mucor mucedo; Mucor piriformis; Mucor racemosus

The three species of *Mucor* causing rot of apple fruit 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 the three species assessed.

Mucor rot is a fungal post-harvest disease of apple and pear primarily caused by *Mucor piriformis*, but also by *Mucor mucedo* or *Mucor racemosus* (Spotts 1990b). Infection usually occurs through stem wounds (Washington State University 2005b), turning the tissue soft, watery and light brown. Measurable lesions on fruit are detectable after 10 days at -1ºC (Bertrand and Saulie-Carter 1980). After about two months in cold storage at 0ºC, infected fruit completely decay and release juice containing sporangiospores. Secondary spread in cold storage is uncommon in apples (Bertrand and Saulie-Carter 1980; Michailides and Spotts 1990a; Spotts 1990b). Serious losses due to Mucor rot have occurred in the US (Spotts 1990b).

Mucor mucedo and *M. piriformis* are closely related species forming sporangiospores and zygospores (Schipper 1975). *Mucor racemosus* is a member of a different clade (Schipper 1976; Jacobs and Botha 2008). All these species may be associated with decaying fruit, soil and dung (Schipper 1975, 1976; Jacobs and Botha 2008). There is considerable variation in each species and a number of forms have been described (Schipper 1975, 1976; Papp *et al.* 1997).

Mucor piriformis is a soilborne fungus that survives primarily as sporangiospores. The spores are associated with organic matter, such as fallen fruit, in the top layer of the soil (Spotts 1990b). In the orchard, fallen fruit is infected by direct contact with infected soil or by spores dispersed by rodents, birds and insects from decaying fruit. Rain washes spores from decaying fruit into the soil. Spores can also be dispersed as a result of mowing, which can spread pieces of infected fruit. Spores of *M. piriformis* are not dispersed by wind because they are embedded in a mucilaginous matrix (Spotts 1990b).

The fungus enters the packing house in soil adhering to fruit bins. Infection of apple fruit occurs during harvest or in the dump tank during processing in the packing house. Late harvested, overmature or injured apples are particularly susceptible to infection (Michailides and Spotts 1990a; Spotts 1990b; Washington and Holmes 2006).

Spore germination, infection and disease development can occur at temperatures used for the storage of apples and the disease develops rapidly at cold storage temperature (Bertrand and Saulie-Carter 1980). *Mucor piriformis* survives well in cool, dry soil. Soil temperatures of 33ºC and above lead to a rapid decline in spore viability. To be able to propagate in the soil, the fungus requires a nutrient base of fallen fruit, low temperatures and a high moisture level (Michailides and Spotts 1990a; Spotts 1990b).

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[14] In this section, the common name Mucor rot will be used to refer to all three species. The scientific name will be used when the information is about a specific species.

Mucor mucedo has not been recorded in Australia. *Mucor piriformis* and *M. racemosus* have been recorded in some parts of Australia (*M. piriformis* in Queensland and Victoria; *M. racemosus* in the Australian Capital Territory, New South Wales and Victoria) but not in Western Australia (APPD 2009).

The risk posed by the assessed Mucor rot fungi is that symptomless infected fruit may be exported and result in the establishment of these pathogens in Australia.

This assessment considers *M. mucedo* as a quarantine pest for Australia, and *M. piriformis* and *M. racemosus* as quarantine pests for Western Australia.

4.24.1 Probability of entry

Probability of importation

The likelihood that the Mucor rot fungi assessed will arrive in Australia with the importation of the commodity: **HIGH**.

Supporting information for this assessment is provided below:

- Serious losses due to Mucor rot have occurred in the US, both in the eastern and in the western states (Spotts 1990b).
- A survey of post-harvest diseases in stored apples conducted in 2003–2005 in Washington State showed that *M. piriformis* accounted for 0.6% of the total decay of apple fruit (Kim and Xiao 2008).
- Mucor rot has been a serious problem in apples in the PNW (Michailides and Spotts 1990a; Michailides 1991). It caused major losses in pears and apples in the PNW during 1970 to 1980 (Michailides and Spotts 1990a).
- Michailides and Spotts (1990a) claimed that Mucor rot of pears and apples in the PNW and of stone fruit in California were caused only by *M. piriformis*. However, Michailides (1991) demonstrated the pathogenicity of *M. racemosus* isolates from stone fruit in California. All three assessed Mucor species have been reported from the PNW, and it must be assumed that all three can contribute to Mucor rot.
- During harvest, the underside of harvest bins can be covered with soil and debris. In Oregon, as many as 8333 propagules (mycelia and spores) of *M. piriformis* have been recovered per gram of dry soil sampled from harvest bins in pear orchards (Michailides and Spotts 1986)
- In packing houses, apple fruit are commonly removed from field bins by immersion dumping (Bertrand and Saulie-Carter 1979). Dump-tank water is thus contaminated with the soil and debris brought in with the bin. Studies conducted in 1975 and 1978 showed that dump-tank water samples collected from packing houses in Oregon commonly contained spores of *M. piriformis* (Bertrand and Saulie-Carter 1979, 1980). *Mucor piriformis* was also isolated from dump-tank water in 1981 to 1983 from apple and pear packing houses even though the water contained chlorine. The levels of *M. piriformis* increased as the packing season progressed (Spotts and Cervantes 1986).
- Infection of apple fruit occurs during harvest or in the dump-tank during processing in the packing house. Late harvested, overmature or injured apples are particularly susceptible to infection (Michailides and Spotts 1990a; Spotts 1990b; Washington and Holmes 2006).

- *Mucor piriformis* can grow well at temperatures used for cold storage of apples (Smith *et al*. 1979; Bertrand and Saulie-Carter 1980). It can cause post-harvest fruit decay at 0–20ºC (Smith *et al.* 1979).
- Infected fruit completely decay after about two months in cold storage at 0ºC and release juice containing sporangiospores. Secondary spread in cold storage is uncommon in apples (Bertrand and Saulie-Carter 1980; Michailides and Spotts 1990a; Spotts 1990b).
- No fungicide is presently registered in the US that is effective against *M. piriformis* (Spotts 1990b).

The wide distribution of these fungi in the US, including the PNW, their ability to grow at temperatures used for cold storage and the potential for infection occurring during harvest or during processing in the packing house, support a risk rating for importation of ‘high’.

Probability of distribution

The likelihood that the Mucor rot fungi assessed will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **HIGH**.

Supporting information for this assessment is provided below:

- Imported apple fruit is intended for human consumption in Australia. It is expected that once the apple fruit has arrived in Australia, it will be distributed throughout Australia for wholesale or retail sale. Any infected fruit present may be distributed during these procedures. However, infected fruit with obvious signs of rot are expected to be disposed of rather than distributed further. Measurable lesions on fruit are detectable after 10 days at -1ºC (Bertrand and Saulie-Carter 1980).
- If fruit purchased by consumers are found to be rotten, they will be disposed of into garden compost bins, possibly near host plants, or into landfills. Individual consumers will distribute small quantities of apples to a variety of urban, rural and wild environments, where they will be consumed, or disposed of, in close proximity to a suitable host plant.
- Infected fruit disposed near suitable hosts may serve as a source of inoculum.
- Sporangiospores of *M. piriformis* are primarily dispersed by rain, insects and birds. Experiments have shown that, on peach, nitidulid beetles (*Carpophilus hemipterus* and *C. freemani*) and vinegar flies (*Drosophila melanogaster*) can spread the fungus from fruit to fruit. In orchards with high incidence of decayed, infected fruit contamination of vinegar flies can be expected to be very high (Michailides and Spotts 1990b). Vinegar flies are very common in pome fruit orchards (Michailides and Spotts 1990a).
- It is likely that if infected fruit is eaten by wild animals, spores will survive passage through the gut and germinate and grow on dung (Schipper 1975, 1976; Jacobs and Botha 2008).
- Sporangiospores of *M. piriformis* are not dispersed by wind (Spotts 1990b), but those of *M. racemosus* are (Sarbhoy 1966). *Mucor racemosus* forms abundant chlamydospores in the aerial mycelium (Sarbhoy 1966) which probably function as long-lived survival propagules. *Mucor piriformis* and *M. mucedo* do not form chlamydospores.
- If zygospores are present, they may serve as a long-lived source of inoculum.

- All three *Mucor* species occur in a wide range of environments (see Appendix B) suggesting that the climate in most parts of Australia is likely to be suitable for the survival of these species. *Mucor piriformis* has already been recorded in Queensland and Victoria, and *M. racemosus* in the Australian Capital Territory, New South Wales and Victoria (APPD 2009).

The potential distribution of infected fruit throughout Australia, the disposal of fruit waste in the environment and the ability of rodents, birds and insects to transfer spores from the fruit waste to a host, support a risk rating for distribution of 'high'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that the assessed Mucor rot fungi will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **HIGH**.

4.24.2 Probability of establishment

The likelihood that the assessed Mucor rot fungi will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **HIGH**.

Supporting information for this assessment is provided below:

- The Mucor rot fungi assessed have a wide host range. Hosts of *M. piriformis* include apple, carrot, gooseberry, orange, pear, plum, stone fruit, strawberry, sweet potato and tomato (Smith *et al.* 1979; Kirk 1997). Hosts of *M. racemosus* include sweet potato, potato and citrus (Lunn 1977). Hosts of *M. mucedo* include tomato and strawberry (Moline and Kuti 1984).
- Suitable hosts are widely present in Australia. The three species of *Mucor* are widely distributed overseas (Sarbhoy 1966; Schipper 1975, 1976; Kirk 1997).
- *Mucor piriformis* is a soilborne fungus that survives primarily as sporangiospores. The spores are associated with organic matter, such as fallen fruit, in the top layer of the soil (Spotts 1990b). Species of *Mucor* can survive as saprotrophs (Kirk 1997).
- *Mucor piriformis* survives well in cool, dry soil. Sporangiospores of *M. piriformis* do not survive well at soil temperatures of 27ºC or above. Soil temperatures of 33ºC and above lead to a rapid decline in spore viability (Michailides and Ogawa 1987).
- Sporangiospores of *M. piriformis* are able to survive in soil for up to one year if average weekly soil temperatures are below 27ºC (Michailides and Ogawa 1987).
- Under experimental conditions, optimal growth and sporulation of *M. piriformis* occurs at 10–15ºC. No growth was observed at 30ºC, both for *M. mucedo* and *M. piriformis* (Schipper 1975). The optimum temperature for growth and sporulation of *M. racemosus* is higher, 5–30ºC (Schipper 1976).
- Under experimental conditions, spore germination of *M. piriformis* occurs at temperatures -1–20ºC. Optimal germination occurs at 20ºC. Germination at 25ºC was abnormal and no germination was observed at 30ºC (Bertrand and Saulie Carter 1980).

- Viability of sporangiospores decreases rapidly in wet soils, but soil temperature is more important than soil moisture (Michailides and Ogawa 1987). Clamydospores in mycelium of *M. racemosus* would permit it to persist in soil.
- *Mucor piriformis* cannot compete effectively with other soil microbes at 20ºC and above (Michailides and Spotts 1990a).
- To be able to propagate, the fungus requires a nutrient base of fallen fruit or other organic matter, low temperatures and a high moisture level in the soil (Michailides and Spotts 1990a; Spotts 1990b).

The wide distribution of hosts, the occurrence of suitable temperature and moisture conditions for spore germination and infection in some parts of Australia, support a risk rating for establishment of 'high'. *Mucor piriformis* has been recorded in Queensland and Victoria and *M. racemosus* has been recorded in the Australian Capital Territory, New South Wales and Victoria, further supporting the risk rating for establishment of 'high' for these fungi.

4.24.3 Probability of spread

The likelihood that the assessed Mucor rot fungi will spread based on a comparison of those factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pest: **HIGH**.

Supporting information for this assessment is provided below:

- Spores of *M. piriformis* are primarily dispersed by rain, insects and birds. (Michailides and Spotts 1990b). In the orchard, fallen fruit is infected by direct contact with infected soil or by spores dispersed by rodents, birds and insects from decaying fruit. Rain washes spores from decaying fruit into the soil. Sporangiospores can also be dispersed as a result of mowing, which scatters pieces of infected fruit (Spotts 1990b). The fungus can persist as a saprotroph (Kirk 1997). Sporangiospores of *M. racemosus* are wind dispersed (Sarbhoy 1966).
- The fungus can be dispersed via movement of infected soil, e.g. with harvest bins or machinery, or via water borne dispersal of sporangiospores (Kirk 1997). It enters the packing house in soil adhering to harvest bins. Infection of apple fruit occurs during harvest or in the dump tank during processing in the packing house. Late harvested, overmature or injured apples are particularly susceptible to infection (Michailides and Spotts 1990a; Spotts 1990b; Washington and Holmes 2006).
- Spores of *M. piriformis* are not dispersed by wind (Spotts 1990b), but may be splash dispersed (Kirk 1997).
- Hosts of the Mucor rot fungi assessed are present in Australia in commercial orchard districts, suburban and rural areas.
- All three *Mucor* species occur in a wide range of environments (see Appendix B) suggesting the climate in most parts of Australia is likely to be suitable for the survival of these species. *Mucor piriformis* has already been recorded in Queensland and Victoria, and *M. racemosus* in the Australian Capital Territory, New South Wales and Victoria.
- *Mucor piriformis* survives well in cool, dry soil. Soil temperatures of 33ºC and above lead to a rapid decline in spore viability (Spotts 1990b).

- Sporangiospores of *M. piriformis* are able to survive in soil for up to one year if average weekly soil temperatures are below 27ºC (Michailides and Ogawa 1987).
- To be able to propagate, the fungus requires a nutrient base of fallen fruit, low temperatures and a high moisture level in the soil (Michailides and Spotts 1990a; Spotts 1990b).

The dispersal of spores with infected soil, by animals or rain, and in the case of *M. racemosus* by wind, support a risk rating for spread of 'high'. *Mucor piriformis* has been recorded in Queensland and Victoria and *M. racemosus* has been recorded in the Australian Capital Territory, New South Wales and Victoria, further supporting the risk rating for spread of 'high' for these fungi.

4.24.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that the Mucor rot fungi assessed will enter Austrlaia as a result of trade in the commodity from the country of origin, be distributed in a viable state to a suitable host, establish in the area and subsequently spread within Australia: **HIGH**.

4.24.5 Consequences

The consequences of the establishment of the assessed Mucor rot fungi in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision rules described in Table 2.4 on page 12, 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**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D – Significant at the district level:** Mucor rot is a post harvest disease and does not affect life or health of the plant or of the fruit pre harvest. Infection of apple fruit occurs during harvest or during processing in the packing house. Infected tissue is soft, watery and light brown, and infected fruit completely decay after about two months in cold storage at 0ºC (Spotts 1990b). Secondary spread in cold storage is uncommon in apples (Bertrand and Saulie-Carter 1980; Michailides and Spotts 1990a; Spotts 1990b). Serious losses due to this disease have occurred in the US, but it occurs less consistently than blue mould (caused by *Penicillium* spp.) or grey mould (caused *by Botrytis cinerea*) (Spotts 1990b). In some seasons considerable losses have occurred in areas of Australia where Mucor rot is present (Washington and Holmes 2006). It is not known if the assessed *Mucor* spp. would have any effects on native plants.
Other aspects of the environment	**A – Indiscernible at the local level:** There are no known direct consequences of these species on other aspects of the environment.
Indirect	
Eradication, control etc.	**D – Significant at the district level:** No fungicides are registered for the control of *Mucor* on apples in Australia (Washington and Holmes 2006). Recommended measures for the control of *M. piriformis* in the orchard include: cleaning of fruit bins before harvest, harvesting in dry weather, avoiding fruit injury, minimising the collection of soil and debris on the underside of fruit bins, avoiding the movement of infected soil with machinery, avoiding to put fruit that has fallen to the ground during harvest into bins with harvested fruit, removing fallen fruit from the orchard floor (Spotts 1990b; Washington and Holmes 2006). Some of these measures are very labour-intensive and not always practicable. Implementation of these control measures would result in an increase in the cost of production. Additionally, costs for crop monitoring and consultant's advice to manage these pests may be incurred by the producer.
Domestic trade	**B – Minor at the local level:** Apple fruit infected with *Mucor* spp. completely decay after about two months in cold storage at 0ºC. Measurable lesions on fruit are already detectable after 10 days at -1ºC (Bertrand and Saulie-Carter 1980). Secondary spread in cold storage is uncommon in apples (Bertrand and Saulie-Carter 1980; Michailides and Spotts 1990a; Spotts 1990b). Serious losses due to this disease have occurred in the US (Spotts 1990b). The *Mucor* species assessed also infect fruit of other commercial species, including *Fragaria X ananassa* Duch. (strawberry), *Prunus* spp., *Rubus idaeus* L. (raspberry) and *Solanum lycopersicum* L. var. *lycopersicum* (tomato) (Dennis and Mountford 1975; Moline and Kuti 1984; Kirk 1997). *Mucor mucedo* has not been recorded in Australia. *Mucor piriformis* and *M. racemosus* have been recorded in some parts of Australia but not in Western Australia (APPD 2009). The presence of these species of *Mucor* in commercial production areas could result in the implementation of interstate quarantine measures, causing loss of market and subsequent industry adjustment.
International trade	**D – Significant at the district level:** The presence of these Mucor rot fungi in commercial production areas of a range of commodities, including apple, raspberry, stone fruit, strawberry and tomato, would have a significant effect at the district level due to potential limitations of accessing international markets where these pests are absent, such as New Zealand. Mucor rot is already present in the US, Canada, South Africa and Europe (Spotts 1990b). *Mucor piriformis* is present in Queensland and Victoria, and *M. racemosus* in the Australian Capital Territory, New South Wales and Victoria.
Environmental and non-commercial	**A – Indiscernible at the local level:** Additional fungicide applications are unlikely because, currently, no fungicides are registered for the control of Mucor rot in Australia (Washington and Holmes 2006). Other control activities would be required to control these pathogens on susceptible crops.

4.24.6 Unrestricted risk estimate

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 12.

Unrestricted risk estimate for the assessed Mucor rot fungi	
Overall probability of entry, establishment and spread	High
Consequences	Low
Unrestricted risk	Low

As indicated, the unrestricted risk estimate for the assessed Mucor rot fungi has been assessed as ‘low’, which is above Australia’s ALOP. Therefore, specific risk management measures are required for these pests.

4.25 Black pox

Helminthosporium papulosum

Black pox, caused by *Helminthosporium papulosum*, affects bark, fruit, and leaves of apples (Yoder 2009). *Helminthosporium papulosum* also causes blister canker of pear (Yoder 1990d). It has a narrow range of hosts consisting of *Malus* spp. and *Pyrus communis* (Farr and Rossman 2009). However, the apple strain does not infect pear and the pear strain does not infect apple (Yoder 1990d). *Helminthosporium papulosum* has been reported on apple in the PNW (Glawe 2009). It is more common in the southeastern and Atlantic States of the US (Yoder 1990d; Farr and Rossman 2009).

Fruit symptoms are small, shiny, black, circular and slightly sunken lesions 3–9 mm in diameter (Yoder 1990d). The infection first appears on twigs of the current season as shiny black swellings that keep enlarging and increasing in numbers. Twigs may remain susceptible for several years. Leaf symptoms are circular lesions of 1.5–11 mm in diameter which start red and turn brown (Yoder 1990d).

Helminthosporium papulosum overwinters and produces conidia on mature lesions (Yoder 1990d). The optimum temperature for mycelial growth is 28°C (Yoder 1990d). Conidia are dispersed by wind and water and initiate new infections. Infected propagating material may play an important role in spreading the disease to new areas (Yoder 1990d)

The risk posed by *Helminthosporium papulosum* is that apple fruit may be infected yet show no obvious symptoms of the disease.

4.25.1 Probability of entry

Probability of importation

The likelihood that the *Helminthosporium papulosum* assessed will arrive in Australia with the importation of commodity: **LOW**.

Supporting information for this assessment is provided below:

- *Helminthosporium papulosum* has been reported as associated with apple in the PNW (Farr and Rossman 2009; Glawe 2009).
- The pathogen does not appear to be common in the PNW, but is more common in the southeastern states of the US (Yoder 1990d).
- The incubation period of *H. papulosum* is 3–6 months on fruit (Taylor 1970; Yoder 1990d). The first lesions on fruit may appear in late July (Taylor 1970). It is therefore possible that non-symptomatic fruit with latent infections are imported into Australia.
- Apple cultivars differ in susceptibility (Yoder 2009). The apple variety ‘Golden Delicious’ is very susceptible to the disease (Sutton *et al.* 2004).

The association of the fungus with apple in the PNW and its long incubation period, moderated by its sporadic occurrence in the PNW, support a risk rating for importation of ‘low’.

Probability of distribution

The likelihood that *Helminthosporium papulosum* will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **MODERATE**.

Supporting information for this assessment is provided below:

- Imported apple is intended for human consumption in Australia. It is expected that once the apple fruit has arrived in Australia, it will be distributed throughout Australia for wholesale or retail sale. Any infected fruit may be distributed during these procedures.
- Apple waste disposed of as litter may be deposited into urban, peri-urban and agricultural situations, as well as areas of natural vegetations, throughout Australia.
- Apple waste products disposed of as municipal waste and compost are unlikely to distribute *H. papulosum* into the environment.
- Conidia are produced on lesions and splash and wind dispersed (Taylor 1963; Yoder 1990d).
- The incubation period is 3–6 months on fruit (Taylor 1970). Therefore, asymptomatic infected fruit may be distributed after entry.

The potential distribution of infected fruit throughout Australia, the disposal of fruit waste in the environment, and the asymptomatic nature of the disease, moderated by the narrow range of hosts, support a risk rating for distribution of 'moderate'.

Overall probability of entry

The overall probability of entry is determined by combining the probability of importation with the probability of distribution using matrix of rules shown in Table 2.2 on page 9.

The likelihood that *Helminthosporium papulosum* will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **LOW**.

4.25.2 Probability of establishment

The likelihood that *Helminthosporium papulosum* will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **MODERATE**.

Supporting information for this assessment is provided below:

- *Helminthosporium papulosum* has a narrow range of hosts consisting of *Malus* spp. and *Pyrus communis* (Farr and Rossman 2009). However, the apple strain is unlikely to infect pears (Yoder 1990d). *Malus pumila* is commercially grown in most Australian states/territories with climate conditions varying from subtropical, warm and cool temperate. *Malus* spp. are also found in many urban areas and wild environment of Australia.
- *Helminthosporium papulosum* appears to prefer a warm, moist environment such as the southeastern US (Yoder 1990d), but also occurs in the PNW (Glawe 2009). Similar conditions exist in some temperate and subtropical regions of Australia.

- Conidia are found on infected fruit, are wind or splash dispersed and can infect leaves, twigs, bark and fruit of *Malus* spp. (Taylor 1963; Yoder 1990d). New infections could occur throughout the year.
- Volunteer apple trees grown along highways and apple trees grown in urban environment may support the establishment of the pathogen.
- The incubation period of *H. papulosum* is 3–6 months on fruit and 3–10 months on bark (Yoder 1990d). Infections may remain latent and the fungus may be introduced into new plantings on infected nursery stock or other propagated material (Yoder 1990d). The disease could be established well before it is detected.

The availability of hosts, favourable environmental conditions, the long incubation period, moderated by the narrow range of hosts, support a risk rating for establishment of 'moderate'.

4.25.3 Probability of spread

The likelihood that *Helminthosporium papulosum* will spread based on a comparison of those factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pest: **MODERATE**.

Supporting information for this assessment is provided below:

- *Helminthosporium papulosum* has a narrow range of hosts consisting of *Malus* spp. and *Pyrus communis* (Farr and Rossman 2009). *Malus pumila* is commercially grown in most Australian states/territories with climate conditions varying from subtropical, warm and cool temperate. *Malus* spp. are also found in many urban areas and wild environment of Australia.
- *Helminthosporium papulosum* occurs in various regions of the US from the PNW to the southeast (Farr and Rossman 2009). Similar conditions exist in some temperate and subtropical regions of Australia.
- Conidia are blown or splashed to twigs, bark, leaves and fruit of new host plants (Taylor 1963; Yoder 1990d, 2009).
- No sexual stage is known.
- The incubation period for disease symptom expression is 3–6 months on fruit and 3–10 months on bark (Taylor 1970). Symptomless yet infected fruit and nursery stock may aid the spread of the disease to new areas.
- Volunteer apple trees are commonly observed along roadsides in Australia. Apple trees are also commonly grown in urban environment. The readily available hosts may aid the spread of the disease.
- Host plants grown in backyards are often not sprayed on regular basis. They could become an important source of spreading the disease to commercial orchards.
- Geographical areas such as arid regions between western and eastern parts of Australia could be natural barriers for the spread of *H. papulosum*.

The availability of hosts, favourable environments and the ability of fungus to spread by wind and water moderated by narrow range of hosts, support a risk rating for spread of 'moderate'.

4.25.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *Helminthosporium papulosum* will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **LOW**.

4.25.5 Consequences

The consequences of the establishment of *Helminthosporium papulosum* in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision rules described in Table 2.4 on page 12, that is, where the consequences of a pest with respect to one or more criteria are '**C**', the overall consequences are estimated to be **VERY LOW**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**C– Minor significance at the district level:** The pathogen infects twigs, bark, leaves and fruit of apples and pears (Yoder 1990d, 2009). Fruit on amenity trees may be unsightly and there may be dieback symptoms. Severely affected leaves may drop within two to three weeks after infection (Taylor 1963). This will likely affect tree growth and productivity. Fruit showing symptoms are not marketable. There is unlikely to be any effect on native plants.
Other aspects of the environment	**A – Indiscernible at the local level:** There are no known direct consequences of this species on other aspects of the environment.
Indirect	
Eradication, control etc.	**C– Minor significance at the district level;** Many chemical control measures used for some of the major fungal diseases of apple will control *H. papulosum* as well (Yoder 1990d). Additional spray programs may be required for effective control of the disease, especially for post-harvest spraying of trees of early-maturing varieties (Yoder 1990d). This would increase the cost of production.
Domestic trade	**C – Minor significance at the district level:** If *H. papulosum* established in Australia, it may result in some minor industry adjustment and the implementation of some interstate quarantine measures at the district level.
International trade	**C – Minor significance at the district level:** If *H. papulosum* established in Australia, it may affect international trade, as the fungus is not reported from many countries. Countries where the disease is not reported may put some quarantine restrictions in place.
Environmental and non-commercial	**B – Minor significance at the local level:** As a post-harvest pathogen of apples, *H. papulosum* may affect the quality of infected apples if symptoms become apparent. This may be especially significant in a home orchard situation when no or irregular fungicide applications are practised. Control activities for *H. papulosum* are not considered to impact significantly on the environment.

4.25.6 Unrestricted risk estimate

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 12.

Unrestricted risk estimate for *Helminthosporium papulosum*	
Overall probability of entry, establishment and spread	Low
Consequences	Very low
Unrestricted risk	Negligible

As indicated, the unrestricted risk for *Helminthosporium papulosum* has been assessed as ‘negligible’, which achieves Australia’s ALOP. Therefore, no specific risk measures are required for this pest.

4.26 Apple scab

Venturia inaequalis

Venturia inaequalis is not present in Western Australia and is a pest of regional quarantine concern for that state.

Apple scab caused by *V. inaequalis* attacks leaves, petioles, blossoms, sepals, fruits, pedicels and less frequently, young shoots and bud scales. The fungus produces two distinct types of spores, conidia (asexual) and ascospores (sexual) (Biggs 1990). Ascospores released from overwintered leaves and fruit on the orchard floor are the principal source of inoculum in the spring (Biggs 1990). The lesions resulting from these infections produce conidia throughout the spring and summer, and serve as secondary inoculum (Schwabe 1982; Biggs 1990). Under favourable conditions, the pathogen can cause serious damage.

The risk posed is that *Venturia inaequalis* may be present on the fruit as symptomatic or asymptomatic infections.

Venturia inaequalis was assessed in the Final Import Risk Analysis Report for Apples from New Zealand (Biosecurity Australia 2006a). In that assessment, the overall probability of entry, establishment and spread was assessed to be 'high' using a semiquantitative method and the consequences were assessed to be 'moderate'. As a result, the unrestricted risk was assessed to be 'moderate' and specific risk management measures were determined to be necessary.

Venturia inaequalis is similarly abundant in the PNW, especially in the western parts of the region (Pscheidt 2008b). The likelihood of *V. inaequalis* is associated with apple fruit is comparable to that from New Zealand. The timing of imports of apples from the US coincides with leaf and fruit development of hosts in Western Australia, a receptive stage for *V. inaequalis* infections (Biggs 1990). Pest management procedures for this pathogen (including sorting, packing and shipping procedures) are similar for both countries. Transport of apple fruit from the US will normally take longer than from New Zealand. However, *V. inaequalis* has been shown to survive and develop during extended periods of cold storage (Biosecurity Australia 2006a). For these reasons, Biosecurity Australia considers that the probability of importation of *V. inaequalis* on apple fruit from the PNW would be in the same range as that for apple fruit from New Zealand. Factors affecting the distribution of the commodity (and with it the pathogen) in Australia are similar for both countries. The probability of establishment and of spread of *V. inaequalis* in Western Australia, and the consequences it may cause will be the same for any commodity with which the species is imported into Western Australia. Therefore, the existing pest risk assessment for *V. inaequalis* is proposed for the importation of apple fruit from the PNW as the unrestricted risk estimate is considered to be in the same range.

4.26.1 Unrestricted risk estimate

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 12.

Biosecurity Australia considers that the probability of entry of *V. inaequalis* on apple fruit from the PNW would be the same as that for apple fruit from New Zealand. Therefore, the existing pest risk assessment for *V. inaequalis* has been adopted for the importation of apple fruit from the PNW.

Unrestricted risk estimate for *Venturia inaequalis*	
Overall probability of entry, establishment and spread	High
Consequences	Moderate
Unrestricted risk	Moderate

As indicated, the unrestricted risk estimate for *Venturia inaequalis* has been assessed as ‘moderate’, which is above Australia’s ALOP. Therefore, specific risk management measures are required for this pest.

4.27 Thread blight

Ceratobasidium ochroleucum

Ceratobasidium ochroleucum is a plurivorous basidiomycete that grows on apple, coffee, and citrus, among many other hosts (see Appendix B). On apple, it is known as thread blight and in the US, it occurs mainly in the southeastern states (Hartman 1990). It presents as white to brown strands of hyphae (rhizomorphs) on leaves, branches and fruit (Wolf and Bach 1927; Hartman 1990).

Affected leaves wilt and die, often remaining suspended by mycelial threads. Bark and wood of blighted branches do not appear to be affected by the fungus (Hartman 1990). It overwinters as sclerotia, often on native woody plants near orchards (Hartman 1990). After the fungus establishes on a branch, it spreads on the plant by rhizomorphs (Hartman 1990). Sclerotia develop and remain superficially attached to bark or fruits, without the fungus further colonising the tissues (Hartman 1990).

Basidiospores are mainly formed on leaves and are unlikely to be on fruit (Hartman 1990).

Ceratobasidium ochroleucum prefers a humid, high-rainfall environment for development. Areas with extended foggy periods are particularly susceptible (Mathew 1954; Hartman 1990).

Ceratobasidium ochroleucum is more common in poorly managed orchards in the absence of fungicide treatments.

The risk posed by *Ceratobasidium ochroleucum* is that sclerotia remain undetected on fruit (such as on the stem and calyx ends) and may be exported and result in the establishment of this pathogen in Australia.

4.27.1 Probability of entry

Probability of importation

The likelihood that *Ceratobasidium ochroleucum* will arrive in Australia with the importation of the commodity: **EXTREMELY LOW**.

Supporting information for this assessment is provided below:

- *Ceratobasidium ochroleucum* mycelium can colonise apple fruit, and sclerotia can persist there (Wolf and Bach 1927; Hartman 1990).
- Fruit infection is most abundant in russet apples (Wolf and Bach 1927). Russet apples are seldom used in modern apple production and are unlikely to be exported from the US to Australia.
- *Ceratobasidium ochroleucum* usually occurs in humid, high-rainfall climates, especially in situations where there are extended periods of fog or mist (Mathew 1954; Hartman 1990). In the US, it almost exclusively occurs in the southeastern states. While Ginns and Lefebvre (1993) record the fungus in Washington, it is not clear on which host it was found. It is unlikely that *C. ochroleucum* occurs in apple-producing areas of the PNW.

- Standard fungicidal treatments in apple production usually suppress the fungus. It is usually not observed until after harvest, when the spray program has been discontinued (Hartman 1990).
- Basidiospores on leaf trash may contaminate harvested apples. This is unlikely to occur for export-quality fruit free of trash.
- Fruit affected by *C. ochroleucum* are more susceptible to storage moulds (Wolf and Bach 1927) and therefore more likely to be culled post-harvest.

The potential for *Ceratobasidium ochroleucum* to infect apple fruit, moderated by the unsuitable climate for the fungus in PNW apple producing areas, its susceptibility to standard fungicide treatments and its easy detection in orchards support a risk rating for importation of ‘extremely low’.

Probability of distribution

The likelihood that *Ceratobasidium ochroleucum* will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **LOW**.

Supporting information for this assessment is provided below:

- Imported apple fruit is intended for human consumption in Australia. It is expected that once the apple fruit has arrived in Australia, it will be distributed throughout Australia for wholesale or retail sale. Any infected fruit present may be distributed during these procedures. However, infected fruit with obvious signs of rot are likely to be disposed of rather than distributed further. Disposal of the infected fruit is likely to be via commercial or domestic rubbish systems.
- If fruit purchased by consumers are found to be rotten, they will be disposed of into garden compost bins, possibly near host plants, or into landfills.
- Infected fruit disposed near suitable hosts (see Appendix B) may aid distribution of the pathogen. Individual consumers will distribute small quantities of apples to a variety of urban, rural and wild environments, where they will be consumed, or disposed of, in close proximity to a suitable host plant.
- Sclerotia on the surface of affected fruit may produce hyphae that colonise a host. This would require close proximity of the discarded fruit to host material. Basidiospores mainly form on leaves (Mathew 1954; Hartman 1990). There are no records of basidiospores forming on apple fruit, and on another host, coffee, occurrence of basidiospores on berries is only occasional (Mathew 1954).

The potential distribution of infected fruit throughout Australia and the disposal of fruit waste in the environment, moderated by the limited reach of propagules, support a risk rating for distribution of ‘low’.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that of *Ceratobasidium ochroleucum* will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **EXTREMELY LOW**.

4.27.2 Probability of establishment

The likelihood that *Ceratobasidium ochroleucum* will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **HIGH**.

Supporting information for this assessment is provided below:

- *Ceratobasidium ochroleucum* has a very wide host range, including *Coffea*, *Citrus*, *Malus*, *Prunus* spp. and many plants from genera that are native in Australia, especially in rainforest environments, such as *Clematis*, *Clerodendrum*, *Dioscorea*, *Diospyros*, *Eucalyptus*, *Ficus*, *Jasminum*, *Melia*, *Pavetta*, *Pittosporum*, *Psychotria*, *Randia*, *Smilax*, and *Syzygium* (Mathew 1954; Segura 1970; Farr and Rossman 2009).
- Suitable hosts are widespread in Australia, in production orchards, amenity plantings and native vegetation.
- *Ceratobasidium ochroleucum* usually occurs in humid, high-rainfall climates, especially in situations where there are extended periods of fog or mist (Mathew 1954; Hartman 1990). This would make Australia's wet tropical and subtropical environments suitable.

The wide host range and geographical distribution of hosts as well as the climatic suitability of northern Australia for *Ceratobasidium ochroleucum* support a risk rating for establishment of 'high'.

4.27.3 Probability of spread

The likelihood that *Ceratobasidium ochroleucum* will spread based on a comparison of factors in the area of origin and in Australia that affect the expansion of geographic distribution of the pest: **HIGH**.

Supporting information for this assessment is provided below:

- *Ceratobasidium ochroleucum* forms basidiospores on infected leaves. These spores can be dispersed by wind and rain (Wolf and Bach 1927).
- Resting sclerotia are the main survival structure for *C. ochroleucum* during adverse conditions such as dry and cold periods and perpetuate the fungus from season to season (Wolf and Bach 1927; Mathew 1954; Hartman 1990).
- *Ceratobasidium ochroleucum* has a very wide host range, including *Coffea*, *Citrus*, *Malus*, *Prunus* spp. and many plants from genera that are native in Australia, especially in rainforest environments, such as *Clematis*, *Clerodendrum*, *Dioscorea*, *Diospyros*, *Eucalyptus*, *Ficus*, *Jasminum*, *Melia*, *Pavetta*, *Pittosporum*, *Psychotria*, *Randia*, *Smilax*, and *Syzygium* (Mathew 1954; Segura 1970; Farr and Rossman 2009).
- Suitable hosts are widespread in Australia, in production orchards, amenity plantings and native vegetation.
- *Ceratobasidium ochroleucum* usually occurs in humid climates, especially in situations where there are extended periods of fog or mist (Mathew 1954; Hartman 1990). This would make Australia's wet tropical and subtropical environments suitable.

The ability of the fungus to be wind- and rain-dispersed, the ability of its sclerotia to survive unsuitable temperature and humidity conditions, and the wide distribution of its many hosts support a risk rating for spread of 'high'.

4.27.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *Ceratobasidium ochroleucum* will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread throughout Australia: **EXTREMELY LOW**.

4.27.5 Consequences

The consequences of the establishment of *Ceratobasidium ochroleucum* in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision described in Table 2.4 on page 12, 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**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D - Significant at the district level:** *Ceratobasidium ochroleucum* is a potentially serious pest of coffee, particularly in humid conditions. It leads to rots of leaves and berries and can cause severe yield and quality losses (Mathew 1954; Rangasvami and Mahadevan 2002; Segura *et al*. 2004; Waller *et al*. 2007). In 2002, Australia produced ~500 tonnes of dry green coffee beans, largely in northern NSW and northern Queensland. *Ceratobasidium ochroleucum* has also been reported on eucalypts (Segura 1970) and may affect the health of a number of Australian native plants, especially in rainforest environments. It has been found on members of the genera *Clematis*, *Clerodendrum*, *Dioscorea*, *Diospyros*, *Eucalyptus*, *Ficus*, *Jasminum*, *Melia*, *Pavetta*, *Pittosporum*, *Psychotria*, *Randia*, *Smilax*, and *Syzygium* (Mathew 1954; Segura 1970; Farr and Rossman 2009). *Ceratobasidium ochroleucum* also is an often minor pest on many other crops, such as apple, pear, quince, *Prunus* spp., *Citrus* spp., persimmon, mango, and avocado among many others (Farr and Rossman 2009).
Other aspects of the environment	**A - Indiscernible at the local level:** There are no known direct consequences of this pathogen on other aspects of the environment.
Indirect	
Eradication, control etc.	**C - Significant at the local level:** Recommended measures for the control of C. *ochroleucum* include removal of branches and twigs with symptoms (Waller *et al*. 2007) and fungicidal treatments (Rangasvami and Mahadevan 2002; Waller *et al*. 2007). Implementation of these control measures would result in an increase in the cost of production. Additionally, costs for crop monitoring and consultant's advice to manage these pests may be incurred by the producer.
Domestic trade	**C - Significant at the local level:** The presence of *C. ochroleucum* in commercial production areas could result in the implementation of interstate quarantine measures between NSW and Queensland, causing loss of market and subsequent industry adjustment.
International trade	**B - Minor significance at the local level:** The presence of C. *ochroleucum* in commercial production areas may have some effect at the local level due to potential limitations of accessing international markets where this pathogen is absent.
Environmental and non-commercial	**B - Minor significance at the local level:** Additional fungicide applications or other control activities would be required to control this disease on susceptible crops. Any additional fungicide usage may affect the environment.

4.27.6 Unrestricted risk estimate

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 12.

Unrestricted risk estimate for *Ceratobasidium ochroleucum*	
Overall probability of entry, establishment and spread	Extremely low
Consequences	Low
Unrestricted risk	Negligible

As indicated, the unrestricted risk estimate for *Ceratobasidium ochroleucum* has been assessed as ‘negligible’, which achieves Australia’s ALOP. Therefore, no specific risk management measures are required for this pest.

4.28 Gymnosporangium rusts[15]

Gymnosporangium juniperi-virginianae; Gymnosporangium libocedri

Cedar apple rust and Pacific Coast pear rust are fungal diseases caused by *Gymnosporangium juniperi-virginianae* and *Gymnosporangium libocedri*, respectively. Both species are heteroecious rusts that require *Juniperus* spp. (junipers) or *Calocedrus decurrens* (incense cedar) as telial hosts and rosaceous species as aecial hosts to complete their life cycle (Farr and Rossman 2009).

These two rust fungi have been grouped together because of their related biology and taxonomy, and are predicted to post a similar risk and to require similar mitigation measures. Unless explicitly stated, the information presented is considered as applicable to both species assessed.

Both of the rust fungi assessed have similar life cycles and cause similar symptoms in their hosts. Most *Gymnosporangium* species require two years to complete their life cycle (Sinclair and Lyon 2005). Telia are produced from galls on bark or leaves of the juniper/cedar hosts during spring. Telia produce two-celled teliospores which, under wet conditions, germinate to produce basidia on which are borne basidiospores. Basidiospores are wind-dispersed and are able to infect nearby apple trees. Infection from basidiospores on apples gives rise to pycnia on the upper surface of apple leaves and eventually reaches the lower surface of the leaves. Later aeciospores are produced in aecia on the *Malus* host on the lower leaf surface or on fruit. These aeciospores are released during dry weather in late summer and capable of being wind dispersed to infect the alternate juniper/cedar host (Aldwinckle 1990c; Sinclair and Lyon 2005). After germinating on the juniper/cedar host, an overwintering mycelium is produced. The telial state appears from mature galls on juniper/cedar hosts in the first or second spring to begin the life cycle again. Galls of *G. libocedri* are perennial, whereas those of *G. juniperi-virginianae* produce teliospores during one spring only and fresh infections are needed every year for the life cycle to be maintained (Sinclair and Lyon 2005; Aldwinckle 1990c; CABI/EPPO 1997l).

Symptoms on apple are listed below:

- *Gymnosporangium juniperi-virginianae*: Orange-yellow spots on the upper side of leaves followed by light-coloured spots on the under side of leaves. Both types of spots can also sometimes develop on fruit and green stems (Sinclair and Lyon 2005; Aldwinckle 1990c). However, lesions on fruit are rare. On susceptible cultivars, severe defoliation can occur (CABI/EPPO 1997l).
- *Gymnosporangium libocedri*: Produces aecia on leaves and fruit (Laundon 1977d). Colourful, swollen spots on the upper side of leaves and white spots mostly on the underside (Sinclair and Lyon 2005). It causes malformation and premature drop of fruit (Aldwinckle 1990d; Pscheidt 2008a).

[15] In this section, the common name rust fungi will be used to refer to both species. The scientific name will be used when the information is about a specific species.

Infection of the rosaceous host does not persist after infected leaves or fruit have fallen, or it dies out in stems during winter in most cases (Sinclair and Lyon 2005).

The risk posed by the assessed rust fungi is that symptomless infected fruit may be picked and exported to Australia.

4.28.1 Probability of entry

Probability of importation

The likelihood that *Gymnosporangium juniperi-virginianae* or *Gymnosporangium libocedri* will arrive in Australia with the importation of the commodity: **LOW**.

Supporting information for this assessment is provided below:

- Cedar apple rust caused by *G. juniperi-virginianae* is the best known of the Gymnosporangium rusts in the US (Sinclair and Lyon 2005). It is widespread in the US east of the Rocky Mountains (Sinclair and Lyon 2005). Although it is uncommon in the West, it has been reported from California and Washington State (Sinclair and Lyon 2005). Species of *Malus*, or less commonly *Crataegus*, are the aecial hosts (Sinclair and Lyon 2005).
- Pacific coast pear rust caused by *G. libocedri* is present in the PNW (Washington State) and northern California (Sinclair and Lyon 2005; Aldwinckle 1990d; Farr and Rossman 2009). It has occasionally caused severe infection of pear and quince fruit, but also infects apple fruit (Sinclair and Lyon 2005; Aldwinckle 1990d).
- Basidiospores are released from germinated teliospores on the alternate host during wet weather in spring and are therefore unlikely to be present on mature harvested apple fruit.
- *Gymnosporangium juniperi-virginianae* can infect apple fruit causing swollen lesions (Sinclair and Lyon 2005; Aldwinckle 1990c). *Gymnosporangium libocedri* causes malformation and premature drop of fruit (Aldwinckle 1990d); it is most severe on pear, but also attacks apple (Aldwinckle 1990d).
- Young, succulent tissues of apple can become infected by basidiospores from the juniper/cedar host if a film of water is present for a sufficiently long period (Sinclair and Lyon 2005; Aldwinckle 1990c). A wet period of 4–6 hours at 10–24ºC is sufficient for severe infection with *G. juniperi-virginianae* (Sinclair and Lyon 2005). Infection with *G. juniperi-virginianae* can occur at temperatures of 2–24ºC. Infected fruit develop lesions; deformation of fruit and premature fruit drop can also occur. Mature apple fruit is more resistant to infection by basidiospores (Sinclair and Lyon 2005).
- Fruit exhibiting visual symptoms of the rust fungi assessed would be rejected during harvesting and routine grading and sorting operations (CABI/EPPO 1997l). However, symptomless infected fruit and fruit with small lesions may not be detected during these processes.

The potential for symptomless infected fruit and fruit with small lesions to pass through packing house processes without being detected, moderated by the limited distribution of *G. juniperi-virginianae* in the PNW and the fact that *G. libocedri* mainly attacks pear and is therefore unlikely to be present on mature harvested apple fruit, support a risk rating for importation of ‘low’.

Probability of distribution

The likelihood that the rust fungi assessed will be distributed within Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **MODERATE**.

Supporting information for this assessment is provided below:

- Imported apple fruit is intended for human consumption in Australia. It is expected that once the apple fruit has arrived in Australia, it will be distributed throughout Australia for wholesale or retail sale. Any infected fruit present may be distributed during these procedures.
- Infected fruit disposed near alternate hosts may aid distribution of the pathogen. Individual consumers will distribute small quantities of apples to a variety of urban, rural and wild environments, where they will be consumed or disposed of, in close proximity to a suitable host plant.
- The rust fungi assessed require an alternate juniper/cedar host to complete their life cycle (Sinclair and Lyon 2005). Therefore, the aeciospores from the discarded apple fruit must disperse to their alternate host, *Juniperus* spp. or *Calocedrus decurrens*, for these pathogens' life cycles to be completed. Aeciospores are dispersed by wind (Sinclair and Lyon 2005).
- Basidiospores are released from germinated teliospores on the alternate juniper/cedar host during wet weather in spring and are therefore unlikely to be present on mature harvested apple fruit.

The potential distribution of infected fruit throughout Australia, the disposal of fruit waste in the environment and the ability of wind to transfer rust spores from the fruit waste to a host, moderated by the limited number of alternate hosts in Australia, support a risk rating for distribution of 'moderate'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that *Gymnosporangium juniperi-virginianae* or *G. libocedri* will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **LOW**.

4.28.2 Probability of establishment

The likelihood that the assessed rust fungi will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **MODERATE**.

Supporting information for this assessment is provided below:

- Species of *Gymnosporangium* are obligate plant pathogens (Sinclair and Lyon 2005).
- Infection of the rosaceous hosts does not persist after infected leaves or fruit have fallen, or it dies out in stems during winter in most cases (Sinclair and Lyon 2005).
- The rust fungi assessed require an alternate juniper/cedar host to complete their life cycle (Sinclair and Lyon 2005). Therefore, the aeciospores from the discarded apple fruit must

disperse to their alternate host, *Juniperus* spp. or *Calocedrus decurrens*, for these pathogens' life cycles to be completed. Aeciospores are dispersed by wind (Sinclair and Lyon 2005).

- *Juniperus* spp. and *Calocedrus decurrens* are grown in home gardens, parks, along roadsides, in commercial orchard districts and as bonsai plants in Australia (e.g. ABC 2008). *Juniperus communis* and *J. virginianae* have been recorded as weeds in Australia (Randall 2007).
- Most *Gymnosporangium* spp. require two years to complete their life cycle (Sinclair and Lyon 2005). On the apple host, aecia develop after dikaryotization of spermatia produced in pycnia. The aecia form aeciospores which infect the alternate hosts, *Juniperus* spp. and *Calocedrus decurrens*. The fungus overwinters on the juniper/cedar host and forms teliospores from mature galls in the first or second spring. The basidiospores released from the germinated teliospores infect apples (Sinclair and Lyon 2005; Van Haperen and de Gruyter 2006).
- The rust fungi assessed are obligate pathogens that require an alternate host (*Juniperus* spp. or *Calocedrus decurrens*) to complete their life cycles. Guidelines for plant disease control generally recommend removal of these alternate hosts from orchard areas for control of the *Gymnosporangium* fungi (Pscheidt 2008a). Basidiospores can be carried long distances on air currents (Aldwinckle 1990c). The use of resistant *Malus* cultivars or the use of appropriate fungicides (e.g. sterol-inhibiting fungicides or dithiocarbamates), which must be applied before infections occur, are other strategies to control these fungi (CABI/EPPO 1997l; Cornell Cooperative Extension 2008).
- Only the basidiospores produced on juniper can infect apple hosts (Sinclair and Lyon 2005).
- Under natural conditions, basidiospores (from *Juniperus* spp. and *Calocedrus decurrens* to *Malus*) and aeciospores (from *Malus* to *Juniperus* spp. and *Calocedrus decurrens*) are dispersed by wind (Sinclair and Lyon 2005). The basidiospores from juniper hosts of *G. libocedri* can infect *Malus* hosts at distances as far as 12–16 km from the inoculum source (Sinclair and Lyon 2005). Spores from juniper sources of *G. juniperi-virginianae* mostly infect *Malus* hosts at distances of a few hundred metres but may remain able to germinate and infect after being carried in the air for several kilometres (Sinclair and Lyon 2005).
- Aeciospores produced on apple fruit or leaves can only infect the alternate *Juniperus* or *Calocedrus* hosts (Sinclair and Lyon 2005).
- Young, succulent tissues of apple can become infected by basidiospores from the juniper/cedar host if a film of water is present for a sufficiently long period (Sinclair and Lyon 2005; Aldwinckle 1990c). A wet period of 4–6 hours at 10–24ºC is sufficient for severe infection with *G. juniperi-virginianae* (Sinclair and Lyon 2005). Infection with *G. juniperi-virginianae* can occur at temperatures of 2–24ºC. Infected fruit develop lesions; deformation of fruit and premature fruit drop can also occur. Mature apple fruit is more resistant to infection by basidiospores (Sinclair and Lyon 2005).
- Galls of *G. libocedri* are perennial whereas those of *G. juniperi-virginianae* produce teliospores during one spring only and fresh infections are needed every year for the life cycle to be maintained (Sinclair and Lyon 2005; Aldwinckle 1990c; CABI/EPPO 1997l).

- Infection of the *Malus* host does not persist after infected leaves or fruit have fallen, or it dies out in stems during winter (Sinclair and Lyon 2005).
- *Gymnosporangium juniperi-virginianae* occurs in Canada and the US (CABI/EPPO 1997l). *Gymnosporangium libocedri* occurs in the western US (Aldwinckle 1990d). Environments with climates similar to these countries exist in many parts of temperate southeastern and southwestern Australia where apples are produced, suggesting that the climate in these parts of Australia is likely to be suitable for the establishment of these *Gymnosporangium* species.
- The *Gymnosporangium* species assessed have a restricted host range, including *Malus* species and its alternate host species (*Juniperus* spp. and *Calocedrus decurrens*) (Farr and Rossman 2009). These host plants are grown in Australia, in commercial orchard districts, suburban and rural areas (e.g. ABC 2008).
- For *G. juniperi-virginianae*, the optimum temperature range for germination of teliospores is 11–25ºC. During rain, teliospores germinate to produce basidiospores within 4 hours at these temperatures and within 5–7 hours at 7–11ºC (Aldwinckle *et al.* 1980). Infections can occur at temperatures of 2–24ºC. A wet period of 4–6 hours at 10–24ºC is sufficient for severe infection (Sinclair and Lyon 2005). These temperatures are found across the apple growing regions of temperate Australia for much of the year (Bureau of Meteorology 2009).

The occurrence of suitable temperature and moisture conditions for spore germination and infection in some parts of Australia moderated by the need for proximity of alternate hosts, support a risk rating for establishment of ‘moderate’.

4.28.3 Probability of spread

The likelihood that the assessed rust fungi will spread based on a comparison of those factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pest: **HIGH**.

Supporting information for this assessment is provided below:

- Under natural conditions, basidiospores (from *Juniperus* spp. and *Calocedrus decurrens* to *Malus*) and aeciospores (from *Malus* to *Juniperus* spp. and *Calocedrus decurrens*) are dispersed by wind (Sinclair and Lyon 2005). Spores from juniper sources of *G. juniperi-virginianae* mostly infect *Malus* hosts at distances of a few hundred metres but may remain able to germinate and infect after being carried in the air for several kilometres (Sinclair and Lyon 2005).
- Spread by humans may occur by transporting infected plants of *Juniperus* species in which infections may be latent (CABI/EPPO 1997l). In addition, aeciospores can be carried on fruit, stems and leaves of infected apple plants during trade and transport. However, infection of apple trees does not persist after infected leaves or fruit have fallen, or it dies out in stems during winter in most cases (Sinclair and Lyon 2005).
- The aecial hosts of *G. juniperi-virginianae* are species of *Malus* and *Crataegus*; the telial hosts are species of *Juniperus* (Sinclair and Lyon 2005; Farr and Rossman 2009). For *G. libocedri*, the aecial hosts are species of *Amelanchier*, *Chaenomeles*, *Crataegus*, *Cydonia*, *Pyrus* and *Sorbus*; the telial host is *Calocedrus decurrens* (Sinclair and Lyon 2005; Farr and Rossman 2009). *Calocedrus decurrens* is less common than species of

Juniperus, but has been widely planted as an ornamental tree and is a common bonsai plant.

- The climates in which the rust fungi assessed are present in North America and other parts of the world are found in many parts of temperate southeastern and southwestern Australia where apples are produced.
- No species of *Gymnosporangium* is known to be established in Australia. No species of native *Cupressaceae* is known to be susceptible to any *Gymnosporangium* species.

The long distance dispersal of spores by wind and the potential for movement of symptomless infected planting material, support a risk rating for spread of ‘high’.

4.28.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of ‘rules’ for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *Gymnosporangium juniperi-virginianae* or *G. libocedri* will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to a suitable host, establish in that area and spread within Australia: **LOW**.

4.28.5 Consequences

The consequences of the establishment of the assessed rust fungi in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision rules in Table 2.4 on page 12, that is, where the consequences of a pest with respect to one or more criteria are ‘**E**’, the overall consequences are estimated to be **MODERATE**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**E – Significant at the regional level:** *Gymnosporangium juniperi-virginianae* is considered the most serious rust disease of apples in eastern North America (Aldwinckle 1990c). On susceptible cultivars, it can lead to severe defoliation, weakening tree growth (Cornell Cooperative Extension 2008; CABI/EPPO 19997l; Aldwinckle 1990c). *Gymnosporangium libocedri* causes a serious disease of pears in the western US and sometimes infects apples (Aldwinckle 1990d). The rust fungi assessed infect leaves and stems of *Juniperus* spp. and *Calocedrus decurrens*, and leaves, stems and fruit of apple (Sinclair and Lyon 2005). Damage caused on apple can include lesions on fruit, leaves and sometimes on green stems, defoliation, deformation of fruit or green stems and premature drop of fruit (Sinclair and Lyon 2005; Aldwinckle 1990 c, d; CABI/EPPO 1997l). As a result, apple fruit yield and quality, and plant health are affected. The rust fungi assessed also affect other Rosaceae hosts, including *Pyrus* spp., *Crataegus* spp. and *Cydonia oblonga* (quince), and are detrimental to ornamental *Juniperus* spp. and *Calocedrus decurrens*.
Other aspects of the environment	**A – Indiscernible at the local level:** There are no known direct consequences of these species on other aspects of the environment.
Indirect	
Eradication, control etc.	**D – Significant at the district level:** Programs to monitor and eradicate the rust fungi assessed, should they reach Australia, would be costly. Recommended control measures include the use of routine fungicides and resistant apple cultivars, and to avoid planting the juniper or cedar hosts close to orchards (CABI/EPPO 1997l). Existing integrated disease management programs for other pests may be disrupted due to possible increases in the use of fungicides and the use of other types of fungicide. Costs for crop monitoring and consultant's advice regarding management of these pathogens may also be incurred by the producers.
Domestic trade	**D – Significant at the district level:** The presence of the rust fungi assessed in commercial apple production areas in Australia would result in the implementation of interstate quarantine measures and potential loss of markets.
International trade	**E – Significant at the regional level:** *Gymnosporangium juniperi-virginianae* is one of the non-European *Gymnosporangium* spp. listed as A1 quarantine organisms by EPPO (CABI/EPPO 1997l). It is also listed as a quarantine pest by the Interafrican Phytosanitary Council and by the Comité de Sanidad Vegetal del Cono Sur (whose members are Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay). The presence of the assessed species in commercial apple or pear production areas in Australia would limit market access for Australian apples to overseas markets where these pests are absent.
Environmental and non-commercial	**B – Minor significance at the local level:** Additional fungicide applications or other control activities would be required to control these diseases on susceptible crops. Any additional fungicide usage may affect the environment.

4.28.6 Unrestricted risk estimate

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 12.

Unrestricted risk estimate for *Gymnosporangium juniperi-virginianae* and *Gymnosporangium libocedri*	
Overall probability of entry, establishment and spread	Low
Consequences	Moderate
Unrestricted risk	Low

As indicated, the unrestricted risk estimate for *Gymnosporangium juniperi-virginianae* and *Gymnosporangium libocedri* has been assessed as 'low' which exceeds Australia's ALOP. Therefore, specific risk management measures are required for theses pests.

4.29 Truncatella leaf spot

Truncatella hartigii

The ascomycete *Truncatella hartigii* (syn. *Pestalotia hartigii*) belongs to the family Amphisphaeriaceae in the order Xylariales. Amphisphaeriaceae contain a number of plant pathogenic genera such as *Seiridium* and *Pestalotiopsis* (Jeewon *et a*l. 2003). Many amphisphaeriaceous species are endophytes (Jeewon *et al*. 2003) and may be latent pathogens.

Truncatella hartigii has a wide host range across several unrelated plant families and including Asteraceae: *Lactuca*; Fagaceae: *Fagus*; Oleaceae: *Fraxinus*, *Olea*; Pinaceae: *Abies*, *Picea*, *Pinus*, *Pseudotsuga*; Restionaceae: *Cannomois*, *Rhodocoma* and Rosaceae: *Malus*, *Pyrus* (Cooke 1906; Spaulding 1956; Vujanovic *et al.* 2000; Lee *et al*. 2006; Farr and Rossman 2009). Records of the fungus from the PNW have been on *Malus* and *Pyrus* (Zeller 1929; Heald and Ruehle 1931; Pierson *et al*. 1971; Glawe 2009). On these species, it causes leaf spots (Chaudhary *et al.* 1987) and post-harvest decay of fruit (Rosenberger 1990b).

Truncatella hartigii has been associated with damage to many coniferous species. It has been reported to destroy the bark of and stem-girdle *Abies* and *Picea* spp. (Cooke 1906), and has been associated with damaged cones of many *Pinus* spp. (Vujanovic *et al.* 2000). However, while commonly found in *Pinus* spp. showing dieback symptoms, a clear association between the fungus and the symptoms could not be established (Doğmuş-Lehtijärvi *et al.* 2007).

The risk posed by *Truncatella hartigii* is that apple fruit, including seed, may be infected yet shows no obvious symptoms of the disease.

4.29.1 Probability of entry

Probability of importation

The likelihood that *Truncatella hartigii* will arrive in Australia with the importation of the commodity: **HIGH**.

Supporting information for this assessment is provided below:

- *Truncatella hartigii* is present in the PNW on apples and pears (Zeller 1929; Heald and Ruehle 1931; Pierson *et al.* 1971; Glawe 2009).
- *Truncatella hartigii* has been reported as a post-harvest decay pathogen on apple fruit (Heald and Ruehle 1931; Pierson *et al.* 1971; Rosenberger 1990b) and in apple seeds (Chaudhary *et al.* 1987).
- *Truncatella hartigii* may not be symptomatic when kept in cold storage (Pierson *et al.* 1971; Rosenberger 1990b), and it is possible for infected fruit to escape visual detection.

The presence of *Truncatella hartigii* in the PNW and the difficulty of detection on apple fruit, support a risk rating for importation of 'high'.

Probability of distribution

The likelihood that *Truncatella hartigii* will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **HIGH**.

Supporting information for this assessment is provided below:

- Imported apple fruit is intended for human consumption in Australia. It is expected that once the apple fruit has arrived in Australia, it will be distributed throughout Australia for wholesale or retail sale. Any infected fruit present may be distributed during these procedures.
- The cores of apple fruit, including seeds, are not normally consumed by humans and are disposed of as waste.
- Apple waste products disposed of as municipal waste and compost are unlikely to distribute *T. hartigii* into the environment.
- Apple waste disposed of as litter may be deposited into urban, peri-urban and agricultural situations, as well as areas of natural vegetation, throughout Australia.
- The mode of infection by *T. hartigii* is not clearly known. However, *T. hartigii* can be seed-borne (Chaudhary *et al.* 1987). Discarded apple cores may give rise to infected seedlings.
- *Truncatella hartigii* has many potential hosts in addition to *Malus* and *Pyrus* spp., including *Abies* spp., *Fagus sylvatica*, *Fraxinus excelsior*, *Larix occidentalis*, *Olea laurifolia*, *Picea* spp., *Pinus* spp. (Farr and Rossman 2009) and some South African Restionaceae (Lee *et al.* 2006).

The potential distribution of infected fruit throughout Australia, the disposal of fruit waste in the environment and the seed-borne nature of the fungus support a risk rating for distribution of 'high'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that *Truncatella hartigii* will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **HIGH**.

4.29.2 Probability of establishment

The likelihood that *Truncatella hartigii* will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **HIGH**.

Supporting information for this assessment is provided below:

- The risk of establishment principally depends on the ability to establish from infected apple trees, some of which may have grown from discarded infected apple cores.
- There are numerous potential host species (Vujanovic 2000; Doğmuş-Lehtijärvi *et al.* 2007; Farr and Rossman 2009) (see Appendix B), many of them coniferous. Records of *T. hartigii* are from Europe, Turkey, India, Pakistan, South Africa, and North America and include a range of climates from temperate to subtropical and mediterranean (Farr and Rossman 2009). Within Australia, *T. hartigii* may be capable of occupying a range of habitats in temperate, subtropical and mediterranean Australia where suitable hosts grow in commercial plantations and often as naturalised plants (Hnatiuk 1990).

- Species of Restionaceae are widespread in Australia. Some of these are probably susceptible to *T. hartigii* (Lee *et al.* 2006).
- In commercial apple and pear orchards, *T. hartigii* may be controlled by frequent fungicide applications. This is less likely in commercial plantations of conifers such as *Pinus radiata*, park and garden plantings, or for naturalised pome fruit trees and conifers.
- The cryptic nature of *T. hartigii* would make early detection of the fungus in Australia difficult.

The number and wide distribution of hosts supports a risk rating for distribution of 'high'.

4.29.3 Probability of spread

The likelihood that *Truncatella hartigii* will spread based on a comparison of factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pest: **HIGH**.

Supporting information for this assessment is provided below:

- There are numerous potential host species (Vujanovic 2000; Doğmuş-Lehtijärvi *et al.* 2007; Farr and Rossman 2009) (see Appendix B), many of them coniferous. Records of *T. hartigii* are from Europe, Turkey, India, Pakistan, South Africa, and North America and include a range of climates from temperate to subtropical and mediterranean. Within Australia, *T. hartigii* may be capable of occupying a range of habitats in temperate, subtropical and mediterranean Australia where suitable hosts also grow, in commercial plantations and often as naturalised plants (Hnatiuk 1990). Native species of Restionaceae may be susceptible to *T. hartigii* (Lee *et al.* 2006).
- Geographical areas such as arid regions between the western and eastern parts of Australia could be natural barriers for the spread of *T. hartigii.*
- There are no reports on the mechanism of spread for *T. hartigii*, but it is probably by splash and wind.

The number and wide distribution of hosts supports a risk rating for spread of 'high'.

4.29.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *Truncatella hartigii* will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in the area and subsequently spread within Australia: **HIGH**.

4.29.5 Consequences

The consequences of the establishment of *Truncatella hartigii* in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision described in Table 2.4 on page 12, 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**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D – Significant at the district level:** *Truncatella hartigii* is considered a minor pest for apples and pears (Pierson *et al.* 1971). It causes leaf spots (Chaudhary *et al.* 1987) and post-harvest decay of fruit (Rosenberger 1990b). As a pathogen of conifers, it attacks the bark of seedlings, stem-girdling young plants of *Picea*, *Abies*, and *Pseudotsuga* spp. (Cooke 1906; Spaulding 1956). It has also been associated with seed and cone damage in *Pinus sylvestris* (Vujanovic *et al.* 2000). The fungus has the potential to affect the Australian softwood timber industry, although records on the impact of *T. hartigii* internationally are inconsistent. *Truncatella hartigii* is a pathogen of some Restionaceae in South Africa (Lee *et al*. 2006). The introduction of *T. hartigii* may affect some native species in susceptible families such as Rosaceae, Oleaceae or Restionaceae.
Other aspects of the environment	**A – Indiscernible at the local level:** There are no known direct consequences of this species on other aspects of the environment.
Indirect	
Eradication, control etc.	**B – Minor significance at the local level:** Once introduced, it would be difficult to eradicate or control *T. hartigii*. In pome fruit orchards, it is not expected to play a major role and could be controlled in the course of routine fungicide applications. For other trees, screening of nursery material could provide pathogen-free seedlings.
Domestic trade	**B – Minor significance at the local level:** If *T. hartigii* is established in Australia, it is not likely to affect interstate trade in pome fruit or timber. It may affect the domestic trade in pine nursery stock.
International trade	**A – Indiscernible at the local level:** If *T. hartigii* is established in Australia, it is not likely to affect international trade.
Environmental and non-commercial	**B – Minor significance at the local level:** As a post-harvest pathogen of apples, *T. hartigii* may affect the quality of apples for the consumer if rot symptoms become apparent. This may be especially significant in a home orchard situation with no or irregular fungicide applications.

4.29.6 Unrestricted risk estimate

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 12.

Unrestricted risk estimate for *Truncatella hartigii*	
Overall probability of entry, establishment and spread	High
Consequences	Low
Unrestricted risk	Low

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

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4.30 Tobacco necrosis viruses

Tobacco necrosis virus A, Tobacco necrosis virus D, tobacco necrosis virus Nebraska isolate and related viruses

The taxonomy of 'tobacco necrosis virus' (TNV) has been revised. *Tobacco necrosis virus A* (TNV-A) and *Tobacco necrosis virus D* (TNV-D) have been recognised as distinct species in the *Necrovirus* genus (Meulewaeter *et al*. 1990; Coutts *et al*. 1991), as have *Chenopodium necrosis* virus (ChNV) and *Olive mild mosaic virus* (OMMV), which were previously considered TNV isolates (Tomlinson *et al*. 1983; Cardoso *et al*. 2005). TNV isolates from Nebraska and Toyama (TNV-NE and TNV-Toyama) represent another species in the genus, as yet not officially recognised (Zhang *et al*. 1993; Saeki *et al*. 2001) and molecular sequence data indicates some other necroviruses called 'tobacco necrosis virus' are also distinct species (NCBI 2009).

Necroviruses are transmitted through soil. ChNV, TNV-A and TNV-D are transmitted by the root-infecting chytrid fungus Olpidium brassicae (Wor.) Dang (Rochon *et al*. 2004) and at least one TNV strain is transmitted by the related chytrid *Olpidium virulentus* (Sasaya and Koganezawa 2006). Virus particles released from roots and other plant matter are acquired in soil water by fungal zoospores and transmitted when the spores infect the roots of a suitable host. TNV particles are stable and relatively long lived. Transmission probably only occurs when there is sufficient soil water for *Olpidium* zoospore activity (Uyemoto 1981; Spence 2001). TNVs cause sporadic disease in some vegetable crops, strawberry, tulip and soybean. TNVs have been detected in apple causing symptomless systemic infections (Uyemoto and Gilmer, 1972). The necrovirus species involved in these infections of apple were not identified. Although TNVs have been reported in Queensland and Victoria (Findlay and Teakle 1969; Teakle 1988), it is not known if the species or strains that infect apple are present in Australia. TNV was thought to be ubiquitous and have a world-wide distribution (Uyemoto 1981; Brunt and Teakle 1996), but this status has not been reviewed since the taxonomic revision of the viruses. A satellite virus replicates with some strains of TNV.

A pathway is considered where the particles of foreign TNV species or strains are released from fruit waste, acquired in soil by a vector and transmitted to suitable host plants. TNVs may enter Australia in hyacinth (*Hyacinthus* sp.), lily (*Lilium* sp.) and tulip (*Tulipa* sp.) bulbs imported for planting under current conditions (ICON 2009). It is not known if the species and strains infecting monocots are the same as those infecting

4.30.1 Probability of entry

Probability of importation

The likelihood that tobacco necrosis viruses will arrive in Australia with the importation of the commodity: **MODERATE**.

Supporting information for this assessment is provided below:

- TNVs are widely prevalent in Oregon (APHIS 2007b) and TNVs are probably present in all states of the PNW. TNVs likely to be strains of TNV-A and TNV-D have been detected in the US (Babos and Kassanis, 1963; Grogan and Uyemoto 1967) and TNV-NE was first described in Nebraska (Zhang *et al*. 1993).

- Strains of TNV were found naturally infecting several apple cultivars in the US and Europe (Kegler *et al*. 1969; Uyemoto and Gilmer, 1972). The taxonomy, incidence and distribution of the apple-infecting TNVs in the US are not known. No recent reports of testing of apples for TNV have been found.
- Apple trees are systemically infected and virus particles are present in fruit (Uyemoto and Gilmer 1972).
- Some TNV species and strains may not infect apple systemically and may not be in apple fruit. Detectable systemic infection only occurs with certain combinations of host species and TNV species or strain (Uyemoto 1981; Brunt and Teakle 1996).
- Infected apple trees and their fruit are symptomless (Uyemoto and Gilmer 1972).

The prevalence of TNVs in the USA and the likelihood of symptomless systemic infection of apple, moderated by uncertainty about the incidence and distribution of infections of apple, support a risk rating for importation of 'moderate'.

Probability of distribution

The likelihood that tobacco necrosis viruses will be distributed in Australia in a viable state, and distributed to a susceptible host, as a result of the processing, sale or disposal of the commodity is: **MODERATE.**

Supporting information for this assessment is provided below:

- Imported apple fruit is intended for human consumption. Fruit will be distributed to many localities by wholesale and retail trade and by individual consumers. Apple fruit may be distributed to all states in unrestricted trade.
- Most apple fruit waste will be discarded into managed waste systems and will be disposed of in municipal tips. Consumers will discard small quantities of apple waste in urban, rural and natural localities. Small amounts of apple waste will be discarded in domestic compost.
- Fruit waste may be discarded near host plants.
- TNV particles are present in low concentrations in infected apple fruit and their distribution in apple tissue may be erratic (Uyemoto and Gilmer 1972).
- TNV particles are moderately to highly stable and survive for long periods in plant debris. TNV particles survive in soil containing infected roots for up to 130 days (18.5 weeks) and remain viable *in vitro* at 20°C for one to eight weeks, depending on the strain, and up to several years *in vitro* at -20°C (Smith *et al*. 1969; Kassanis 1970; Gibbs and Harrison 1976; Brunt and Teakle 1996; Nemeth 1986).
- TNV particles tolerate temperatures as high as 95°C (Brunt and Teakle 1996), so the temperatures achieved by composting and soil pasteurization may not eliminate the viruses.
- Virus particles are released from roots and plant debris (CABI 2009).
- TNVs are transmitted by the zoospores of the chytrid fungi *Olpidium brassicae* and *Olpidium virulentus* (Rochon *et al*. 2004; Sasaya and Koganezawa 2006). The chytrids probably occur throughout Australia. *Olpidium brassicae* has been recorded in New South Wales and Western Australia (APPD 2009). *Olpidium virulentus* has been recorded in Western Australia (Maccarone *et al.* 2008).
- *Olpidium brassicae* is an efficient vector of TNV-D and can acquire particles from very dilute solutions and transmit the virus to susceptible hosts in short time periods (Kassanis

and MacFarlane 1964). If infected fruit waste is discarded in areas where *Olpidium* zoospores are active, then zoospores may acquire particles and transmit the virus.

- Species of *Olpidium* form resting spores through sexual reproduction (Spence 2001; Herrera-Vesquez *et al*. 2009). Resting spores resist dessication, are long lived and may be distributed in dust, soil and roots. They germinate to produce zoospores
- Zoospores need water to germinate and move and they are only active when there is sufficient soil moisture (Spence 2001). During drought and dry weather, zoospores are unlikely to be active in some areas because of dry conditions.
- Only certain *Olpidium brassicae* biotypes will transmit particular TNV strains (Uyemoto 1981). Some isolates of *Olpidium brassicae* will parasitize a wide range of host plants whereas others are more specific (Campbell 1996).
- TNV strains typically have wide experimental host ranges (Uyemoto 1981). TNVs have been found collectively to naturally infect apple (*Malus pumila*), apricot (*Prunus armeniaca*), adzuki bean (*Vigna angularis*), beetroot (*Beta vulgaris*), cabbage (*Brassica oleracea*), carrot (*Daucus carota*), citrus (*Citrus* spp.), common bean (*Phaseolus vulgaris*), crab apple (*Malus sylvestris*), cucumber (*Cucumis sativus*), European pear (*Pyrus communis*), grapevine (*Vitis vinifera*), hyacinth (*Hyacinthus* sp.), lettuce (*Lactuca sativa*), lily (*Lilium* sp.) olive (*Olea europaea*), passionfruit (*Passiflora edulis*), pea (*Pisum sativum)*, plum (*Prunus domestica*), potato (*Solanum tuberosum*), sour cherry (*Prunus cerasus*), soybean (*Glycine max*), strawberry (*Fragaria* × a*nanassa*), tomato (*Solanum esculentum*) tulip (*Tulipa gesneriana*) and zucchini (*Cucurbita pepo*) (Kassanis 1970; Brunt and Teakle 1996; Pham *et al*. 2007a, b; CABI 2009; Zitikaite and Staniulis 2009). Commercial crops of some of these plants are grown in every Australian state and territory and others are grown commercially in several states (HAL 2004; SAI 2009). Many of the plants are grown in domestic gardens and tulip is grown as an ornamental in Tas., Vic. and parts of NSW.
- TNVs are also found in some wild plants, weeds and forest trees including birch (*Betula* spp.), European ash (*Fraxinus excelsior*), European beech (*Fagus sylvatica*), Norway spruce (*Picea abies*), pedunculate oak (*Quercus robur*), poplar (*Populus* spp.) and potato weed (*Galinsoga parviflora*) (Hibben *et al*. 1979; Teakle 1988; Nienhaus and Castello 1989; Bos, 1999)
- It is unlikely that the TNV strains that infect apple will also infect all of the species recorded as hosts of TNVs collectively. The host ranges of many strains and the newly recognised species are largely unknown. The TNVs were considered to be a single species when most host range studies were done (Brunt and Teakle 1996).

The presence of efficient vectors in Australia, moderated by the low concentration of TNV particles in apple fruit flesh and the chance that infected fruit waste will be discarded near a plant host while vector chytrids are active, support a risk rating for distribution of ‘moderate’.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that tobacco necrosis viruses will enter Australia and be transferred in a viable state to a susceptible host, as a result of trade in the commodity is: **LOW**.

4.30.2 Probability of establishment

The likelihood that tobacco necrosis viruses will establish based on a comparison of factors in the source and destination areas considered pertinent to its survival and reproduction: **HIGH**.

Supporting information for this assessment is provided below:

- The presence of TNVs in many countries (CABI 2009) suggests these viruses can become established in places with widely differing conditions.
- TNV-NE and its close relative TNV-Toyama were isolated in Nebraska and Japan (Zhang *et al*. 1993; Saeki *et al*. 2001) and a closely related TNV has been detected in Europe (Zitikaite and Staniulis 2009).
- Viruses likely to be strains of TNV-A and TNV-D have been recorded in Victoria and in three sites in Queensland (Findlay and Teakle 1969; Teakle 1988). TNV incidence in Queensland varies from year to year depending on rainfall (Teakle 1988). Conditions exist in Australia that will suit other necrovirus species and strains.
- In the United Kingdom, TNVs produce greater levels of disease in glasshouse grown plants in winter than in summer (Bawden 1956). The infectivity of TNVs present in the United Kingdom, as measured by mechanical inoculation of leaves, is reduced when plants are exposed to higher light intensities (Bawden 1956).
- Commercial crop, ornamental plant and fruit tree hosts of TNVs are common throughout Australia.
- In general, plants that are growing vigorously are more likely to be infected by viruses (Bawden 1956; Gibbs and Harrison 1976). In Australia, potential hosts of TNVs will be growing during most of the year depending on temperature and rainfall.
- *Olpidium brassicae* and *Olpidium virulentus*, the vectors of TNVs, probably occur throughout Australia. Evidence of the widespread nature of *Olpidium virulentus* comes from knowledge of lettuce big-vein disease that occurs throughout Australia and is caused by *Mirafiori Lettuce Big-Vein Virus* (MLBVV) which is transmitted by *Olpidium virulentus* (McDougall 2006; Maccarone *et al.* 2008).
- *Olpidium* zoospores acquire TNV particles within a few minutes of mixing *in vitro* in solution (Kassanis and MacFarlane 1964; Gibbs and Harrison 1976). Zoospores can drift and swim in films of soil water to a root surface, where they form a cyst and then penetrate the root epidermal cells and infect the plant (Gibbs and Harrison 1976).
- Transmission only occurs when there is sufficient soil water for *Olpidium* activity (Uyemoto 1981; Spence 2001). Drought and long dry spells may limit the opportunity for TNVs to establish by limiting zoospore activity, whereas high rainfall may favour TNVs as it favours zoospore activity.
- When infected by TNVs many plant species appear symptomless (Uyemoto 1981). Many hosts of TNVs appear not to be systemically infected (Bawden 1956). TNV infections may not be detected.

The distribution of hosts and the presence of two TNV strains in Australia support an establishment risk rating of ‘high’.

4.30.3 Probability of spread

The likelihood that tobacco necrosis viruses will spread based on a comparison of those factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pest: **HIGH**.

Supporting information for this assessment is provided below:

- TNVs are transmitted by the zoospores of *Olpidium brassicae* and *Olpidium virulentus*. These chytrids probably occur throughout Australia. (Rochon *et al*. 2004; McDougall 2006; Sasaya and Koganezawa 2006; Maccarone *et al.* 2008; APPD 2009).
- The viruses are transmitted to the roots of susceptible plants and to leaves that are touching the ground (Bawden 1956; Uyemoto 1981).
- Climatic conditions that favour plant growth may increase the chance of a TNV spreading in Australia. Rainfall will favour zoospore activity, as may cool conditions because of reduced evaporation.
- No measurements of the rate at which TNV spreads through fields have been found.
- In moist soil and without physical assistance, zoospores only move very short distances (10-20 mm) (Dixon 2009). Rain splash will disperse the fungus. Sporagia and zoospores will be dispersed in runoff water, irrigation channels and waterways.
- It is not known how long *Olpidium* zoospores remain infective, but the zoospores may only live for a few days (Gibbs and Harrison 1976; Spence 2001).
- TNVs spread through soil with the movement of soil water (Smith *et al*. 1988) and can be found in waterways (Tomlinson *et al*. 1983). Drainage water from contaminated soil contains infectious TNV particles as does runoff. However, a report of TNV spreading from waterways has not been found.
- TNVs are spread in a glasshouse if an irrigation source is contaminated with the virus (Bawden 1956; Harrison 1960) or viruliferous zoospores.
- *Olive latent virus 1*, another necrovirus, is probably transmitted through soil water without the aid of a vector (Lommel *et al*. 2005) and it is possible some TNVs may be transmitted in this way.
- TNV particles are probably spread in dust by wind (Harrison 1960), although drying prevents transmission. They are probably also spread by splashing.
- Root-infecting viruses are spread to new sites by movement of soil, root fragments and drainage water and by transplanting infected plants (Harrison 1977). Soil-borne viruses may be spread to new localities by the transfer of soil on agricultural implements and possible also on the boots of farm workers (Harrison 1960).

The presence of chytrid vectors in Australia and the likely spread of TNVs in soil and water supports a spread risk rating of ‘high’.

4.30.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of ‘rules’ for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that tobacco necrosis viruses will be imported as a result of trade in the commodity from the country of origin, be distributed in a viable state to susceptible hosts, establish and subsequently spread within Australia is: **LOW**.

4.30.5 Consequences

The consequences of the establishment of tobacco necrosis viruses in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision rules described in Table 2.4 on page 12, that is, where the consequences of a pest with respect to one or more criteria are '**C**', the overall consequences are estimated to be **VERY LOW**.

Reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**C – Minor significance at the district level:** Among the hosts in which TNVs cause disease, carrot, potato and strawberry are the most economically important in Australia, with the estimated value in 2002 of the carrot crop being $198.5 million, the potato crop being $485.4 million and the strawberry crop being $107.72 million (HAL 2004). The sporadic diseases caused by TNVs are economically important in some vegetable and ornamental crops in some years (Kassanis 1970; Uyemoto 1981; Nemeth 1986; Smith *et al*. 1988; Zitikaite and Staniulis 2009). No reports of adverse effects on fruit trees have been found (Nemeth 1986). A deterioration disease in trembling aspen (*Populus tremuloides*) may be caused by TNVs (Hibben *et al*. 1979) TNVs cause rusty root disease of carrot, Augusta disease of tulip, stipple streak disease of common bean, necrosis diseases of cabbage, cucumber, soybean and zucchini and ABC disease of potato (Uyemoto 1981; Smith *et al.* 1988; Zitikaite and Staniulis 2009). Losses as high as 50% have been recorded in tulips and glasshouse grown cucumbers (CABI 2009). No estimates of losses in carrot, potato and strawberry have been found. Symptomless viral infections of plants, in general, may cause no yield loss, but they may cause yield losses as high as 15% (Gibbs and Harrison 1976; Bos 1999). Naturally infected vegetable crops show a range of symptoms including spots, flecks, streaks, necrosis and stunting. In strawberry in the Czech Republic, TNV has caused dwarfing and leaf and root necrosis (Martin and Tzanetakis 2006). Stipple streak disease has been reported in Queensland causing small yield losses (Teakle 1988), but no reports of TNVs causing other diseases in Australia have been found, suggesting the combinations of virus strain, vector biotype and host plant cultivar that result in disease have not occurred in Australia. Strains have been distinguished by various characteristics including the symptoms they cause, their host ranges and genetic sequences (Kassanis 1970). The diseases recorded in common bean and cucumber are probably caused by distinct TNV strains (Brunt and Teakle 1996; Zitikaite and Staniulis 2009). The TNV strains detected in apple caused lesions in tests with cowpea (*Vigna sinensis*) and *Chenopodium quinoa* (Uyemoto and Gilmer 1972), but no report of further investigation of their disease causing potential was found. A satellite virus replicates with some strains of TNV (Kassanis, 1970; Uyemoto 1981) but no report has been found indicating greater disease when the satellite virus is present. Given the wide host range of TNVs and their chytrid vectors it is likely that some native plants will be susceptible, although no supporting evidence was found.
Other aspects of the environment	**A - Indiscernible at the local level:** No report was found that indicated an effect.
Indirect	
Eradication, control etc.	**C - Significant at the local level:** Virus control measures in fields are limited and eradication may not be possible unless an outbreak is detected at an early stage. Resistant cultivars may be planted, if they are available, and crop rotations may be altered to reduce incidence (CABI 2009). Establishment and spread in a glasshouse may be controlled by reducing or eliminating *Olpidium* infestation of soil by chemical treatment or by heating by composting or soil pasteurization (Asjes and Blom-Barnhoorn 2002; CABI 2009). This may add significantly to costs. TNVs tolerate temperatures as high as 95°C (Brunt and Teakle 1996), so the temperatures achieved by composting and pasteurization may not eliminate the viruses. Propagation of virus free plants and careful sanitation may reduce the chance of outbreaks (Smith *et al*. 1988; CABI 2009).
Domestic trade	**C – Minor significance at the district level;** Australian states are unlikely to set up restrictions on interstate trade if a foreign TNV becomes established unless it causes significant disease, which is unlikely.
International trade	**C – Minor significance at the district level:** If a damaging foreign TNV became established in Australia additional restrictions might be introduced on the international trade of some vegetables or ornamentals that might lead to the loss of markets and some industry adjustment.
Environmental and non-commercial	**A - Indiscernible at the local level:** No report was found that could indicate an effect.

4.30.6 Unrestricted risk estimate

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 12.

Unrestricted risk estimate for tobacco necrosis viruses	
Overall probability of entry, establishment and spread	Low
Consequences	Very low
Unrestricted risk	Negligible

As indicated, the unrestricted risk estimate for tobacco necrosis viruses has been assessed as ‘negligible’, which achieves Australia’s ALOP. Therefore, no specific risk management measures are required for these viruses.

4.31 Apple scar skin or dapple apple

Apple scar skin viroid

Apple scar skin or dapple apple is a disease caused by *Apple scar skin viroid* (ASSVd), which is also known as *Dapple apple viroid* or *Pear rusty skin viroid*. The disease defaces the fruit which may remain small and hard, and develop an unpleasant flavour. The severity of the disease depends on the cultivar and the duration of infection. In severe cases in susceptible cultivars, the fruit is affected by scarring, necrosis and cracking. Some apple cultivars may develop leaf roll or leaf epinasty symptoms (Koganezawa *et al.* 2003).

Apple scar skin viroid is a small circular nucleic acid molecule. It infects apple, pear and apricot (Koganezawa *et al*. 2003; Zhao and Niu 2008) and spreads systemically through trees. Latent symptomless infection of pear by ASSVd is common in China, and pear trees are considered to be a source of inoculum for apple trees (Koganezawa *et al.* 2003; Kyriakopoulou *et al.* 2003). The viroid is persistent and may have a long incubation (latency) period. Pear and apple trees may be infected for several years before showing the symptoms of the disease. The symptoms keep on increasing every year after onset in susceptible cultivars (Desvignes *et al.* 1999).

Apple scar skin viroid has been found in apple fruit, seed (Kim *et al.* 2006), anthers, petals, receptacles, leaves, bark and roots (Hadidi *et al.* 1991). *Apple scar skin viroid* is spread by grafting and budding, infected rootstocks and contaminated equipment and tools (Hadidi *et al.* 1991; Grove *et al.* 2003). It is also transmitted naturally between trees by an unknown mechanism (Kyriakopoulou and Hadidi 1998; Koganezawa *et al.* 2003). Transmission by root to root contact has been proposed and may involve natural root grafting (Desvignes *et al.* 1999).

The possibility of the importation and establishment of ASSVd was considered in the final extension of policy for the importation of pears from the People's Republic of China (Biosecurity Australia 2005a) and the potential for establishment and spread from the fruit pathway was assessed as not feasible because seed transmission had not been reported at the time. However, seed transmission was recently shown to occur (Kim *et al.* 2006). The new findings indicate that the viroid can be transmitted through seeds of fruit from infected trees.

The risk posed by ASSVd is that asymptomatic infected fruit containing infected seeds may be exported and result in the establishment of this virus in Australia.

The assessment of the ASSVd presented here builds on the existing pest risk analysis and takes into account information on seed transmission.

4.31.1 Probability of entry

Probability of importation

The likelihood that *Apple scar skin viroid* will arrive in Australia with the importation of the commodity: **MODERATE**.

Supporting information for this assessment is provided below:

- *Apple scar skin viroid* is present in Washington State (Hadidi *et al*. 1991; CABI 2007). According to Agrios (1989), the disease caused by ASSVd is relatively rare in the US.

- *Apple scar skin viroid* spreads systemically through apple trees and is present in fruit and seed from infected trees (Hadidi *et al*. 1991).
- Almost all fruit on an infected tree of a susceptible cultivar will show symptoms and is unmarketable (Koganezawa *et al*. 2003). Infected fruit from susceptible cultivars is likely to be rejected during harvesting, grading and packing processes.
- Infected tolerant cultivars may produce asymptomatic fruit. However, slightly sensitive cultivars produce both asymptomatic and symptomatic fruit with dappled skin (Desvignes *et al*. 1999; Di Serio *et al*. 2001). Golden Delicious, Granny Smith, Pink Lady, Fuji and Gala, the commonly grown cultivars in the PNW, are tolerant or slightly sensitive to the viroid (Desvignes *et al*. 1999; Di Serio *et al*. 2001).
- Trees may not express symptoms for some years after infection by the viroid (Desvignes *et al*. 1999; Kwon *et al*. 2002) and continue to produce asymptomatic fruit.
- Symptomless fruit infected with the viroid would not be removed in the grading process and could be exported to Australia.

The potential for asymptomatic fruit from recently infected trees or from tolerant or slightly sensitive cultivars to carry the viroid and the unknown status of the viroid in tolerant apple cultivars, support a risk rating for importation of ‘moderate’.

Probability of distribution

The likelihood that *Apple scar skin viroid* will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **HIGH**.

Supporting information for this assessment is provided below:

- Imported apple fruit is intended for human consumption in Australia. It is expected that once the apple fruit has arrived in Australia, it will be distributed throughout Australia for wholesale or retail sale.
- Individual consumers will carry small quantities of apples to urban, rural and natural locations.
- Apple cores are not usually consumed and are discarded with the seed.
- Some of the apple waste containing seed will be sent to municipal tips and some of it will be disposed of in contained compost.
- A relatively small proportion of apple cores will not be disposed of through a managed waste process but will instead be discarded into the environment in urban, rural and natural locations.
- A small number of apple cores with viable infected seed may be discarded into the environment in apple growing regions.
- Imported apple fruit might be consumed by orchard workers.

The distribution of imported apple fruit throughout Australia, the disposal of fruit waste containing seed into the environment and the possibility of seed transmission of the viroid support a risk rating for distribution of ‘high’.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that *Apple scar skin viroid* will enter Australia as a result of trade in the commodity and be trasnsferred in a viable state to a suitable host: **MODERATE**.

4.31.2 Probability of establishment

The likelihood that *Apple scar skin viroid* will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **MODERATE**.

Supporting information for this assessment is provided below:

- No seed transmission of ASSVd was detected in experiments in the 1990s (Desvignes *et al.* 1999; Howell *et al.* 1995).
- It was recently reported that 7.7% of apple seedlings germinated from ASSVd-positive fruit were infected (Kim *et al.* 2006), indicating that seed transmission occurs under some conditions.
- *Apple scar skin viroid* nucleic acids have been detected in the cotyledons and embryos of seed from infected plants (Kim *et al.* 2006), supporting the finding of seed-transmission.
- Within the climatic conditions that allow cultivation of pome fruit, *apple scar skin viroid* does not appear to be limited by climate. It occurs in apples and pears in Asia, Europe and North America, although the level of infection varies widely (Koganezawa *et al.* 2003; Kyriakopoulou *et al.* 2003).
- Volunteer apple trees are commonly observed along roadsides in southern Australia, presumably arising from seed in discarded apple cores.
- Some volunteer apple trees will grow from seed from imported apples.
- Apple seeds normally germinate only after moist winter chilling. Apple trees are unlikely to grow from discarded seeds in many areas of northern Australia where minimum winter temperatures usually exceed 5°C (Bureau of Meteorology 2009).
- Apple trees are unlikely to grow from seed in municipal waste as such waste is covered.
- Some cores with seed from imported apples will be discarded in environments in southern Australia where apple trees can grow. These environments will include poorly managed compost heaps and uncontained areas such as roadsides, including roadsides in apple growing regions.
- Orchard workers might contaminate orchard equipment if they consume imported fruit while working, although this is unlikely.

The possibility of seed transmission of ASSVd, moderated by the small number of apple trees that will grow from seed in discarded imported fruit or fruit residues support a risk rating for establishment of ‘moderate’.

4.31.3 Probability of spread

The likelihood that Apple scar skin viroid will spread based on a comparison of factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the virus: **LOW**.

Supporting information for this assessment is provided below:

- *Apple scar skin viroid* infects most *Malus* and *Pyrus* species and cultivars (Kyriakopoulou and Hadidi 1998; Koganezawa *et al*. 2003; Kyriakopoulou *et al.* 2003). Natural infections of ASSVd are found in apple, pear, apricot, peach and sweet cherry. Experimentally, ASSVd also infects the species of *Chaenomeles*, *Cydonia*, *Pyronia* and *Sorbus* (Koganezawa *et al.* 2003). These host plants are grown in Australia.
- Although volunteer apple trees from seed from imported apples will establish in Australia where host plants are grown, few of the volunteer trees are likely to be infected with ASSVd.
- *Apple scar skin viroid* has no known natural vectors, but knowledge of transmission is incomplete (Cohen *et al*. 2005; Koganezawa *et al*. 2003).
- *Apple scar skin viroid* is transmitted by grafting and budding, infected rootstocks and on contaminated equipment and tools (Hadidi *et al.* 1991; Grove *et al.* 2003).
- Fruit growers will not use volunteer plants for grafting or budding, nor are they likely to use orchard equipment on volunteer plants.
- *Apple scar skin viroid* is naturally transmitted between neighbouring trees by an unknown mechanism (Desvignes *et al.* 1999; Koganezawa *et al*. 2003). Transmission by root to root contact has been proposed and may involve natural root grafting. This natural transmission is slow and takes several years.
- *Apple scar skin viroid* has been found in wild pear in isolated areas, suggesting natural transmission by some unknown means (Kyriakopoulou and Hadidi 1998; Kyriakopoulou *et al*. 2003). Some other viroids are transmitted by aphids or by pollen (Singh *et al*. 2003), but no evidence has been reported of ASSVd transmission by aphids or pollen. Mechanical transmission of some viroids by grazing animals has also been suggested based on experiments in Greece where orchards are commonly grazed (Cohen *et al*. 2005). In Australia, commercial orchards are rarely grazed.
- Seed transmission of ASSVd may occur under some circumstances (Desvignes *et al.* 1999; Howell *et al*. 1995; Kim *et al*. 2006).
- If trees in commercial orchards become infected, some fruit with infected seed may be distributed and give rise to new infected volunteer apple trees.
- *Apple scar skin viroid* can be controlled by removing infected trees from orchards, avoiding spread to neighbouring trees, and by propagating nursery stock from ASSVd-indexed mother trees (Koganezawa *et al.* 2003). *Apple scar skin viroid* is eliminated from most infected apple plants when plants are subjected to a dormant stage followed by thermotherapy (Koganezawa *et al*. 2003).

The small number of infected volunteer apple trees likely to grow in fruit growing regions, the very limited opportunity for transmission from volunteer trees to cultivated host plants and its slow natural transmission support a risk rating for spread of ‘low’.

4.31.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *Apple scar skin viroid* will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **VERY LOW**.

4.31.5 Consequences

The consequences of the establishment of *Apple scar skin viroid* in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision rules described in Table 2.4 on page 12, that is, where the consequences of a pest with respect to one or more criteria are '**E**', the overall consequences are estimated to be **MODERATE**.

Reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**E – Major significance at the district level:** ASSVd infects a wide range of apple and pear cultivars as well as cultivars of apricot, peach and sweet cherry (Kaponi *et al.* 2009; Koganezawa *et al.* 2003; Kyriakopoulou and Hadidi 1998; Kyriakopoulou *et al.* 2003; Zhao and Niu 2007). The viroid causes a range of symptoms in apple depending on the cultivar (Desvignes *et al.* 1999). It causes pear rusty skin disease, although it is often symptomless in pear (Kyriakopoulou *et al.* 2003). No report of symptoms in other natural hosts has been found. There may be no marketable yield from infected susceptible apple and pear cultivars (i.e. 100% loss) as all the fruit may be blemished (Koganezawa *et al.* 2003; Kyriakopoulou *et al.* 2003). Yield may be reduced by 10-20% in symptomless apple cultivars (Lemoine and Cathala 2006). ASSVd caused one of the most damaging apple diseases in China and Japan in the 1950s to 1960s and 1970s, respectively (Han *et al.* 2003). In some counties in China more than 50% of apple trees were affected in the 1950s to 1960s (Koganezawa *et al.* 2003). By contrast, the viroid was relatively rare in North America and Europe over the same period. ASSVd is transmitted by horticultural activity including grafting and budding and the use of contaminated equipment (Grove *et al.* 2003; Hadidi *et al.* 1991). Natural transmission is slow (Desvignes *et al.* 1999; Koganezawa *et al.* 2003). The spread of ASSVd between trees in orchards is considered to be likely but slow and limited in range. In Australia, pathogen tested scion material and clonal root stocks are used to establish most orchards, which would limit the potential for ASSVd to cause production losses. In addition, some of the apple cultivars grown in Australia, such as Golden Delicious, Granny Smith and Pink Lady are tolerant to the viroid (Desvignes *et al.* 1999).
Other aspects of the environment	**A - Indiscernible at the local level:** There are no known direct consequences of this viroid on other aspects of the environment.
Indirect	
Eradication, control etc.	**D - Significant at the district level:** The major local control measures for the viroid are to remove the infected trees from orchards and to propagate nursery stock from ASSVd-indexed mother trees. ASSVd is eliminated from most infected apple plants when plants are subjected to a dormant stage followed by thermotherapy (Koganezawa *et al.* 2003).
Domestic trade	**D - Significant at the district level;** The presence of ASSVd in commercial pome and stone fruit orchards could result in the implementation of interstate quarantine measures, causing loss of markets and subsequent significant industry adjustment at the district level.
International trade	**D - Significant at the district level:** The presence of ASSVd in apple production areas of Australia could have impacts on the export of Australia's fresh fruit and planting material of apples, pears, apricot, peach and sweet cherry to countries where this pathogen is not present.
Environmental and non-commercial	**A - Indiscernible at the local level:** Control activities for ASSVd on susceptible crops are not considered to impact on the environment.

4.31.6 Unrestricted risk estimate

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 12.

Unrestricted risk estimate for *Apple scar skin viroid* (ASSVd)	
Overall probability of entry, establishment and spread	Very low
Consequences	Moderate
Unrestricted risk	Very low

As indicated, the unrestricted risk estimate for *Apple scar skin viroid* has been assessed as 'very low', which achieves Australia's ALOP. Therefore, no specific risk management measures are required for this pest.

Assessments for quarantine pests not recorded in the PNW

4.32 Blister spot

Pseudomonas syringae pv. *papulans*

Pseudomonas syringae pv. *papulans* has not been recorded from the PNW. However, as there is no evidence of official control measures in place to prevent its spread into the PNW, the pest is considered in this IRA.

Blister spot is a bacterial disease of apple caused by *Pseudomonas syringae* pv. *papulans* (Burr 1990). It is of economic concern on the cultivar Mutsu (also known as cultivar Crispin), but is occasionally found on other cultivars, especially when grown near infected Mutsu trees (Burr 1990; Celetti 2005). Infection with *P. syringae* pv. *papulans* also occurs on the varieties Golden Delicious and Jonagold, but these infections are much less severe than on Mutsu and do not cause a serious economic problem (Burr 1982). In British Columbia, Canada, the cultivars Jonagold and Fuji that were planted close to Mutsu trees showed symptoms of blister spot. Fuji apples were almost as susceptible to blister spot as Mutsu apples (Sholberg and Bedford 1997). Smith (1944) reported natural infection with *Pseudomonas syringae* pv. *papulans* on 35 apple cultivars, many of which are no longer in commercial production. Artificial inoculation of seven apple cultivars with high inoculum levels of the bacterium resulted in fruit lesions, but lesions were fewer and smaller than on Mutsu (Burr and Hurwitz 1981). These studies indicate that, if pathogen populations are high, blister spot might develop on several apple varieties, especially if they are planted near Mutsu (Burr 1982).

Pseudomonas syringae pv. *papulans* is a gram-negative, oxidase-negative, aerobic, motile, rod-shaped bacterium (Burr 1990). Fruit infections first appear as small raised green blisters, associated with stomata, which develop from early to mid July (approximately six weeks after the calyx stage of fruit development). These blisters continue to expand during the growing season and near harvest they range from 1–5 mm in diameter and are purplish black. More than 100 lesions may develop on a single fruit. The lesions rarely extend more than 1–2 mm into the flesh, but they render the fruit unsuitable for fresh market use (Bedford *et al.* 1988; Burr 1982, 1990; Burr and Hurwitz 1979).

The bacterium also causes midvein necrosis of leaves. Affected leaves are curled, puckered and misshapen, and may show white to necrotic spots (Burr 1990). Earlier reports indicate that *P. syringae* pv. *papulans* also causes cankers on the woody parts of infected trees (Bradbury 1986), but this has not been substantiated (Burr 1990).

Pseudomonas syringae pv. *papulans* overwinters in apple buds (Burr and Katz 1984), leaf scars and diseased fruit on the orchard floor (Burr 1990). Throughout the growing season, the bacterium can survive as an epiphyte on leaves and fruit, and on weeds in the orchard (Burr 1990). The bacterium was consistently isolated from Mutsu leaf and fruit surfaces from before bloom until harvest (Bedford *et al.* 1988).

The bacterium can spread to susceptible fruit by insects and rain (Burr 1982). Mutsu fruit show increased susceptibility to infection by *P. syringae* pv. *papulans* beginning about two weeks after petal fall and susceptibility lasts for about six weeks (Burr and Hurwitz 1981; Burr 1990). Infection of fruit is first noticeable 2–3 months after petal fall (Burr 1990). Mutsu fruit that were inoculated with a bacterial suspension in the orchard developed blister spot lesions in 8–10 days (Burr and Hurwitz 1979). The disease seems to be favoured by wet weather (Burr 1990).

Streptomycin sprays were effective for controlling *P. syringae* pv. *papulans* until 1985, when strains resistant to streptomycin were isolated from orchards in New York State and later also from orchards in Michigan (Burr *et al*. 1988; Jones *et al.* 1991). Streptomycin is still used successfully in some orchards (Burr 1990). Copper sprays are also used for control of blister spot (Burr 1990; Celetti 2005).

Pseudomonas syringae pv. *papulans* has not been recorded in Australia (APPD 2009).

The risk posed by *Pseudomonas syringae* pv. *papulans* is that symptomless infected fruit may be exported and result in the establishment of this pathogen in Australia.

Probability of entry

Probability of importation

The likelihood that *Pseudomonas syringae* pv. *papulans* will arrive in Australia with the importation of the commodity: **EXTREMELY LOW**.

Supporting information for this assessment is provided below:

- *Pseudomonas syringae* pv. *papulans* has been reported in the US (Burr 1990).
- *Pseudomonas syringae* pv. *papulans* is an economic problem of the apple cultivar Mutsu in the areas extending from Michigan through southern Ontario, Canada, to New York (Dhanvantari 1969; Jones *et al.* 1991). Its presence has also been confirmed in British Columbia, Canada (Sholberg and Bedford 1997). However, it is not known to be present in the PNW.
- The apple cultivar Mutsu is grown in Washington and Oregon (USDA/NASS 2006a, b).
- *Pseudomonas syringae* pv. *papulans* is widespread in Mutsu orchards. If the pathogen is uncontrolled, it usually infects 5–60% of the fruit in an orchard (Burr 1982).
- Infection with *P. syringae* pv. *papulans* is also found on other cultivars, especially when grown near infected Mutsu trees (Burr 1990; Celetti 2005). It occurs on the varieties Golden Delicious and Jonagold, but these infections are much less severe than on Mutsu and do not cause a serious economic problem (Burr 1982). In British Columbia, Canada, the cultivars Jonagold and Fuji that were planted close to Mutsu trees showed symptoms of blister spot. Fuji apples were almost as susceptible to blister spot as Mutsu apples (Sholberg and Bedford 1997). Studies indicate that, if pathogen populations are high, blister spot might develop on several apple varieties, especially if they are planted near Mutsu (Burr 1982).
- The bacterium infects fruit during a six week period beginning about two weeks after petal fall (Burr and Hurwitz 1981; Burr 1990). Infection of fruit is first noticeable 2–3 months after petal fall (Burr 1990). Throughout the growing season, the bacterium can survive as an epiphyte on the fruit (Bedford *et al.* 1988; Burr 1990).
- Fruit exhibiting visual symptoms of blister spot would be rejected during harvesting and routine grading and sorting operations. However, symptomless infected fruit and fruit with

small lesions, which are likely to occur on less susceptible cultivars, may not be detected during these processes.

- The bacterium can be isolated and cultivated from apple fruit, showing blister spots, that were stored at 1ºC (Sholberg and Bedford 1997), indicating that it can survive in cold storage.

The ability of the bacterium to survive epiphytically on apple fruit moderated by the limited distribution of this bacterium in the US and the lack of record of its presence in the PNW, support a risk rating for importation of 'extremely low'.

If *P. syringae* pv. *papulans* were to be detected in the PNW, the risk rating for importation of this pest would have to be re-assessed.

Probability of distribution

The likelihood that *Pseudomonas syringae* pv. *papulans* will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **HIGH**.

Supporting information for this assessment is provided below:

- Imported apple fruit is intended for human consumption in Australia. It is expected that once the apple fruit has arrived in Australia, it will be distributed throughout Australia for wholesale or retail sale. Any infected fruit present may be distributed during these procedures.
- Infected fruit disposed near suitable hosts may provide inoculum for distribution of the pathogen. Individual consumers will distribute small quantities of apples to a variety of urban, rural and wild environments, where they will be consumed, or disposed of, in close proximity to a suitable host plant.
- The pathogen overwinters in apple buds, leaf scars and diseased fruit on the orchard floor. Throughout the growing season, *P. syringae* pv. *papulans* can survive as an epiphyte on leaves and fruit. It also survives on some orchard weeds including *Agropyron repens* L. (quackgrass), *Euphorbia escula* L. (leafy spurge), *Malva neglecta* L. (common mallow), *Taraxacum officinale* Weber (dandelion) and *Trifolium* sp. (clover) (Burr 1982, 1990; Bedford *et al.* 1988).
- The bacterium can spread to susceptible fruit by insects and rain (Burr 1982). It infects the fruit through stomata (Celetti 2005).
- In North America, *P. syringae* pv. *papulans* is present in British Columbia, Canada, and in the area extending from Michigan through southern Ontario, Canada, to New York (Dhanvantari 1969; Jones *et al*. 1991; Sholberg and Bedford 1997). It is also found in England, Germany and Italy (Bradbury 1986; Burr 1990; Moltmann 2002). The survival of this pathogen in these temperate climates suggests that temperate regions of Australia, where suitable hosts may occur, are likely to be suitable for the survival of this pathogen.

The potential distribution of infected fruit throughout Australia, the disposal of fruit waste in the environment and the ability of insects to transfer the bacterium to a host, support a risk rating for distribution of 'high'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that *Pseudomonas syringae* pv. *papulans* will enter Australia as a result of trade in the commodity and be transferred in a viable state to a suitable host: **EXTREMELY LOW**.

Probability of establishment

The likelihood that *Pseudomonas syringae* pv. *papulans* will establish based on a comparison of factors in the source and destination areas considered that affect pest survival and reproduction: **MODERATE**.

Supporting information for this assessment is provided below:

- Suitable hosts are present in Australia. The major hosts of *P. syringae* pv. *papulans* are *Malus pumila* (apple) and *Pyrus communis* (pear) (Bradbury 1986). *Pseudomonas syringae* pv. *papulans* can also survive and multiply on some orchard weeds including *Agropyron repens* L. (quackgrass), *Euphorbia escula* L. (leafy spurge), *Malva neglecta* L. (common mallow), *Taraxacum officinale* Weber (dandelion) and *Trifolium* sp. (clover) (Burr 1982, 1990; Bedford *et al.* 1988).
- Mutsu fruit show increased susceptibility to infection by *P. syringae* pv. *papulans* beginning about two weeks after petal fall and susceptibility lasts for only about six weeks (Burr and Hurwitz 1981; Burr 1990). As a result, fruit would have to become infected during this short period.
- The bacterium can be spread to susceptible fruit by insects and rain (Burr 1982). It infects the fruit through stomata (Celetti 2005).
- The pathogen overwinters in apple buds, leaf scars and diseased fruit on the orchard floor. Throughout the growing season, *P. syringae* pv. *papulans* can survive as an epiphyte on leaves and fruit, and on weeds in the orchard (Burr 1990). These weeds include *Agropyron repens* (quackgrass), *Euphorbia escula* (leafy spurge), *Malva neglecta* (common mallow), *Taraxacum officinale* (dandelion) and *Trifolium* sp. (clover) (Burr 1982, 1990; Bedford *et al.* 1988).
- Under experimental conditions, *P. syringae* pv. *papulans* grows best at temperatures between 25–28ºC. It does not grow at 37ºC (Rose 1917).
- There have been some reports suggesting that for continuous survival and propagation, the bacterium seems to require Mutsu trees (Burr and Hurwitz 1981; Bedford *et al.* 1988; Sholberg and Bedford 1997). However, it is more likely that the bacterium can survive and propagate without Mutsu trees because the bacterium was reported from apples in the US since 1917 (Rose 1917), well before Mutsu apple was developed in Japan in 1930 (CABI 2007).
- The survival of this pathogen in the temperate climates of Canada, England, Germany, Italy and the US (Dhanvantari 1969; Bradbury 1986; Burr 1990; Jones *et al.* 1991; Sholberg and Bedford 1997; Moltmann 2002) suggests that temperate regions of Australia, where suitable hosts may occur, are likely to be suitable for the establishment of this pathogen.

The availability of suitable hosts and climate for the survival of the bacterium, moderated by the short period that fruit are susceptible to infection, support a risk rating for establishment of ‘moderate’.

Probability of spread

The likelihood that *Pseudomonas syringae* pv. *papulans* will spread based on a comparison of those factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pest: **MODERATE**.

Supporting information for this assessment is provided below:

- The bacterium can be spread by insects and water (Burr 1982, 1990).
- Blister spot seems to be favoured by wet weather, as its occurrence on susceptible hosts is relatively low in dry years (Burr 1990).
- The bacterium overwinters in apple buds, leaf scars and diseased fruit on the orchard floor. Throughout the growing season, *P. syringae* pv. *papulans* can survive as an epiphyte on leaves and fruit and on weeds in the orchard (Burr 1990).
- The major hosts of *P. syringae* pv. *papulans* are *Malus pumila* (apple) and *Pyrus communis* (pear) (Bradbury 1986). These hosts are present in Australia in commercial orchard districts, suburban and rural areas. *Pseudomonas syringae* pv. *papulans* can also survive and multiply on some orchard weeds including *Agropyron repens* L. (quackgrass), *Euphorbia escula* L. (leafy spurge), *Malva neglecta* L. (common mallow), *Taraxacum officinale* Weber (dandelion) and *Trifolium* sp. (clover) (Burr 1982, 1990; Bedford *et al.* 1988).
- There have been a few reports suggesting that for continuous survival and propagation, the bacterium seems to require Mutsu trees (Burr and Hurwitz 1981; Bedford *et al.* 1988; Sholberg and Bedford 1997). However, it is more likely that the bacterium can survive and propagate without Mutsu trees since the bacterium was reported from apples in the US since 1917 (Rose 1917), well before Mutsu apple was developed in Japan in 1930 (Campbell 2005).
- Under experimental conditions, *P. syringae* pv. *papulans* grows best at temperatures between 25–28ºC. It does not grow at 37ºC (Rose 1917).
- The survival of this pathogen in the temperate climates of Canada, England, Germany, Italy and the US (Dhanvantari 1969; Bradbury 1986; Burr 1990; Jones *et al*. 1991; Sholberg and Bedford 1997; Moltmann 2002) suggests that temperate regions of Australia, where suitable hosts may occur, are likely to be suitable for the spread of this pathogen.

The dispersal of the bacterium by insects and water, moderated by its limited host range, support a risk rating for spread of ‘moderate’.

Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of ‘rules’ for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *Pseudomonas syringae* pv. *papulans* will enter Australia as a result of trade in the commodity, be distributed in a viable state to a suitable hosts, establish in that area and subsequently and spread within Australia: **EXTREMELY LOW**.

Consequences

The consequences of the establishment of *Pseudomonas syringae* pv. *papulans* in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision rules described in Table 2.4 on page 12, 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**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**C - Significant at the local level:** Blister spot is of economic concern on the cultivar Mutsu, but is occasionally found on other cultivars, especially when grown near infected Mutsu trees (Burr 1990; Celetti 2005). Although the cultivar Mutsu is not one of the major cultivars in Australia (HAL 2004). Apples and pears are the main hosts of *P. syringae* pv. *papulans*. It is unlikely that there would be an effect on native plant species. *Pseudomonas syringae* pv. *papulans* causes purplish black lesions, ranging from 1–5 mm near harvest, on apple fruit. More than 100 lesions may develop on a single fruit. The lesions rarely extend more than 1–2 mm into the flesh (Burr and Hurwitz 1979; Burr 1982, 1990; Bedford *et al.* 1988). The bacterium also causes midvein necrosis of leaves. Affected leaves are curled, puckered and misshapen, and may show white to necrotic spots (Burr 1990). *Pseudomonas syringae* pv. *papulans* does not cause extensive decay of the fruit, but it renders the fruit unsuitable for fresh market use (Burr 1982).
Other aspects of the environment	**A - Indiscernible at the local level:** There are no known direct consequences of this pathogen on other aspects of the environment.
Indirect	
Eradication, control etc.	**C - Significant at the local level:** Blister spot is of economic concern only on the cultivar Mutsu, but is occasionally also found on other commercially important cultivars (Burr 1990; Celetti 2005). Streptomycin sprays have been effective for controlling blister spot until 1985. In 1985, strains resistant to streptomycin have been isolated from orchards in New York State and later also from orchards in Michigan (Burr *et al.* 1988; Jones *et al.* 1991). No alternative antibiotics are available for the control of blister spot (Burr *et al*. 1988). Streptomycin is still used successfully in some orchards (Burr 1990). Copper sprays are also used for control of blister spot (Burr 1990; Celetti 2005). Additionally, costs for crop monitoring and consultant's advice to manage this pest may be incurred by the producer.
Domestic trade	**C - Significant at the local level:** Blister spot is of economic concern on the cultivar Mutsu, but is occasionally also found on other cultivars, especially when grown near infected Mutsu trees (Burr 1990; Celetti 2005). Apple fruit infected with *P. syringae* pv. *papulans* are unsuitable for fresh market use (Burr 1982). If the pathogen is uncontrolled, it usually infects 5–60% of the fruit in a Mutsu orchard (Burr 1982). *Pseudomonas syringae* pv. *papulans* has not been recorded in Australia (APPD 2009). The presence of *P. syringae* pv. *papulans* in commercial production areas would result in the implementation of interstate quarantine measures, causing loss of market and subsequent industry adjustment.
International trade	**D - Significant at the district level:** The presence of *P. syringae* pv. *papulans* in commercial apple production areas would have a significant effect at the district level due to limitations of accessing international markets where this bacterium is absent. *Pseudomonas syringae* pv. *papulans* is currently present in Canada, England, Germany, Italy and the US (Bradbury 1986; Burr 1990; Moltmann 2002), but not in Japan where Mutsu is commercially important (Burr 1990).
Environmental and non-commercial	**B - Minor at the local level:** Additional antibiotics applications or other control activities would be required to control this disease on susceptible crops. Usage of antibiotics may affect the environment and may affect animal and human health.

Unrestricted risk estimate

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 12.

Unrestricted risk estimate for *Pseudomonas syringae* pv. *papulans*	
Overall probability of entry, establishment and spread	Extremely low
Consequences	Low
Unrestricted risk	Negligible

As indicated, the unrestricted risk estimate for *Pseudomonas syringae* pv. *papulans* has been assessed as ‘negligible’, which achieves Australia's ALOP. Therefore, no specific risk management measures are required for this pest.

There is no evidence of official control measures in place to prevent the spread of this pest into the PNW. If this pest is detected in the PNW in the future, it would need to be reported to Australia immediately. The risk associated with the pest would then need to be re-assessed.

4.33 Armoured scales

Lopholeucaspis japonica; *Parlatoria oleae*

Lopholeucaspis japonica (Japanese baton shaped scale) and *Parlatoria oleae* (olive parlatoria scale) are pests on a large range of hosts, including apples, pears and stone fruit (Watson 2005; Miller and Gimpel 2009a, b).

Parlatoria oleae is not present in Western Australia and is a pest of regional quarantine concern for that state. *Lopholeucaspis japonica* was reported from the Northern Territory in the early 20th century (Donaldson and Tsang 2002), but is now considered absent from Australia (CABI/EPPO 1997c). It is a pest of quarantine concern for all Australia.

Risks associated with the other armoured scale species, *Palatoria pergandii*, have been assessed and presented in section 4.8 on pages 73–76. The overall consequences have been estimated as ‘low’.

The biology and taxonomy of *L. japonica* and *P. oleae* are similar to *P. pergandii*, therefore, they are predicted to pose similar risks. However, *L. japonica* and *P. oleae* have not been recorded in the PNW. The lack of records for these pests suggests absence from the PNW. Therefore, the importation risk of *L. japonica* and *P. oleae* is considered to be ‘extremely low’. Accordingly, the overall probability of entry, establishment and spread for these species is ‘extremely low’. Combined with the ‘low’ rating of consequences, the unrestricted risk of these pests is ‘negligible’ which achieves Australia’s ALOP. Therefore, no specific risk management measures are required.

There is no evidence of official control measures in place to prevent the spread of these pests into the PNW. If any of these pests is detected in the PNW in the future, it would need to be reported to Australia immediately. The risk associated with the pest would then need to be re-assessed.

4.34 Mealybugs

Pseudococcus calceolariae; *Pseudococcus comstocki*

Pseudococcus calceolariae (citrophilus mealybug) and *Pseudococcus comstocki* (Comstock's mealybug) are pests on a large range of hosts, including apples and pears (Ben-Dov 2009b, c).

Pseudococcus calceolariae is not present in Western Australia and is a pest of regional quarantine concern for that state. It is a widespread pest throughout the eastern states of Australia, and is a serious pest of citrus in South Australia (Smith *et al*. 1997). *Pseudococcus comstocki* is a pest of quarantine concern for all Australia.

Risks associated with the other two mealybug species, *Phenacoccus aceris* and *Pseudococcus maritimus*, have been assessed and presented in section 4.9 on pages 77–79. The overall consequences have been estimated as 'low'.

The biology and taxonomy of *P. calceolariae* and *P. comstocki* are similar to *P. aceris* and *P. maritimus*, therefore they are predicted to pose similar risks. However, *P. calceolariae* and *P. comstocki* have not been recorded in the PNW. The lack of records for these pests suggests absence from the PNW. Therefore, the importation risk of *P. calceolariae* and *P. comstocki* is considered to be 'extremely low'. Accordingly, the overall probability of entry, establishment and spread for these species is 'extremely low'. Combined with the 'low' rating of consequences, the unrestricted risk of these pests is 'negligible', which achieves Australia's ALOP. Therefore, no specific risk management measures are required.

If these mealybug species were present in the PNW, their unrestricted risk estimate would likely be above ALOP, and specific risk management measures would be required for these pests.

There is no evidence of official control measures in place to prevent the spread of these pests into the PNW. If any of these pests is detected in the PNW in the future, it would need to be reported to Australia immediately. The risk associated with the pest would then need to be re-assessed.

4.35 Leafroller moths

Argyrotaenia velutinana*; *Platynota flavedana*; *Platynota idaeusalis*; *Platynota stultana*; *Pseudexentera mali

Argyrotaenia velutinana (redbanded leafroller), *Platynota flavedana* (variegated leafroller or rusty brown tortricid), *Platynota idaeusalis* (tufted apple budworm) and *Platynota stultana* (omnivorous leafroller) are pests on a wide range of hosts, including apples (Flaherty *et al*. 1992; Hull *et al*. 1995a, b; CABI 2007). *Malus* spp. are major hosts of *Pseudexentera mali* (pale apple leafroller) (Miller 1986).

Risks associated with the other nine leafroller moth species have been assessed and presented in section 4.11 on pages 86–93. The overall consequences have been estimated as ‘moderate’.

The biology and taxonomy of the leafroller moth species assessed here are similar to those species assessed in section 4.11, therefore, they are predicted to pose similar risks. However, the leafroller moth species assessed here have not been recorded in the PNW. The lack of records for these pests suggests absence from the PNW. Therefore, the importation risk of these pests is considered to be ‘extremely low’. Accordingly, the overall probability of entry, establishment and spread for these species is ‘extremely low’. Combined with the ‘moderate’ rating of consequences, the unrestricted risk of these pests is ‘negligible’ which achieves Australia’s ALOP. Therefore, no specific risk management measures are required.

If these leafroller moth species were present in the PNW, their unrestricted risk estimate would likely be above ALOP, and specific risk management measures would be required for these pests.

There is no evidence of official control measures in place to prevent the spread of these pests into the PNW. If any of these pests is detected in the PNW in the future, it would need to be reported to Australia immediately. The risk associated with the pest would then need to be re-assessed.

4.36 European corn borer

Ostrinia nubilalis

Ostrinia nubilalis is recognised as a minor pest of apple that has not been recorded from the three exporting states under consideration. However, as there is no evidence of official control measures in place to prevent its spread from the east it is considered in this IRA.

When *O. nubilalis* is found on a crop such as apple, it is usually related to incidental infestations resulting from high populations in adjacent corn crops. However, infestations may cause significant economic losses, depending on the value of the crop. Crops with a high value and low consumer tolerance for damage, such as apples, can have a substantial economic loss due to infestation of fruit (Iowa State University 2006).

Ostrinia nubilalis is a moth of the family Pyralidae. The genus *Ostrinia* contains 20 species of which only four of these are recognized as major or minor pests of maize or legumes (CABI 2007). *Ostrinia nubilalis* is now common in the US, and was accidentally introduced from Europe about 1908 or 1909 (Covell 1984) and has since spread as far west as the Rocky Mountains in both Canada and the US (Capinera 2000).

Ostrinia nubilalis has four life stages: egg, larva, pupa and adult (Capinera 2000). The moths are fairly small, with adults measuring 20–34 mm in wingspan. Moths are pale yellow to light brown in colour, with both the forewing and hind wing crossed by dark zigzag lines and bearing yellowish, patches. Larvae tend to be light brown or pinkish gray in colour with round dark spots on each body segment (Capinera 2000).

The number of generations per year ranges from one to six and is related to strains and geographic area. In the US, there are from one to four generations per year. One generation per year occurs in northern New England and Minnesota. Two generations per year occur in eastern and north central states where it has become the dominant ecotype especially throughout the central Corn Belt (Iowa State University 2006). Three to four generations per year occur in Virginia and other southern locations. In many areas generation number varies depending on weather (Capinera 2000).

Ostrinia nubilalis has a very wide host range, attacking practically all robust herbaceous plants with a stem large enough for the larvae to enter. Two strains are known, the eastern strain accounts for most of the wide host range, while the western strain feeds primarily on corn (*Zea mays*) (Capinera 2000). Vegetables other than corn tend to be infested if they are abundant before corn is available, or late in the season when senescent corn becomes unattractive for egg-laying; snap and lima beans (*Phaseolus* spp.), capsicum (*Capsicum* spp.), and potato (*Solanum tuberosum*) are especially damaged. Other crops sometimes attacked include buckwheat (*Eriogonum* spp.), hops (*Humulus lupulus*), millet (*Panicum* spp.), oats (*Avena sativa*), and soybean (*Glycine max*), and such flowers as aster (*Aster* spp.), cosmos (*Cosmos* spp.), dahlia (*Dahlia* spp.), gladiolus (*Gladiolus* spp.), hollyhock (*Alcea rosea*), and zinnia (*Zinnia* spp.). Common weeds infested include barnyard grass (*Echinochloa crus-galli*), beggarticks (*Bidens* spp.), cocklebur (*Xanthium* spp.), dock (*Rumex* spp.), jimsonweed (*Datura* spp.), panic grass (*Panicum* spp.), pigweed (*Amaranthus* spp.), and smartweed (*Polygonum* spp.) (Capinera 2000).

The larva feeds inside weed stems and corncobs (Iowa State University 2006) as well as boring inside apple fruit (Straub *et al.* 1986). Full grown larvae overwinter in cornstalks, corn cobs, weed stems or in a spun-silk covering located in plant debris (Iowa State University 2006).

The pupa is ordinarily, but not always, enveloped in a thin cocoon formed within the larval tunnel (Capinera 2000) within the host plant.

The risk posed by *Ostrinia nubilalis* is that sometimes the larvae develop within apple fruit leaving no obvious external injury (Weires and Straub 1982; Straub *et al*. 1986).

Probability of entry

Probability of importation

The likelihood that the *Ostrinia nubilalis* will arrive in Australia with the importation of the commodity: **EXTREMELY LOW**.

Supporting information for this assessment is provided below:

- There are records of *O. nubilalis* causing damage to apple fruit of established trees (MacCreary and Milliron 1952) and shoots of newly planted trees (Weires and Straub 1982; Straub *et al.* 1986). Records show that 0.5% of picked apple fruit were infested with *O. nubilalis* larvae in Delaware and a few borers were found as high as 7 feet (2.13 m) above the ground in unharvested apples (MacCreary and Milliron 1952).
- Recurring infestations of apple have been recorded in New York State (Straub *et al.* 1986).
- Cultivars in orchard situations were not equally susceptible to larval infestations of fruits 'McIntosh' sustained more damage than 'Empire' due to the relative maturity and firmness of the cultivars (Straub *et al.* 1986).
- In laboratory experimental bioassays significantly more larvae entered 'Golden Delicious' than 'Rome Beauty' also probably due to relative maturity and firmness (Straub *et al.* 1986).
- *Ostrinia nubilalis* was accidentally introduced from Europe about 1908 or 1909 (Covell 1984) and has since spread as far west as the Rocky Mountains in both Canada and the US (Hudon and LeRoux 1986a; Capinera 2000). However, it has not been recorded from Washington, Oregon or Idaho states of the PNW.
- Apple damage ranges from straight tunnels extending nearly through the fruits, to tortuous galleries that ruined most of all the interior of the apple fruit (MacCreary and Milliron 1952).
- In dropped apples many of the larval entrances are plugged with frass, making detection difficult (MacCreary and Milliron 1952).
- Penetration of windfall apples is a common occurrence in areas of heavy borer population (Caffrey and Worthley 1927).
- Field infestations with egg masses pinned to apple fruits resulted in no damage, indicating that neonate larvae do not establish on fruits (Straub *et al.* 1986).

- In growth chamber tests neonate larvae displayed a low degree of establishment in apples compared to subsequent instars, but benefitted from a cut in the apple skin which facilitated penetration (Straub *et al.* 1986).
- Later instars readily penetrated intact apple skin in growth chamber studies (Straub *et al.* 1986).
- Straub *et al*. (1986) conclude on the basis of their experiments that even though apple fruit is a suboptimal host, viable populations could result should infestations of fruit occur.

Although *Ostrinia nubilalis* is known to bore into apple fruit in the eastern US and fruit damage can be hard to detect, the absence of this pest from the PNW support a risk rating for importation of 'extremely low'.

If *O. nubilalis* were to be detected in the PNW, the risk rating for importation of this pest would have to be re-assessed.

Probability of distribution

The likelihood that *Ostrinia nubilalis* will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **HIGH**.

Supporting information for this assessment is provided below:

- *Ostrinia nubilalis* has a very wide host range attacking practically all robust herbaceous plants with a stem large enough for the larvae to enter. *Ostrinia nubilalis* hosts especially damaged include corn (*Zea mays*), snap and lima beans (*Phaseolus* spp.), capsicum (*Capsicum* spp.), and potato (*Solanum tuberosum*). Several flowers and common weeds as well as apple also serve as host plants for *O. nubilalis*. These hosts are widely distributed throughout Australia in urban, rural and wild environments increasing the chance that the pest will find a suitable host.
- It is likely that it will take at least 1–3 weeks to transport apples from the US to Australia, arriving spring to mid-summer or beginning of the New Year at latest. At this time, host plants and alternate host plants will be well developed and able to provide adequate food resources for *O. nubilalis*.
- Distribution of the commodity in the PRA area would be for wholesale and retail sale, processing and human consumption. The intended end-use for the commodity in Australia is human consumption. Consumers will distribute small quantities of apples to many urban, rural and wild environments, where infested fruit could be disposed of in close proximity to a suitable host, or suitable site to pupate.
- A successful transfer of *O. nubilalis* to a susceptible host will depend on multiple insects escaping from the importation pathway, where large numbers of imported apples are stored for unpacking or packing. These points would have more infested fruits for males and females of *O. nubilalis* to emerge and successfully mate.
- Waste material would be generated during distribution and consumption. Waste produced by apple retailers and processors may be disposed into landfills. Commercial host fruit crops would usually not be near these sites. However, wild and amenity host plants may be near landfill areas and may be susceptible to *O. nubilalis* infestation if eggs and larvae were able to survive landfill procedures and reach maturity.

- Some households dispose of their organic waste as compost. Host plants within the back-yard garden may be exposed to *O. nubilalis* larvae from infested apples if larvae are able to survive and transfer from the composting site.

The ability of the larvae to complete its development inside its host plant, combined with a wide host range, support a risk rating for distribution of 'high'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that the *Ostrinia nubilalis* will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **EXTREMELY LOW**.

Probability of establishment

The likelihood that the *Ostrinia nubilalis* will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **HIGH**.

Supporting information for this assessment is provided below:

- *Ostrinia nubilalis* has a very wide host range feeding on beans, capsicums, maize, potato, as well as being found on fruit trees boring into apples and pears (Capinera 2000; Iowa State University 2006; CABI 2007). *Ostrinia nubilalis* also feeds on ground cover plants beneath orchard trees such as barnyard grass (*Echinochloa crus-galli*), beggarticks (*Bidens* spp.), cocklebur (*Xanthium* spp.), dock (*Rumex* spp.), jimsonweed (*Datura* spp.), panic grass (*Panicum* spp.), pigweed (*Amaranthus* spp.), smartweed (*Polygonum* spp.) and others (Hudon and LeRoux 1986a; Capinera 2000).
- *Ostrinia nubilalis* is a European native also known from north Africa (Mutuura and Munroe 1970; CABI 2007) that has been introduced to North America. There, it has spread throughout the corn growing areas of the US, north into Canada, west to the Rocky Mountains and south to Florida and New Mexico (Iowa State University 2006). Many of these areas have climatic conditions similar to those in Australia. Most of Australia's fruit growing regions have cool temperate to warm temperate climates suitable for *O. nubilalis* to survive. The ground-cover host plants, which include many cosmopolitan weeds, are widespread in Australia also occurring in areas that have climatic conditions similar to those found in North America.
- *Ostrinia nubilalis* reproduces sexually (Hudon and LeRoux 1986b) and needs to find a mate to breed. Total adult longevity is normally 18–24 days (Capinera 2000), and adults are able to fly strongly (Iowa State University 2006), facilitating distribution from infested apple fruits discarded into the environment. The timing of moth flights varies considerably from year to year. In warmer years, the flights occur earlier than in cooler years (Iowa State University 2006).
- Moths leave emergence sites and fly to nearby areas of dense vegetation, usually brome (*Bromus* spp.) and other grasses, in roadside verges and along fence boundaries (Iowa State University 2006).
- Moths must drink water before they can begin emitting a sex attractant (pheromone). The emission of the sex pheromone usually begins before midnight, peaks after midnight, and ends at dawn (Iowa State University 2006). It draws large aggregations of *O. nubilalis* into

relatively small areas of dense vegetation where they mate (Iowa Sate University 2006). The use of a sex pheromone to attract a mate will facilitate mating and reproduction.

- After the introduction of *O. nubilalis* into North America it produced one generation per year. Thirty years later a two-generation per year population appeared in the eastern and north central states. Later, three- and four-generation per year populations had appeared in the south along the Atlantic coast (Iowa State University 2006). In Canada, populations are usually one generation per year although traces of two generations per year biotype have begun to appear (Hudon and LeRoux 1986b).
- In the US, the number of generations per year ranges from one to four (Iowa State University 2006). In temperate areas such as the mid-western US, there are usually two or three overlapping generations present (INRA 1997).
- Matteson and Decker (1965) reported the duration of development at two temperatures. At 21°C, development times were: egg – 6 days, L1 – 4.5 days, L2 – 4 days, L3 – 4 days, L4 – 4 days, L5 – 10 days and pupa – 12 days. At 26° C, they were: egg – 3.5 days, L1 – 3 days, L2 – 2 days, L3 – 2 days, L4 – 2.5 days, L5 – 6.5 days and pupa – 7 days.
- During the fifth instar, all larvae either prepare to pupate and become adults or enter diapause. This physiological condition results in suspended development and is controlled by day length, temperature, genetic composition of the population, and host plant nutritional quality (Iowa State University 2006). Diapause ensures survival through autumn and winter until spring when environmental triggers cause diapause to end and the larvae to resume development and pupation.
- Three ecotypes of *O. nubilalis* populations have developed in North America: northern (one generation), central (two generations) and southern (three or more generations). In addition, two pheromone types are known in *O. nubilalis* (Iowa State University 2006). These types of adaptation in a species would enhance its ability to establish in new areas.
- The total adult life span is 18–24 days (average 10–15 days) and females can mate more than once (Capinera 2000). The maximum number of eggs produced per female is 800–900 (average 500–600 eggs per female). It deposits on average 20–50 eggs per day (Capinera 2000). Females that have mated multiple times are significantly more fecund than females that mate only once (Fadamiro and Baker 1999).

The very wide host range that includes many cultivated fruit trees, flowers and cosmopolitan understorey weeds, a distribution across many climatic zones in both Europe and America, ability to change the number of generations per year in the population, and genetic predisposition for a portion of the population to enter diapause in the fifth instar to overwinter until next season, support a risk rating for establishment of ‘high’.

Probability of spread

The likelihood that *Ostrinia nubilalis* will spread based on a comparison of factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pest: **HIGH**.

Supporting information for this assessment is provided below:

- Host plants such as maize, sorghum, millet, potato, capsicums, beans and fruit trees (apples, pears), ground cover plants such as dock, pigweed, and *Polygonum* spp. grow widely throughout Australia in suitable domestic, commercial and wild environments close to fruit production areas.

- *Ostrinia nubilalis* is a strong flier. In central Iowa and much of the Corn Belt, this insect has two distinct flight periods each lasting 4–6 weeks each, one in spring and the other in summer (Sappington 2005). In southern locations with three generations per year, moth flights typically occur on three occasions (May, late June and August), while in locations with four generations, adults are flying in April, June, July and August-September (Capinera 2000). In other words, there are more flight periods further south in warmer areas.
- When infested plant products from Australian growing regions where *O. nubilalis* has become established are sold to the domestic market, increased opportunities for this species to spread will occur. This could occur via a similar pathway to its initial introduction such as the disposal of infested apples or corn cobs into the environment.
- Natural control is not sufficient to reduce the damage caused by *O. nubilalis* larvae below an economic threshold in some crops, for example, seed maize, sweetcorn, potato, capsicum and bean (CABI 2007). In Europe, indigenous parasitoids are not able to maintain *O. nubilalis* populations at tolerable densities (CABI 2007).
- Biological control using augmentative and inundative releases of *Trichogramma* species is used successfully in maize and capsicum in Europe and North America (Kanour and Burbutis 1984; Bigler and Brunetti 1986; Kabiri *et al.* 1991; Prokrym *et al.* 1992; Burgio and Maini 1995). No existing biocontrol program in Australia is likely to be effective against *O. nubilalis*.
- The potential for natural enemies in Australia to reduce the spread of *O. nubilalis* is unknown. Some 67 parasitoids that attack the eggs or larvae have been recorded for *O. nubilalis* as well as 22 pathogens and 34 predators (CABI 2007). It is unknown whether these control agents would be capable of limiting this pest's geographic range in Australia.
- The very wide host range (which includes many ground-cover weeds) of *O. nubilalis* means that spraying of commercial crops alone may not be effective in reducing the pest's ability to spread. However, the advent of transgenic sweet corn engineered to express *Bacillus thuringiensis* (Bt) toxins has resulted in Bt hybrids providing significant control of *O. nubilalis*. For most locations and planting dates, Bt hybrids have provided 100% control of *O. nubilalis* infestations of sweet corn (Burkness *et al.* 2002).

The extremely wide host range including commercial crops as well as cosmopolitan ground cover weeds, ready availability of host plants, the adult's strong ability for flight, the wide spread after introduction into North America in less than 100 years and the unknown effect of pathogens and parasitoids on *Ostrinia nubilalis* in the Australian environment support a risk rating for spread of 'high'.

Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that *Ostrinia nubilalis* will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **EXTREMELY LOW**.

Consequences

The consequences of the establishment of *Ostrinia nubilalis* in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision rules described in Table 2.4 on page 12, that is, where the consequences of a pest with respect to one or more criteria are '**E**', the overall consequences are estimated to be **MODERATE**.

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**E – Significant at the regional level:** *Ostrinia nubilalis* can cause direct harm to a wide range of plant hosts, affecting fruit quality and plant health. It significantly affects production of field corn, seed corn and sweet corn as well as other crops including cotton, sorghum and many vegetables (Hudon and LeRoux 1986a; Iowa State University 2006). Overall, yield losses and control expenses associated with *O. nubilalis* cost farmers in the US more than 1 billion dollars annually (Iowa State University 2006). It is not known if *O. nubilalis* could become a pest of some native plant species, but given the wide host range of this pest this is highly likely.
Other aspects of the environment	**B – Minor at the local level:** *Ostrinia nubilalis* could compete with native pyralid species if it feeds on Australian native plants. This, given its wide host range seems likely.
Indirect	
Eradication, control etc.	**D – Significant at the district level:** Additional programs to eradicate *O. nubilalis* on their host plants may be necessary, including the many weed hosts that are known. Existing control programs may be effective for some hosts (e.g. broad spectrum pesticide applications) but not all hosts (e.g. *Malus* (apples) and *Pyrus* (pears) where specific integrated pest management programs are used) (APAL 2009). 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 the cost of production. Additionally, costs for crop monitoring and consultant's advice to manage this pest may be incurred by the producer.
Domestic trade	**D – Significant at the district level:** The presence of *O. nubilalis* in commercial production areas may have a significant effect at the local level due to resulting trade restrictions on the sale or movement of a wide range of commodities between areas in Australia and between states/territory. These restrictions may 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 *O. nubilalis* in commercial production areas of a range of commodities would have a significant effect at the district level due to limitations of accessing international markets where these pests are absent.
Environmental and non-commercial	**B – Minor at the local level:** Additional pesticide applications or other control activities would be required to control these pests on susceptible crops. Any additional insecticide usage and runoff may affect the environment. Treatment against *O. nubilalis* may disrupt natural biocontrol methods for other pests, and alter aspects of the biotic environment such as native invertebrates and species known to prey on *O. nubilalis*.

Unrestricted risk estimate

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 12.

Unrestricted risk estimate for *Ostrinia nubilalis*	
Overall probability of entry, establishment and spread	Extremely low
Consequences	Moderate
Unrestricted risk	Negligible

As indicated, the unrestricted risk estimate for *Ostrinia nubilalis* has been assessed as 'negligible', which achieves Australia's ALOP. Therefore, no specific risk management measures are required for this pest.

If *Ostrinia nubilalis* were present in the PNW, this unrestricted risk estimate would likely be above ALOP, and specific risk management measures would be required for this pest.

There is no evidence of official control measures in place to prevent the spread of this pest into the PNW. If this pest is detected in the PNW in the future, it would need to be reported to Australia immediately. The risk associated with the pest would then need to be re-assessed.

4.37 Sooty blotch and flyspeck[16]

Colletogloeum spp. (FG2.1, FG2.2, FG2.3); *Dissoconium* spp. (DS1.1, DS1.2, DS2, FG4, FG5); *Geastrumia polystigmatis*; *Mycelia sterilia* spp. (RS1, RS2); *Passalora* sp. FG3; *Peltaster fructicola*; *Peltaster* spp. (P2.1, P2.2, CS1); *Pseudocercospora* spp. (FS4, FG1.1, FG1.2); *Pseudocercosporella* spp. (RH1, RH2.1, RH2.2); *Ramularia* sp. P5; *Xenostigmina* spp. (P3, P4); *Zygophiala cryptogama*; *Zygophiala tardicrescens*; *Zygophiala wisconsinensis*

The fungal species, associated with sooty blotch and flyspeck (SBFS) diseases, assessed here have been grouped together because of their related biology. They 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 the species assessed.

The assessed SBFS fungi have not been recorded from the PNW states. However, as there is no evidence of official control measures in place to prevent their spread into the PNW, the fungi are considered in this IRA.

Sooty blotch and flyspeck are diseases caused by a complex of fungi that colonise the cuticle of apple fruit (Batzer *et al*. 2005). Sooty blotch appears as dark smudges and flyspeck appears as groups of tiny black spots on the fruit surface. Although these fungi do not affect the growth and development of the fruit, they can cause economic loss to growers because of reduced fruit quality. In some cases, the market value can be reduced by more than 90% (Williamson and Sutton 2000; Batzer *et al.* 2002).

Colby (1920) reported that sooty blotch was caused by *Gloeodes pomigena* (Schwein.) Colby and flyspeck was caused by *Schizothyrium pomi* (Mont. & Fr.) Arx. Johnson and Sutton (1994). Later Johnson *et al.* (1997) found sooty blotch could be caused by three additional fungi, *Geastrumia polystigmatis* Batista & M.L. Farr, *Peltaster fructicola* Eric M. Johnson, T.B.Sutton & Hodges and *Leptodontidium elatius* (de Hoog) de Hoog. More recent studies found that a wider range of fungi can cause SBFS. Using molecular methods to identify the fungi from samples from the Midwest of the US, 30 species were found which caused SBFS lesions on apple (Batzer *et al.* 2005). Some of these species, for example, *Gloeodes pomigena* and *Schizothyrium pomi* are present in some parts of Australia.

The fungi associated with SBFS in the US are anamorphic fungi that disperse by means of conidia (Batzer *et al*. 2005). SBFS fungi overwinter on reservoir hosts and apple twigs and fruit. Conidia are spread by wind and rain to developing fruit and new tissues of reservoir hosts in the spring and early summer (Williamson and Sutton 2000). SBFS fungi grow on a wide range of reservoir hosts, including trees, shrubs and vines that are near or bordering orchards (Williamson and Sutton 2000).

The risk posed by the assessed sooty blotch and flyspeck fungi is affected fruit with viable inoculum may be imported to Australia.

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16 In this section, the common name sooty blotch and flyspeck (SBFS) will be used to refer to all 28 species. The scientific name will be used when the information is about a specific species.

Probability of entry

Probability of importation

The likelihood that the SBFS fungi assessed will arrive in Australia with the importation of the commodity: **EXTREMELY LOW**.

Supporting information for this assessment is provided below:

- Sooty blotch and flyspeck are more severe in southern than northern production areas of the eastern US. However, the incidence of SBFS has increased in the mid eighties in New York and New England (Cooley *et al.* 1991).
- In the southeastern US, 5–90% of fruit affected by SBFS fungi occur (Batzer *et al.* 2002).
- There is no report of the presence of the assessed SBFS fungi in the PNW.
- After fruit being affected, it usually takes about 20–28 days for symptoms to develop on fruit. However, under optimum conditions the symptoms may be visible in 8–12 days (Sutton *et al.* 1988).
- Affected fruit may be symptomless at harvest and develop symptoms during storage and transport. When the last fungicide spray is made 8–10 weeks before harvest, fruit with no symptoms at harvest developed extensive SBFS after six months of storage at 0–1°C (Drake 1974).
- Fruit with obvious symptoms will be rejected during harvesting and packing house processes. However, fruit in the early stages of being affected may show no or minute symptoms and may escape detection.

Although there is a possibility of fruit in the early stages of being affected escaping detection, the lack of record of the presence of the assessed SBFS fungi in the PNW support a risk rating for importation of ‘extremely low’.

If the assessed SBFS fungi were to be detected in the PNW, the risk rating for importation of these fungi would have to be re-assessed.

Probability of distribution

The likelihood that SBFS fungi assessed will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of the commodity: **HIGH**.

Supporting information for this assessment is provided below:

- Imported apple fruit is intended for human consumption in Australia. It is expected that once the apple fruit has arrived in Australia, it will be distributed throughout Australia for wholesale or retail sale. Any affected fruit present may be distributed during these procedures.
- Individual consumers will distribute small quantities of apples to a variety of urban, rural and wild environments.
- Sooty blotch and flyspeck fungi will survive distribution in Australia, as they can develop in cold storage at 0–1°C (Drake 1974).

- Fruit waste, that may include the skin of apple fruit with SBFS colonies, may be disposed of in close proximity to a suitable host plant.
- Sooty blotch and flyspeck fungi grow on a wide range of reservoir hosts, including trees, shrubs and vines that are near or bordering orchards (Williamson and Sutton 2000).
- The fungi associated with SBFS in the US are anamorphic fungi that disperse by means of conidia (Williamson and Sutton 2000). Conidia of these fungi on the surface of SBFS colonies could be spread by wind and wind-blown rain to new tissues of hosts in close proximity to discarded apple waste.

The disposal of fruit waste in the environment, the ability of wind and water droplets to transfer spores from the fruit waste to a host and the wide range and distribution of hosts, support a risk rating for distribution of 'high'.

Overall probability of entry

The overall probability of entry 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 9.

The likelihood that the assessed SBFS fungi will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host: **EXTREMELY LOW**.

Probability of establishment

The likelihood that SBFS fungi assessed will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction: **HIGH**.

Supporting information for this assessment is provided below:

- Sooty blotch and flyspeck fungi have a wide range of hosts (Babadoost 2005; see also Appendix B). Some of the host plants are widely distributed throughout Australia.
- The development of SBFS is favoured by warm temperatures, high rainfall and high humidity (Zhang 2006, 2007; Batzer *et al.* 2008).
- The effects of temperatures and relative humidity have been studied in vitro for some fungi associated with SBFS. Conidia germination of *Peltaster fructicola*, *Leptodontium elatius*, and *Zygophiala jamaicensis* occurred at relative humidity of at least 95%, 97% and 96%, respectively and at a temperature range of 12–24°C, 12–32°C and 8–28°C, respectively (Johnson *et al.* 1997; Williamson and Sutton 2000).
- Conditions that would allow the establishment of SBFS fungi on host plants would occur in some warm-temperate and subtropical regions of Australia, especially during periods of wet weather in the warmer months of the year.
- Sooty blotch caused by *Gloeodes pomigena*, and flyspeck caused by *Schizothyrium pomi*, has been recorded in New South Wales (APPD 2009) and Western Australia (Shivas 1989), which suggests that other SBFS fungi have the potential to establish in Australia.

The occurrence of sooty blotch caused by *Gloeodes pomigena* and flyspeck caused by *Schizothyrium pomi* in some parts of Australia and the wide range and distribution of hosts, support a risk rating for establishment of 'high'.

Probability of spread

The likelihood that the assessed SBFS fungi will spread based on a comparison of the factors in the area of origin and in Australia that affect the expansion of the geographic distribution of the pest: **HIGH**.

Supporting information for this assessment is provided below:

- Sooty blotch and flyspeck fungi have a wide range of hosts (Babadoost 2005; see also Appendix B). Some of the host plants are widely distributed throughout Australia.
- The fungi associated with SBFS in the US are anamorphic fungi that disperse by means of conidia (Batzer *et al.* 2005, 2008). Conidia of these fungi could be spread by wind and wind-blown rain to new tissues of hosts.
- Sooty blotch and flyspeck diseases are favoured by warm temperatures, high rainfall and high humidity (Johnson *et al.* 1997; Williamson and Sutton 2000; Zhang 2006, 2007; Batzer *et al.* 2008).
- Conditions that would allow the development and spread of SBSF fungi on host plants would occur in some warm-temperate and subtropical regions of Australia, especially during periods of wet weather in the warmer months of the year.
- Sooty blotch, caused by *Gloeodes* pomigena, and flyspeck, caused by *Schizothyrium pomi*, have been recorded in New South Wales (APPD 2009) and Western Australia (Shivas 1989), which suggests that other SBFS fungi have the potential to spread in Australia.
- Distribution of affected fruit via commercial or domestic movement may aid the spread of the SBFS pathogens.
- Distribution of affected nursery stock may aid long distance movement of SBSF fungi to new areas.

The dispersal of spores by wind and wind-blown rain, the potential movement of symptomless affected planting materials, the wide range and distribution of hosts, and the occurrence of some of the species associated with SBSF in some parts of Australia, support a risk rating for spread of ‘high’.

Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of ‘rules’ for combining qualitative likelihood shown in Table 2.2 on page 9.

The likelihood that the assessed SBFS fungi will enter Australia as a result of trade in the commodity from the country of origin, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **EXTREMELY LOW**.

Consequences

The consequences of the establishment of the assessed SBFS fungi in Australia have been estimated according to the methods described in Table 2.3 on page 11.

Based on the decision rules described in Table 2.4 on page 12, that is, where the consequences of a pest with respect to one or more criteria are ‘C’, the overall consequences are estimated to be **VERY LOW**.

Reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**C – Minor significance at the district level:** Sooty blotch and flyspeck are common diseases of pome fruits in many moist, temperate growing regions of the world (Williamson and Sutton 2000), including the eastern US (Rosenberger *et al.* 1996). They cause considerable economic loss to growers of fresh market fruit because of reduced fruit quality (Sutton 1990b; Williamson and Sutton 2000). The defects caused by SBFS are mainly cosmetic without affecting the eating quality. However, in regions with warm, wet and humid conditions in summer when fruit is developing, such as the south-east of the US and Yunnan Province in China, up to 95% of the crop can be affected by these diseases (Zhang 2006, 2007; Batzer *et al.* 2008). In Australia, SBFS appear to be minor diseases. There are limited records of these diseases, probably due to the drier climates in Australian fruit production areas and the regular application of fungicides to control other diseases. Sooty blotch, caused by *Gloeodes pomigena*, has been recorded in New South Wales on apple, peach and orange (APPD 2009) and in Western Australia on apple (Shivas 1989). Flyspeck, caused by *Schizothyrium pomi*, has been recorded in New South Wales on apple, peach and persimmon (APPD 2009) and in Western Australia on apple (Shivas 1989). There have been no molecular studies to confirm the identity of the fungi causing SBFS in Australia. The entry, establishment and spread of additional species of SBFS fungi from the US may increase the importance of these diseases, especially in seasons with high summer rainfall. Although SBFS fungi have a wide range of host plants, they are unlikely to affect the health of native flora, because they are a complex of fungi that grow on the waxy cuticle of plants (Williamson and Sutton 2000).
Other aspects of the environment	**A - Indiscernible at the local level:** There are no known direct consequences of the assessed SBFS fungi on other aspects of the environment.
Indirect	
Eradication, control etc.	**C – Minor significance at the district level:** It is unlikely that eradication of additional species of SBFS fungi would be possible, due to their wide host range and the difficulty in identifying infected hosts SBFS are only recorded in NSW and WA (APPD 2009; Shivas 1989) and are minor diseases in Australia. This may be due to a combination of the unfavourable climates for disease development in the commercial fruit producing areas and the fungicide spray programs applied for the control of other diseases. It is unlikely that additional control measures would be required should additional species of the SBFS complex establish and spread in Australia.
Domestic trade	**A - Indiscernible at the local level:** It is unlikely that the entry, establishment and spread of additional SBFS fungi in commercial apple production areas in Australia would result in the implementation of interstate quarantine measures. Sooty blotch and flyspeck have been recorded in New South Wales and Western Australia and no interstate quarantine measures have been put in place for these diseases.
International trade	**A - Indiscernible at the local level:** It is unlikely that the entry, establishment and spread of additional SBFS fungi in commercial apple production areas in Australia would result in the introduction of international quarantine measures. Sooty blotch and flyspeck already occur in Australia and there are no restrictions on the export of Australian fruit because of these diseases. In addition, these diseases are widespread around the world.
Environmental and non-commercial	**A – Indiscernible at the local level:** Should additional species of the SBFS complex establish and spread in Australia, it is unlikely that any additional control measures would be required that would impact on the environment.

Unrestricted risk estimate

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 12.

Unrestricted risk estimate for sooty blotch and fly speck Fungi	
Overall probability of entry, establishment and spread	Extremely low
Consequences	Very Low
Unrestricted risk	Negligible

As indicated, the unrestricted risk estimate for the assessed sooty blotch and flyspeck fungi has been assessed as 'negligible', which achieves Australia's ALOP. Therefore, no specific risk management measures are required for these pests.

There is no evidence of official control measures in place to prevent the spread of these pests into the PNW. If any of these pests is detected in the PNW in the future, it would need to be reported to Australia immediately. The risk associated with the pest would then need to be re-assessed.

4.38 Gymnosporangium rusts

Gymnosporangium clavipes; *Gymnosporangium globosum*; *Gymnosporangium yamadae*

Gymnosporangium clavipes (quince rust) *Gymnosporangium globosum* (hawthorn rust) and *Gymnosporangium yamadae* (Japanese apple rust) are heteroecious rusts that require *Juniperus* spp. (junipers) as telial hosts and rosaceous species, including apples, as aecial hosts to complete their life cycle (Farr and Rossman 2009).

Risks associated with the other two rust fungi species, *Gymnosporangium juniperi-virginianae* and *Gymnosporangium libocedri*, have been assessed and presented in section 4.28 on pages 181–185. The overall consequences have been estimated as 'moderate'.

The biology and taxonomy of *G. clavipes*, *G. globosum* and *G. yamadae* are similar to *G. juniperi-virginianae* and *G. libocedri*, therefore, they are predicted to pose similar risks.

Gymnosporangium globosum and *G. yamadae* have not been recorded in the PNW. The lack of records for these pests suggests absence from the PNW. Therefore, the importation risk of *G. globosum* and *G. yamadae* is considered to be 'extremely low'. Accordingly, the overall probability of entry, establishment and spread for these species is 'extremely low'. Combined with the 'moderate' rating of consequences, the unrestricted risk of these pests is 'negligible', which achieves Australia's ALOP. Therefore, no specific risk management measures are required. However, there is no evidence of official control measures in place to prevent the spread of these pests into the PNW. If any of these pests is detected in the PNW in the future, it would need to be reported to Australia immediately. The risk associated with the pest would then need to be re-assessed.

Gymnosporangium clavipes has been reported on *Malus* in eastern US states. However, in the PNW, it has been recorded on *Crataegus douglasii* (black hawthorn) and *Juniperus communis* (common juniper) (Farr and Rossman 2009), but it is not known to be present on *Malus*. Due to the lack of records for *G. clavipes* on *Malus* in the PNW, the importation risk of *G. clavipes* is considered to be 'very low'. Accordingly, the overall probability of entry, establishment and spread for this pest is 'very low'. Combined with the 'moderate' rating of consequences, the unrestricted risk of this pest is 'very low', which achieves Australia's ALOP. Therefore, no specific risk management measures are required. Should this pest be detected on *Malus* in the PNW in the future, then this would need to be reported to Australia immediately. The risk associated with this pest would then need to be re-assessed.

If these *Gymnosporangium* species were present in the PNW, their unrestricted risk estimate would likely be above ALOP, and specific risk management measures would be required for these pests.

4.39 Pest risk assessment conclusions

Key to Table 4.2 (starting next page)

Genus species EP	pests for which policy already exists. The outcomes of previous assessments and/or reassessments in this IRA are presented in table 4.2
Genus species state/territory	state/territory in which regional quarantine pests have been identified

Likelihoods for entry, establishment and spread

N	negligible
EL	extremely low
VL	very low
L	low
M	moderate
H	high
P[EES]	overall probability of entry, establishment and spread

Assessment of consequences from pest entry, establishment and spread

PLH	plant life or health
OE	other aspects of the environment
EC	eradication control etc
DT	domestic trade
IT	international trade
ENC	environmental and non-commercial
A-G	consequence impact scores are detailed in section 2.2.3
URE	unrestricted risk estimate. This is expressed on an ascending scale from negligible to extreme.

Table 4.2a Summary of unrestricted risk estimates for quarantine pests associated with mature fresh apple fruit from the US Pacific Northwest states

Pest name	Likelihood of						Consequences							URE
	Entry			Establishment	Spread	P[EES]								
	importation	distribution	Overall				direct		indirect				Overall	
							PLH	OE	EC	DT	IT	ENC		
DOMAIN BACTERIA														
Fire blight (Enterobacteriales: Enterobacteriaceae)														
Erwinia amylovora EP						**VL**							**H**	**L**
DOMAIN EUKARYA														
Flat scarlet mite (Acariformes: Tenuipalpidae)														
Cenopalpus pulcher	H	M	**M**	**H**	**M**	**L**	E	B	D	D	D	B	**M**	**L**
Spider mites (Acariformes: Tetranychidae)														
Tetranychus mcdanieli	H	M	**M**	**H**	**M**	**L**	D	B	D	C	C	B	**L**	**VL**
Tetranychus pacificus	H	M	**M**	**H**	**M**	**L**	D	B	D	C	C	B	**L**	**VL**
Tetranychus turkestani	H	M	**M**	**H**	**M**	**L**	D	B	D	C	C	B	**L**	**VL**
Apple curculio (Coleoptera: Curculionidae)														
Anthonomous quadrigibbus	L	M	**L**	**L**	**M**	**VL**	D	B	D	B	C	B	**L**	**N**
Apple leafcurling midge (Diptera: Cecidomyiidae)														
Dasineura mali EP						**H**							**L**	**L**
Apple maggot (Diptera: Tephritidae)														
Rhagoletis pomonella	H	M	**M**	**H**	**M**	**L**	F	B	E	D	D	B	**H**	**M**
Plant bugs (Hemiptera: Miridae)														
Lygus elisus	VL	M	**VL**	**H**	**M**	**VL**	E	B	D	C	C	B	**M**	**VL**
Lygus hesperus	VL	M	**VL**	**H**	**M**	**VL**	E	B	D	C	C	B	**M**	**VL**

Pest name	Likelihood of						Consequences							URE
	Entry			Establishment	Spread	P[EES]								
	importation	distribution	Overall				direct		indirect				Overall	
							PLH	OE	EC	DT	IT	ENC		
Lygus lineolaris	VL	M	**VL**	**H**	**M**	**VL**	E	B	D	C	C	B	**M**	**VL**
Chaff scale (Hemiptera: Diaspididae)														
Parlatoria pergandii WA EP	L	L	**VL**	**H**	**M**	**VL**	D	B	D	C	C	B	**L**	**N**
Mealybugs (Hemiptera: Pseudococcidae)														
Phenacoccus aceris EP	H	M	**M**	**H**	**H**	**M**	D	B	D	D	C	B	**L**	**L**
Pseudococcus maritimus EP	H	M	**M**	**H**	**H**	**M**	D	B	D	D	C	B	**L**	**L**
Dock sawfly (Hymenoptera: Tenthredinidae)														
Ametastegia glabrata WA	VL	M	**VL**	**H**	**H**	**VL**	C	B	B	B	C	B	**VL**	**N**
Leafroller moths (Lepidoptera: Tortricidae)														
Archips argyrospila	M	M	**L**	**H**	**H**	**L**	E	B	E	D	D	B	**M**	**L**
Archips podana	M	M	**L**	**H**	**H**	**L**	E	B	E	D	D	B	**M**	**L**
Archips rosana	M	M	**L**	**H**	**H**	**L**	E	B	E	D	D	B	**M**	**L**
Argyrotaenia franciscana	M	M	**L**	**H**	**H**	**L**	E	B	E	D	D	B	**M**	**L**
Choristoneura rosaceana	M	M	**L**	**H**	**H**	**L**	E	B	E	D	D	B	**M**	**L**
Hedya nubiferana	M	M	**L**	**H**	**H**	**L**	E	B	E	D	D	B	**M**	**L**
Pandemis heparana	M	M	**L**	**H**	**H**	**L**	E	B	E	D	D	B	**M**	**L**
Pandemis pyrusana	M	M	**L**	**H**	**H**	**L**	E	B	E	D	D	B	**M**	**L**
Spilonota ocellana	M	M	**L**	**H**	**H**	**L**	E	B	E	D	D	B	**M**	**L**
Apple fruit moth (Lepidoptera: Yponomeutidae)														
Argyresthia conjugella EP	M	L	**L**	**M**	**M**	**L**	D	B	D	C	C	B	**L**	**VL**

Pest name	Likelihood of						Consequences							URE
	Entry			Establishment	Spread	P[EES]	direct		indirect				Overall	
	importation	distribution	Overall				PLH	OE	EC	DT	IT	ENC		
Codling moth (Lepidoptera: Tortricidae)														
Cydia pomonella WA EP	M	M	**L**	**H**	**H**	**L**	D	A	E	B	D	B	**M**	**L**
Grapholita moths (Lepidoptera: Tortricidae)														
Grapholita molesta WA EP	M	M	**L**	**H**	**H**	**L**	E	A	E	B	D	B	**M**	**L**
Grapholita packardi	M	M	**L**	**H**	**H**	**L**	E	A	E	D	E	B	**M**	**L**
Grapholita prunivora	M	M	**L**	**H**	**H**	**L**	E	A	E	D	E	B	**M**	**L**
Lacanobia fruitworm (Lepidoptera: Noctuidae)														
Lacanobia subjuncta	VL	L	**VL**	**M**	**M**	**VL**	D	B	D	C	C	B	**L**	**N**
Thrips (Thysanoptera: Thripidae)														
Frankliniella occidentalis	H	M	**M**	**H**	**H**	**M**	D	B	C	D	D	B	**L**	**L**
Frankliniella tritici	H	M	**M**	**H**	**H**	**M**	D	B	C	D	D	B	**L**	**L**
DOMAIN FUNGI														
Coprinus rot (Agaricales: Psathyrellaceae)														
Coprinopsis psychromorbida	H	H	**H**	**H**	**H**	**H**	D	A	D	D	D	B	**L**	**L**
Apple blotch (Dothideales: BotryospHaereaceae)														
Phyllosticta arbutifolia EP	L	M	**L**	**M**	**M**	**L**	D	A	D	D	E	B	**M**	**L**
Sphaeropsis rot (Dothideales: Botryosphaereaceae)														
Sphaeropsis pyriputrescens	H	H	**H**	**M**	**M**	**L**	E	A	D	D	E	B	**M**	**L**
Hawthorn powdery mildew (Erysiphales: Erysiphaceae)														
Podosphaera clandestina	VL	L	**VL**	**H**	**H**	**VL**	D	A	C	B	C	B	**L**	**N**

Pest name	**Likelihood of**						**Consequences**							**URE**
	Entry			**Establishment**	**Spread**	**P[EES]**								
	importation	distribution	**Overall**				direct		indirect				**Overall**	
							PLH	**OE**	**EC**	**DT**	**IT**	**ENC**		
Bull's eye rot (Helotiales: Dermateaceae)														
Cryptosporiopsis curvispora	H	H	**H**	**M**	**M**	**L**	D	A	C	B	D	B	**L**	**VL**
Cryptosporiopsis perennans WA	H	H	**H**	**M**	**M**	**L**	D	A	C	B	D	B	**L**	**VL**
Phacidiopycnis and Speck rot (Helotiales: Incertae sedis)														
Phacidiopycnis piri	H	M	**M**	**M**	**M**	**L**	E	A	D	D	E	B	**M**	**L**
Phacidiopycnis washingtonensis	H	M	**M**	**M**	**M**	**L**	E	A	D	D	E	B	**M**	**L**
European canker (Hypocreales: Nectriaceae)														
Neonectria ditissima EP						**L**							**M**	**L**
Mucor rot (Mucorales: Mucoraceae)														
Mucor mucedo	H	H	**H**	**H**	**H**	**H**	D	A	D	B	D	A	**L**	**L**
Mucor piriformis WA	H	H	**H**	**H**	**H**	**H**	D	A	D	B	D	A	**L**	**L**
Mucor racemosus WA	H	H	**H**	**H**	**H**	**H**	D	A	D	B	D	A	**L**	**L**
Black pox (Pleosporales: Pleomassariaceae)														
Helminthosporium papulosum	L	M	**L**	**M**	**M**	**L**	C	A	C	C	C	B	**VL**	**N**
Apple scab (Pleosporales: Venturiaceae)														
Venturia inaequalis WA EP						**H**							**M**	**M**
Thread blight (Tulasnellales: Ceratobasidiaceae)														
Ceratobasidium ochroleuca	EL	L	**EL**	**H**	**H**	**EL**	D	A	C	C	B	B	**L**	**N**
Gymnosporangium rusts (Uredinales: Pucciniaceae)														
Gymnosporangium juniperi-verginianae	L	M	**L**	**M**	**H**	**L**	E	A	D	D	E	B	**M**	**L**

Pest name	Likelihood of						Consequences							URE
	Entry			Establishment	Spread	P[EES]								
	importation	distribution	Overall				direct		indirect				Overall	
							PLH	OE	EC	DT	IT	ENC		
Gymnosporangium libocedri	L	M	**L**	**M**	**H**	**L**	E	A	D	D	E	B	**M**	**L**
Truncatella leaf spot (Xylariales: Amphisphaeriaceae)														
Truncatella hartigii	H	H	**H**	**H**	**H**	**H**	D	A	B	B	A	B	**L**	**L**
DOMAIN VIRUSES														
Tobacco necrosis viruses														
Tobacco necrosis virus A, Tobacco necrosis virus D, tobacco necrosis virus Nebraska isolate and related viruses	M	M	**L**	**H**	**H**	**L**	C	A	C	C	C	A	**VL**	**N**
Apple scar skin														
Apple scar skin viroid [EP]	M	H	**M**	**M**	**L**	**VL**	E	A	D	D	D	A	**M**	**VL**

Table 4.2b Summary of unrestricted risk estimates for quarantine pests associated with mature fresh apple fruit from the US, currently not recorded in the Pacific Northwest states, but present in other states

Pest name	Likelihood of						Consequences							URE
	Entry			Establishment	Spread	P[EES]	direct		indirect				Overall	
	importation	distribution	Overall				PLH	OE	EC	DT	IT	ENC		
DOMAIN BACTERIA														
Blister spot (Pseudomonadales: Pseudomonadaceae)														
Pseudomonas syringae pv. *papulans*	EL	H	**EL**	**M**	**M**	**EL**	C	A	C	C	D	B	**L**	**N**
DOMAIN EUKARYA														
Armoured scales (Hemiptera: Diaspididae)														
Lopholeucaspis japonica	EL	L	**EL**	**H**	**M**	**EL**	D	B	D	C	C	B	**L**	**N**
Parlatoria oleae WA	EL	L	**EL**	**H**	**M**	**EL**	D	B	D	C	C	B	**L**	**N**
Mealybugs (Hemiptera: Pseudococcidae)														
Pseudococcus calceolariae WA EP	EL	M	**EL**	**H**	**H**	**EL**	D	B	D	D	C	B	**L**	**N**
Pseudococcus comstocki	EL	M	**EL**	**H**	**H**	**EL**	D	B	D	D	C	B	**L**	**N**
Leafroller moths (Lepidoptera: Tortricidae)														
Argyrotaenia velutinana	EL	M	**EL**	**H**	**H**	**EL**	E	B	E	D	D	B	**M**	**N**
Platynota flavedana	EL	M	**EL**	**H**	**H**	**EL**	E	B	E	D	D	B	**M**	**N**
Platynota idaeusalis	EL	M	**EL**	**H**	**H**	**EL**	E	B	E	D	D	B	**M**	**N**
Platynota stultana	EL	M	**EL**	**H**	**H**	**EL**	E	B	E	D	D	B	**M**	**N**
Pseudexentera mali	EL	M	**EL**	**H**	**H**	**EL**	E	B	E	D	D	B	**M**	**N**
European corn borer (Lepidoptera: Pyralidae)														
Ostrinia nubilalis	EL	H	**EL**	**H**	**H**	**EL**	E	B	D	D	D	B	**M**	**N**

Pest name	Likelihood of						Consequences							URE
	Entry			Establishment	Spread	P[EES]								
	importation	distribution	Overall				direct		indirect				Overall	
							PLH	OE	EC	DT	IT	ENC		
DOMAIN FUNGI														
Sooty blotch and flyspeck complex (Capnodiales)														
Colletogloeum sp. (FG2.1, FG2.2, FG2.3)	EL	H	**EL**	**H**	**H**	**EL**	C	A	C	A	A	A	**VL**	**N**
Dissoconium sp. (DS1.1, DS1.2, DS2, FG4, FG5)	EL	H	**EL**	**H**	**H**	**EL**	C	A	C	A	A	A	**VL**	**N**
Geastrumia polystigmatis	EL	H	**EL**	**H**	**H**	**EL**	C	A	C	A	A	A	**VL**	**N**
Mycelia sterilia spp. (RS1, RS2)	EL	H	**EL**	**H**	**H**	**EL**	C	A	C	A	A	A	**VL**	**N**
Passalora sp. FG3	EL	H	**EL**	**H**	**H**	**EL**	C	A	C	A	A	A	**VL**	**N**
Peltaster fructicola	EL	H	**EL**	**H**	**H**	**EL**	C	A	C	A	A	A	**VL**	**N**
Peltaster spp. (P2.1, P2.2, CS1)	EL	H	**EL**	**H**	**H**	**EL**	C	A	C	A	A	A	**VL**	**N**
Pseudocercospora spp. (FS4, FG1.1, FG1.2)	EL	H	**EL**	**H**	**H**	**EL**	C	A	C	A	A	A	**VL**	**N**
Pseudocercosporella spp. (RH1, RH2.1, RH2.2)	EL	H	**EL**	**H**	**H**	**EL**	C	A	C	A	A	A	**VL**	**N**
Ramularia sp. P5	EL	H	**EL**	**H**	**H**	**EL**	C	A	C	A	A	A	**VL**	**N**
Xenostigmina spp. (P3, P4)	EL	H	**EL**	**H**	**H**	**EL**	C	A	C	A	A	A	**VL**	**N**
Zygophiala cryptogama	EL	H	**EL**	**H**	**H**	**EL**	C	A	C	A	A	A	**VL**	**N**
Zygophiala tardicrescens	EL	H	**EL**	**H**	**H**	**EL**	C	A	C	A	A	A	**VL**	**N**
Zygophiala wisconsinensis	EL	H	**EL**	**H**	**H**	**EL**	C	A	C	A	A	A	**VL**	**N**

Pest name	Likelihood of						Consequences							URE
	Entry			Establishment	Spread	P[EES]								
	importation	distribution	Overall				direct		indirect				Overall	
							PLH	OE	EC	DT	IT	ENC		
Gymnosporangium rusts (Uredinales: Pucciniaceae)														
Gymnosporangium clavipes	VL	M	**VL**	**M**	**H**	**VL**	E	A	D	D	E	B	**M**	**VL**
Gymnosporangium globosum	EL	M	**EL**	**M**	**H**	**EL**	E	A	D	D	E	B	**M**	**N**
Gymnosporangium yamadae	EL	M	**EL**	**M**	**H**	**EL**	E	A	D	D	E	B	**M**	**N**

5 Pest risk management

This chapter provides information on the management of quarantine pests identified with an unrestricted risk exceeding Australia's appropriate level of protection (ALOP). The proposed phytosantitary measures are described below.

5.1 Pest risk management measures and phytosanitary procedures

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 above Australia's ALOP. In calculating the unrestricted risk, existing commercial production practices in Washington, Oregon or Idaho have already been considered, as have post-harvest procedures and packing of fruit.

In this section, Biosecurity Australia has identified risk management measures that may be applied to consignments of apple fruit sourced from Washington, Oregon and Idaho. In some cases, detailed efficacy data on treatments is not available. Such data need to be provided by the US 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.

Consideration of alternative measures

Consistent with the principle of equivalence detailed in ISPM 11: *Pest risk analysis for quarantine pests including analysis of environmental risks and living modified organisms* (FAO 2004), Biosecurity Australia will consider any alternative measure proposed by APHIS, providing that it achieves Australia's ALOP. Evaluation of such measures or treatments will require a technical submission from APHIS that details the proposed treatment and includes data from suitable treatment trials.

Table 5.1 Phytosanitary measures proposed for quarantine pests, for mature fresh apple fruit from the US Pacific Northwest states

Pest	Common name	Measures
Arthropods		
Cenopalpus pulcher	Flat scarlet mite	Visual inspection and remedial action[1] (600-apple inspection with remedial action if arthropods are found)
Phenacoccus aceris	Apple mealybug **EP**	
Pseudococcus maritimus	Grape mealybug EP	
Frankliniella occidentalis	Western flower thrips EP	
Frankliniella tritici	Eastern flower thrips	
Archips argyrospila	Fruit tree leafroller	Visual inspection and remedial action[1] (This may involve examination of a 600 cut fruit sample during the initial trade with remedial action if leafroller moths are found. Based on the results from the fruit cutting the need for fruit cutting in future seasons will be reviewed.)
Archips podana	Great brown twist moth, large fruit tree tortrix	
Archips rosana	European leafroller	
Argyrotaenia franciscana	Orange tortrix, Tortrix citrana	
Choristoneura rosaceana	Oblique-banded leafroller	
Hedya nubiferana	Green budworm	
Pandemis heparana	Dark fruit tree tortrix	
Pandemis pyrusana	Pandemis leafroller	
Spilonota ocellana	Eyespotted bud moth	
Dasineura mali	Apple leafcurling midge EP (ALCM)	Option 1: Pest free areas or pest free places of production or production sites (ISPM 4, 10) Option 2: Visual inspection and remedial action (3000-apple inspection with remedial action if ALCM is found) Option 3: Treatment (e.g. methyl bromide fumigation) of all export lots
Rhagoletis pomonella	Apple maggot	Option 1: Pest free areas or pest free places of production or production sites (ISPM 4, 10) Option 2: Treatment (e.g. methyl bromide fumigation) of all export lots

Pest	Common name	Measures
Cydia pomonella	Codling moth [WA, EP]	Option 1: Areas of low pest prevalence (ISPM 22) Option 2: Treatment (e.g. methyl bromide fumigation) of all export lots
Grapholita molesta	Oriental fruit moth [WA]	
Grapholita packardi	Cherry fruitworm	
Grapholita prunivora	Lesser appleworm	
Pathogens		
Erwinia amylovora	Fire blight [EP]	Areas free from disease symptoms (ISPM 4,10,22) and disinfection with chlorine solution
Coprinopsis psychromorbida	Coprinus rot	Systems approach • Orchard control • Orchard and packing house sanitation practices, including disinfection with chlorine solution • Visual inspection and remedial action
Mucor mucedo	Mucor rot	
Mucor piriformis	Mucor rot [WA]	
Mucor racemosus	Mucor rot [WA]	
Sphaeropsis pyriputrescens	Sphaeropsis rot	These pathogens are the causes of recently reported post-harvest diseases and there is no published data on effective control measures. BA will consult the US to propose measures, with supporting data, for review.
Phacidiopycnis piri	Phacidiopycnis rot	
Phacidiopycnis washingtonensis	Speck rot	
Neonectria ditissima	European canker [EP]	Option 1: Pest free areas (ISPM 4) Option 2: Pest free places of production (ISPM 10) Option 3: Areas of low pest prevalence (ISPM 22)
Phyllosticta arbutifolia	Apple blotch	Systems approach • Orchard control and surveillance • Visual inspection and remedial action
Gymnosporangium juniperi-virginianae	Cedar apple rust	
Gymnosporangium libocedri	Pacific Coast pear rust	
Venturia inaequalis	Apple scab [WA, EP]	Option 1: Pest free areas (ISPM 4) Option 2: Pest free places of production (ISPM 10)
Truncatella hartigii	Truncatella leaf spot	BA will consult the US to propose measures, with supporting data, for review.

Pest	Common name	Measures
Pseudomonas syringae pv. *papulans*	Blister spot	APHIS to provide, prior to each year of trade, a declaration that these pests are still not present in the PNW.
Lopholeucaspis japonica	Japanese baton shaped scale	
Parlatoria oleae	Olive parlatoria scale [WA]	
Pseudococcus calceolariae	Citrophilus mealybug [WA, EP]	
Pseudococcus comstocki	Comstock's mealybug [EP]	
Argyrotaenia velutinana	Redbanded leafroller	
Platynota flavedana	Variegated leafroller, rusty brown tortricid	
Platynota idaeusalis	Tufted apple budworm	
Platynota stultana	Omnivorous leafroller	
Pseudexentera mali	Pale apple leafroller	
Ostrinia nubilalia	European corn borer	
Sooty blotch and flyspeck fungi	Sooty blotch and flyspeck complex	
[1] Remedial action (depending on the location of the inspection) may include: treatment of the consignment to ensure that the pest is no longer viable; withdrawing the consignment from export to Australia; re-export of the consignment from Australia; or destruction of the consignment [EP]: Species has been assessed previously and for which import policy already exists [WA]: Quarantine pest for state of Western Australia		

5.1.1 Pest risk management for pests

Management for *Cenopalpus pulcher, Phenacoccus aceris, Pseudococcus maritimus, Frankliniella occidentalis* and *Frankliniella tritici*

Flat scarlet mite (*Cenopalpus pulcher*), mealybugs (*Phenacoccus aceris* and *Pseudococcus maritimus*) and thrips (*Frankliniella occidentalis* and *Frankliniella tritici*) were all assessed to have an unrestricted risk estimate of 'low'. This exceeds Australia's ALOP. Therefore, measures are required to manage this risk.

Visual inspection and remedial action

Various mite, mealybug and thrips species have been considered in previous import risk analyses and policy extensions undertaken by Biosecurity Australia. These external pests can be detected by trained quarantine inspectors using optical enhancement where necessary. Therefore, the standard 600-unit quarantine inspection undertaken by AQIS would be sufficiently effective at identifying consignments infested with any of these pests.

The objective of visual inspection is to ensure that consignments of apple fruit from the PNW infested with these pests are identified and subjected to appropriate remedial action. The remedial action will reduce the risk associated with flat scarlet mite, spider mites, mealybugs and thrips to a very low level to meet Australia's ALOP.

Remedial action, if required, could include any treatment known to be effective against the target pests. Currently, standard methyl bromide fumigation rates for external pests are recognised. However, Biosecurity Australia would also consider any other treatment that APHIS proposes, providing that it provides an equivalent level of protection.

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

Management for *Archips argyrospila, Archips podana, Archips rosana, Argyrotaenia franciscana, Choristoneura rosaceana, Hedya nubiferana, Pandemis heparana, Pandemis pyrusana* and *Spilonota ocellana*

Leafroller moth species (*Archips argyrospila*, *Archips fuscocupreanus*, *Archips podana*, *Archips rosana*, *Argyrotaenia franciscana*, *Choristoneura rosaceana*, *Hedya nubiferana*, *Pandemis heparana*, *Pandemis pyrusana* and *Spilonota ocellana*) were all assessed to have an unrestricted risk estimate of 'low'. This exceeds Australia's ALOP. Therefore, measures are required to manage this risk.

Visual inspection and remedial action

Various leafroller moth species have been considered in the *Import risk analysis for apples from New Zealand* (Biosecurity Australia 2006a). The proposed risk management measure for leafroller moths in New Zealand apple fruit was inspection and remedial action based on a 600-fruit sample from each lot.

Although leafroller moths are primarily external feeders, some species have been reported to also feed inside the fruit. For example, in Europe, larvae of *Pandemis heparana* was reported to feed on fruit pulp (INRA 1997). Larvae of *Platynota idaeusalis* occasionally enter the calyx and feed unnoticed within the seed cavity (Hull *et al*. 1995b).

Because of the uncertainty about the level of internal infestation of apple fruit by some leafroller moths, APHIS is requested to provide additional information on the level of internal infestation that may not be accompanied by obvious external symptoms. One approach to providing additional data could be the examination of a 600 cut fruit sample for the presence of internal larvae of leafroller moths during the initial trade of all lots in all packing houses that export apples to Australia. Based on the results from the fruit cutting during the initial trade the need for fruit cutting in future seasons will be reviewed. Australia would also consider any other information that quantifies the risk of internally feeding leafroller moths entering Australia with apple fruit.

The objective of visual inspection is to ensure that consignments of apple fruit from the PNW infested with these pests are identified and subjected to appropriate remedial action. The remedial action will reduce the risk associated with these pests to a very low level to meet Australia's ALOP.

Remedial action, if required, could include any treatment known to be effective against the target pests. Currently, standard methyl bromide fumigation rates for external pests are recognised. However, Biosecurity Australia would also consider any other treatment that APHIS proposes, providing that it provides an equivalent level of protection.

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

Management for *Dasineura mali*

Dasineura mali (apple leafcurling midge) was assessed to have an unrestricted risk estimate of 'low'. This exceeds Australia's ALOP, therefore, measures are required to manage this risk.

Dasineura mali has been considered in the *Import risk analysis for apples from New Zealand* (New Zealand apple IRA) (Biosecurity Australia 2006a). The New Zealand apple IRA assessed the option of visually inspecting 600 fruit from each lot and found it insufficient to mitigate the risk posed by *D. mali*. On the basis of this analysis, the first two risk management options (Option 1 and Option 2) have been identified:

Option 1: Visual inspection and remedial action

This option is proposed for apples from the PNW based on the assumption that prevalence of *D. mali* in the PNW is similar to that in New Zealand. A random sample of 3000 fruit from each lot is inspected. Where *D. mali* is found, a suitable treatment, e.g. fumigation with methyl bromide, is applied, or lots are rejected.

The objective of visual inspection is to ensure that consignments of apple fruit from the PNW infested with *D. mali* are identified and subjected to appropriate remedial action. The remedial action will reduce the risk associated with *D. mali* to a very low level to meet Australia's ALOP.

Remedial action, if required, could include any treatment known to be effective against the target pests. Currently, standard methyl bromide fumigation rates for external pests are recognised. However, Biosecurity Australia would also consider any other treatment that APHIS proposes, if it provides an equivalent level of protection.

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

Option 2: Treatment of all lots

This could include any treatment known to be effective against *D. mali*. Currently, standard methyl bromide fumigation rates for external pests are recognised. However, Biosecurity Australia would also consider any other treatment that APHIS proposes, if it provides an equivalent level of protection.

Where fumigation with methyl bromide is utilised as the measure for *D. mali*, it must be carried out for two hours according to the specifications below:

- 32 $g \cdot m^{-3}$ at a pulp temperature of 21°C or greater – minimum concentration time (CT) product of 47 $g \cdot h \cdot m^{-3}$; or
- 40 $g \cdot m^{-3}$ at a pulp temperature of 16°C or greater – minimum CT product of 58 $g \cdot h \cdot m^{-3}$; or
- 48 $g \cdot m^{-3}$ at a pulp temperature of 10°C or greater – minimum CT product of 70 $g \cdot h \cdot m^{-3}$.

It is proposed that fruit should not be fumigated if the pulp temperature is below 10°C and that fumigations should be carried out in accordance with AQIS fumigation standards (AQIS 2008).

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 ($g \cdot m^{-3}$)
- CT product of methyl bromide achieved by the fumigation ($g \cdot h \cdot m^{-3}$)
- the fumigation duration (hours)
- ambient air temperature during fumigation (°C)
- minimum fruit pulp temperature during fumigation (°C).

Based on the information that in the PNW, *D. mali* is currently recorded only in western Washington, the third option is a measure that may be applied to manage the risk posed by *D. mali*.

Option 3: Pest free areas or pest free places of production or production sites

Pest free areas and pest free places of production or production sites are measures that may be applied to manage the risk posed by *D. mali*. The requirements for establishing pest free areas are set out in ISPM No. 4: *Requirements for the establishment of pest free areas* (FAO 1996). The requirements for establishing pest free places of production are set out in ISPM No. 10: *Requirements for the establishment of pest free places of production and pest free production sites* (FAO 1999).

APHIS would be responsible for the establishment and maintenance of pest free areas or pest free places of production or production sites by official surveys and monitoring. These survey results must be submitted to DAFF before access could be considered.

Management for *Rhagoletis pomonella*

Rhagoletis pomonella (apple maggot) was assessed to have an unrestricted risk estimate of 'moderate', which exceeds Australia's ALOP. Measures are therefore required to manage this risk.

As apple maggot larvae feed internally, visual inspection alone is not 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.

Rhagoletis pomonella has not previously been considered in other import policies, and no approved quarantine measures exist for this pest. *Rhagoletis pomonella* is present in all three exporting states. APHIS stated that the exporting states regulate entry of fresh apples from states in which *R. pomonella* is known to occur and operate intrastate quarantines controlling the movement of apples from *R. pomonella* quarantine areas (APHIS 2008).

Proposed risk management options for *R. pomonella* include:

Option 1: Pest free areas or pest free places of production or production sites

Pest free areas and pest free places of production or production sites are measures that may be applied to manage the risk posed by *R. pomonella*. The requirements for establishing pest free areas are set out in ISPM No. 4: *Requirements for the establishment of pest free areas* (FAO 1996). The requirements for establishing pest free places of production or production sites are set out in ISPM No. 10: *Requirements for the establishment of pest free places of production and pest free production sites* (FAO 1999).

APHIS would be responsible for the establishment and maintenance of pest free areas or pest free places of production or production sites by official surveys and monitoring. These survey results must be submitted to DAFF before access could be considered.

Option 2: Treatment of all lots

This could include any treatment known to be effective against *R. pomonella*. Biosecurity Australia would consider any treatment that APHIS proposes, if it provides an equivalent level of protection.

Management for *Cydia pomonella, Grapholita molesta, Grapholita packardi* and *Grapholita prunivora*

Cydia pomonella (codling moth), *Grapholita molesta* (oriental fruit moth), *Grapholita packardi* (cherry fruitworm) and *Grapholita prunivora* (lesser appleworm) were all assessed to have an unrestricted risk estimate of 'low'. This exceeds Australia's ALOP. Therefore, measures are required to manage this risk. Because of the similar biology and related symptomatology of the four species, their pest risk management is considered together.

Cydia pomonella and *Grapholita molesta* are quarantine pests of concern only for Western Australia. *Grapholita packardi* and *Grapholita prunivora* are quarantine pests of concern for the whole of Australia.

Visual inspection of fruit alone may not be an appropriate risk management measure for these species, because signs of infestation may not be visible. In the New Zealand apple IRA, three options were evaluated in detail with a view to manage risks associated with *C. pomonella* on fruit to be imported into Western Australia. These options were (i) sourcing fruit from pest free areas or pest free places of production, (ii) sourcing fruit from areas of low pest prevalence, and (iii) methyl bromide fumigation.

Cydia pomonella, *Grapholita molesta*, *G. packardi* and *G. prunivora* are widely distributed throughout apple growing areas of North America (Moffitt and Willett 1993; Hollingsworth 2008). *Grapholita molesta* is a key pest of apples in Washington (Hollingsworth 2008), *and C. pomonella* is a key pest of apples in all three exporting states (Brunner *et al*. 2002). Therefore, Biosecurity Australia has considered that sourcing fruit from pest free areas or pest free places of production (option (i) evaluated in the New Zealand apple IRA) is not feasible for this IRA. The latter two options evaluated in the New Zealand apple IRA may be applied to apples from the US PNW states.

Biosecurity Australia proposes two risk management options for *C. pomonella*, *G. molesta*, *G. packardi* and *G. prunivora*:

Option 1: Areas of low pest prevalence

Low pest prevalence is a measure that may be applied to manage the risk posed by *Cydia pomonella*, *Grapholita molesta*, *G. packardi* and *G. prunivora*. The requirements for establishing areas of low pest prevalence are set out in ISPM No. 22: Requirements for the establishment of areas of low pest prevalence (FAO 2005). Components of such a program could include:

- registration of grower designated production sites
- monitoring and trapping for the listed species
- specific control requirements for the listed species
- specific requirements for submission of fruit to packing houses
- grower compliance agreements.

APHIS would be responsible for the establishment of areas of low pest prevalence by official surveys and monitoring. These survey results must be submitted to DAFF before access could be considered.

Option 2: Treatment of all lots

This could include any treatment known to be effective against these pests. Currently, standard methyl bromide fumigation rates for external pests are recognised. However, Biosecurity Australia would also consider any other treatment that APHIS proposes, if it provides an equivalent level of protection.

Where fumigation with methyl bromide is utilised as the measure for the listed species, it must be carried out for two hours according to the specifications listed under the management for *D. mali* on page 247.

The objective of these measures is to reduce the likelihood of importation for the listed species to at least 'very low'. The restricted risk would then be reduced to at least 'very low', which would achieve Australia's ALOP.

Management for *Erwinia amylovora*

The unrestricted risk of *Erwinia amylovora* (fire blight) has been assessed as 'low'. This exceeds Australia's ALOP, therefore, measures are required to manage this risk.

The risk pathway of concern to export with regard to fire blight is epiphytic infestation of fruit with *E. amylovora* (Biosecurity Australia 2006a). Such fruit rarely express symptoms.

Symptomless fruit infested by *E. amylovora* will not be detected by fruit inspection. Therefore, the New Zealand apple IRA assessed three management measures and their combinations with a view to mitigating the unrestricted risk by reducing the probability of importation: (i) sourcing fruit from areas free from disease symptoms, (ii) disinfection with chlorine and (iii) storage. The New Zealand apple IRA found that a combination of the former two measures (sourcing fruit from areas free from disease symptoms and disinfection with chlorine) was necessary to reduce the risk associated with *E. amylovora* to 'very low', which would achieve Australia's ALOP. Storage alone or in combination with any single other measure was insufficient to achieve this. The combination of sourcing fruit from areas free from disease symptoms and disinfection with chlorine can be applied to apples from the US PNW states.

Sourcing apples for export from areas established, maintained and verified free from *E. amylovora* ('pest free areas'), in accordance with the guidelines outlined in ISPM No. 4: *Requirements for the establishment of pest free areas* (FAO 1996) would reduce the likelihood of importation of *E. amylovora* and thereby mitigate the risks. However, this option was not considered feasible, given that *E. amylovora* is widely distributed in apple-growing areas of the US PNW states and there is no feasible way to verify if bacteria are present in orchards or not.

However, individual apple orchards in the US PNW states can be maintained free from fire blight disease symptoms ('areas free from disease symptoms') through the use of various management practices. Such orchards are known to have lower levels of bacteria associated with fruit than orchards where symptoms are evident. Similarly, treatments with chlorine and cold storage of apples have been reported to significantly reduce bacterial numbers.

Combining areas free from disease symptoms and chlorine treatment would reduce the restricted risk estimate for *E. amylovora* to 'very low', which meets Australia's ALOP.

Areas free from disease symptoms

Areas free from disease symptoms, as distinct from pest free areas, could be established and maintained following the guidelines described in ISPM No. 4: *Requirements for the establishment of pest free areas* (FAO 1996), ISPM No. 10: *Requirements for the establishment of pest free places of production and pest free production sites* (FAO 1999) and ISPM No. 22*: Requirements for the establishment of areas of low pest prevalence* (FAO 2005). An area free from disease symptoms could be a place of production (an orchard managed as a single unit) or a production site (a designated block within an orchard), for which freedom from fire blight symptoms is established, maintained and verified by APHIS.

The New Zealand apple IRA acknowledged that it would be extremely difficult to confirm absolute freedom from symptoms using visual inspection of orchards. The IRA team concluded that a practical inspection regime should be specified as free from visual symptoms at an inspection intensity that would, at a 95% confidence level, detect visual symptoms if shown by 1% of the trees. This inspection should take place between 4–7 weeks after flowering when conditions for fire blight disease development are likely to be optimal.

Disinfection with chlorine

In general, apple fruit in the US move through a cleaning process in the packing house, often involving chlorinated water or detergent to remove dirt, spray residue and natural wax (Tao 2003).

The principles and practices of application relating to chlorine are well understood. However, it is acknowledged that there are several other bactericidal agents (Ecowise Environmental 2005) that may be equally effective in this application.

Chlorine is known to have strong biocidal properties against a wide range of organisms (Dychdala 1991). It is highly effective against non-spore-forming bacteria, but also to a lesser extent against spore forming bacteria, fungi, algae, protozoa and viruses. Bacteria in suspension are killed very quickly by concentrations of chlorine as low as 5 ppm (Somers 1951), with 50–200 ppm used with a contact time of 1–2 minutes for sanitization of produce for food safety (Parish *et al*. 2003). However, it is recognised that chlorine has poor penetrating powers and is less effective in situations where there are high organic matter loads (Ecowise Environmental 2005). Low temperatures when treating apples from cold storage may also reduce the effectiveness of chlorine. Nevertheless, even in these situations, if chlorine concentration and pH levels are maintained correctly, at least a 10 to 100 fold reduction in the bacterial numbers in solution can be expected.

Chlorine treatment could be applied in the routine packing house process by incorporating chlorine in the floatation tanks and maintaining its concentration at a minimum of 100 ppm free chlorine with a pH range from 5–6. The system of application would need to ensure that fruit is fully exposed to this active concentration for the full time period (1 minute) and prevent subsequent contamination after treatment.

If all packing houses were to treat apples with a minimum of 100 ppm free chlorine, then the risk of *E. amylovora* being present in or on apples for export would be reduced. Bacteria occurring as surface contaminants on the fruit and on associated soil, trash, etc. would mostly be killed when exposed for one minute to 100 ppm free chlorine treatment in the packing house. However, the chlorine treatment would not be fully effective against bacteria protected in the tissue, including those occurring in infested calyces.

Management for *Coprinopsis psychromorbida, Mucor mucedo, Mucor piriformis* and *Mucor racemosus*

Mucor mucedo, *M. piriformis* and *M. racemosus*, which all cause Mucor rot, were assessed to have an unrestricted risk estimate of ‘low’. This exceeds Australia’s ALOP. Therefore, measures are required to manage this risk.

Mucor piriformis and *M. racemosus* are quarantine pests of concern for Western Australia. *Mucor mucedo* is a quarantine pest of concern for the whole of Australia.

Visual inspection of fruit alone is not considered to be an appropriate management option for these pathogens as external signs of infection are not always present and there may be latent infections. Biosecurity Australia proposes sanitation practices to be implemented both in orchards and in packing houses, in addition to visual inspection, to reduce the risk associated with these pathogens to an acceptable level.

Most losses due to Mucor rot are associated with unsanitary practices (Smith *et al.* 1979). A range of sanitation practices is recommended in the literature to control Mucor rot (Spotts

1990b; Washington and Holmes 2006). The aim of the proposed sanitation practices is to prevent contamination of fruit in the field, in the packing house and in storage.

Chlorine reduces germination of *M. piriformis* sporangiospores. At concentrations of 50 mg/L (ppm) and 5 mg/L (ppm), chlorine completely prevents germination of sporangiospores after 0.5 min and 10 min, respectively (Spotts and Peters 1980). It has been shown to kill spores of *M. piriformis* suspended in solution, but may not be effective on spores lodged within wounds and injuries on the fruit (Bertrand and Saulie Carter 1979; Spotts and Peters 1980).

High humidity seems to promote decay caused by infection with *Mucor* species. The incidence of infection in dry weather is lower than in wet weather (Bertrand and Saulie-Carter 1980) and lowering the humidity in storage reduces the incidence of Mucor rot (Michailides and Spotts 1990a).

Orchard and packing house sanitation practices

Registered growers and registered packing house operators would need to implement a range of sanitation practices in the orchards and in the packing houses, respectively. These sanitation practices would need to be approved by APHIS.

Orchard sanitation practices for these pathogens would include:

- clean bins pre-harvest
- minimise build up of soil and debris on the underside of bins during picking
- harvest fruit in dry weather
- do not use fruit that has fallen to the ground for export
- avoid fruit injuries
- remove fallen fruit from the orchard after harvest.

Packing house sanitation practices for these pathogens would include:

- disinfect fruit with chlorine (100 ppm free chlorine for a minimum of 1 minute at pH 5–6)
- rinse fruit thoroughly with fresh water to remove spores
- dry fruit before placing into storage
- avoid fruit injuries.

Many of these proposed sanitation practices are normal practice in the US. However, this must be documented and is subject to audit by APHIS and AQIS.

The objective of all these measures is to reduce the likelihood of importation for these pathogens to at least ‘very low’. The overall probability of entry would then be reduced to ‘very low’. Subsequently, the overall probability of entry, establishment and spread would be reduced to ‘very low’. When this was combined with the ‘low’ estimate of consequences, the restricted risk for these pathogens achieved Australia’s ALOP.

Management for *Gymnosporangium clavipes*, *Gymnosporangium juniperi-virginianae*, *Gymnosporangium libocedri* and *Phyllosticta arbutifolia*

Gymnosporangium clavipes (quince rust), *Gymnosporangium juniperi-virginianae* (cedar apple rust), *Gymnosporangium libocedri* (pacific coast pear rust) and *Phyllosticta arbutifolia* (apple blotch) were assessed to have an unrestricted risk estimate of ‘low’. This exceeds Australia’s ALOP. Therefore, measures are required to manage this risk.

Visual inspection of fruit alone is not considered to be an appropriate management option for these pathogens, as external signs of infection are not always present and there may be latent infections. Biosecurity Australia proposes orchard control and surveillance in addition to visual inspection to reduce the risk associated with these pathogens to an acceptable level.

Orchard control and surveillance

Registered growers would need to implement an orchard control program (i.e. acceptable agricultural practice and integrated disease management (IDM) program for export apples). Programs would need to be approved by APHIS, and incorporate field sanitation and appropriate fungicide applications for the management of pathogens of quarantine concern to Australia.

APHIS would be responsible for ensuring that export apple growers are aware of diseases of quarantine concern to Australia, field sanitation and control measures. Registered growers would be required to keep records of control measures for auditing purposes. Details of the pathogen control program would need to be provided to DAFF by APHIS before trade commenced.

Orchard control and surveillance for these pathogens would include:

- Monitoring/detection surveys for diseases that require orchard management measures must be conducted regularly by APHIS in orchards registered for export to verify the effectiveness of the measures. APHIS will maintain annual survey results using a standard reporting format. These results must be made available to DAFF if requested.
- APHIS would be required to inspect all export orchards prior to harvest for *G. juniperi-virginianae*, *G. libocedri* and *P. arbutifolia* to ensure that they are free from symptoms of the diseases. The inspection method, including details of the timing and size of the sampling to be undertaken for each orchard, appropriate for these diseases would be developed by APHIS. Results of the inspections would subsequently be made available to DAFF for auditing purposes.
- For *G. clavipes*, *G. juniperi-virginianae* and *G. libocedri*, Australia proposes the removal of the juniper hosts (*Juniperus* spp. and *Calocedrus decurrens*) of the telial stage located within 2 km of orchards registered for export to Australia. This is consistent with the requirements for *G. asiaticum* (Japanese pear rust) and *G. sabinae* (European pear rust) for pears from China (Biosecurity Australia 2005a). As it may be difficult to remove alternate hosts completely, alternative measures such as controlling the diseases on the telial host, as suggested below, may be preferable.
- Rather than removal of the telial hosts (*Juniperus* spp. and *Calocedrus decurrens*), an alternative approach is for APHIS to ensure a chemical control program is in place to combat the disease in both the apple orchards as well as any surrounding telial hosts within 2 km. Documented evidence of effective control, i.e. spraying *Juniperus* spp. and *Calocedrus decurrens* in spring in addition to orchard trees, would be required. This

approach was recommended for management of *G. yamadae* for the import of apples from Japan (AQIS 1998a).

The objective of all these measures is to reduce the likelihood of importation for these pathogens to at least 'very low'. The overall probability of entry would then be reduced to 'very low'. Subsequently, the overall probability of entry, establishment and spread would be reduced to 'very low'. When this was combined with the 'moderate' estimate of consequences, the restricted risk for these pathogens achieved Australia's ALOP.

Management for *Sphaeropsis pyriputrescens, Phacidiopycnis piri, Phacidiopycnis washingtonensis* and *Truncatella hartigii*

Sphaeropsis pyriputrescens (causing Sphaeropsis rot), *Phacidiopycnis piri* (causing Phacidiopycnis rot), *Phacidiopycnis washingtonensis* (causing speck rot) and *Truncatella hartigii* (causing truncatella leaf spot) were all assessed to have an unrestricted risk estimate of 'low'. This exceeds Australia's ALOP. Therefore, measures are required to manage this risk.

Sphaeropsis pyriputrescens, *Phacidiopycnis piri*, *Phacidiopycnis washingtonensis* and *Truncatella hartigii* have not previously been considered in other import policies, and no approved quarantine measures exist for these pests. Biosecurity Australia, in its letter of 21 July 2009, has requested APHIS to advise on measures that might be applied to effectively reduce the level of risks associated with these pests in line with Australia's ALOP. Development of final import conditions depends on APHIS proposing the measures and providing additional scientific information supporting the efficacy of the proposed measures.

These pests have been reported as post-harvest decay pathogens on apple fruit. Infected fruit usually exhibit symptoms after some period of storage. Where pre-clearance is used, the commodity must be despatched for export to Australia within 28 days. This is the period of time that a phytosanitary inspection/certification would normally be considered valid by AQIS.

Management for Neonectria ditissima

The unrestricted risk of *Neonectria ditissima* (European canker) has been assessed as 'low'. This exceeds Australia's ALOP. Therefore, measures are required to manage this risk.

The risk pathway of greatest concern to export with regard to *N. ditissima* is symptomless infection of fruit that cannot be detected by inspection.

Inspection of fruit cannot detect symptomless infection. Therefore, the following three options were evaluated in the New Zealand apple IRA in detail with a view to mitigating the unrestricted risk by reducing the probability of importation by sourcing fruit from: (i) pest free areas (ii) pest free places of production and (iii) areas of low pest prevalence. These options can equally be applied to apples from the US PNW states.

Option 1: Pest free areas

A pest free area, as described in ISPM No. 4: *Requirements for the establishment of pest free areas* (FAO 1996), would require systems to be put in place by APHIS to establish, maintain and verify that *N. ditissima* does not occur within that area. Freedom from *N. ditissima* in an area would reduce the overall probability of entry to 'very low'. Subsequently, the overall probability of entry, establishment and spread would be reduced to 'very low'. When this was combined with the 'moderate' estimate of consequences, the restricted risk for *N. ditissima* achieved Australia's ALOP.

APHIS claimed that *N. ditissima* has not been reported to occur in the major apple producing regions of central Washington State, as the climate in these areas is not suitable to the development of the disease. While the option of a pest free area is available, *N. ditissima* (as *N. galligena*) has been reported to occur in all exporting states: Washington, Oregon and Idaho (APHIS 2007a; Glawe 2009) and is an important disease of apple and pear in cool, moist areas of western Oregon and Washington (Grove 1990a). Extensive detection and delineating surveys, including inspection of alternative host plants would be required to confirm pest free areas. Similarly, the establishment and maintenance of pest free areas would need to be relevant to the biology of *N. ditissima*, including its means of spread.

Infected nursery stock presents a pathway for establishment and spread of *N. ditissima*. As there are no restrictions on the movement of fruit and planting materials within the US to stop the transfer of *N. ditissima* from one area to another, maintenance of pest free areas may not be a technically feasible option except with continuous inspection and verification of freedom.

Biosecurity Australia would consider any technical data forwarded by APHIS to support establishment of the pest free areas.

Option 2: Pest free places of production

A second option to mitigate the annual risk of *N. ditissima* is to source apples from export orchards free of the pathogen, that is to establish pest free places of production as outlined in ISPM No.10: *Requirements for the establishment of pest free places of production and pest free production sites* (FAO 1999). A pest free place of production could be a place of production (an orchard managed as a single unit) or a production site (a designated block within an orchard), for which freedom from European canker symptoms is established, maintained and verified by APHIS, and supported by the appropriate documentation.

Option 3: Areas of low pest prevalence

A third option to mitigate the annual risk is to source apples from areas of low pest prevalence (ALPP) as specified in ISPM No 22: *Requirements for the establishment of areas of low pest prevalence* (FAO 2005). When establishing an ALPP, the exporting country is required to meet a number of requirements including establishing the specified level of the relevant pest to sufficient precision, recording and maintaining surveillance and control activities for a sufficient number of years and identifying and regulating pathways of entry. The US should also describe the ALPP with supporting maps demonstrating the boundaries of the area. The US would need to provide such information for this option to be considered by Biosecurity Australia. Further, it is not known if specific surveillance targeted at this pest is being done in the US and there is no evidence of regulation of entry to new areas through pathways such as nursery plants or control activities recorded for a sufficient number of years.

The objective of these measures is to reduce the probability of entry, establishment and spread for *N. ditissima* to at least 'very low'. The overall probability of entry would then be reduced to 'very low'. Subsequently, the overall probability of entry, establishment and spread would be reduced to 'very low'. When this was combined with the 'moderate' estimate of consequences, the restricted risk for *N. ditissima* achieved Australia's ALOP.

Management for *Venturia inaequalis*

Venturia inaequalis (apple scab) is a pest of concern only for Western Australia, as the disease is present throughout apple production areas of eastern Australia. The movement of mature apple fruit and apple nursery stock from the rest of Australia into Western Australia is currently prohibited, because of the lack of risk management measures that would achieve Australia's ALOP for the disease based on regional freedom.

The unrestricted risk of *Venturia inaequalis* has been assessed as 'moderate'. This exceeds Australia's ALOP. Therefore, measures are required to manage this risk.

The risk pathway of greatest concern to export with regard to *V. inaequalis* is symptomless (latent) infection and infestation of fruit that cannot be detected by inspection. Therefore, inspection cannot be used in the evaluation of options to reduce the risk resulting from symptomless infection or infestation by *V. inaequalis*.

In the unrestricted risk assessment for *V. inaequalis* in the New Zealand apple IRA (Biosecurity Australia 2006a), packing house procedures were considered for their effectiveness in eliminating the pathogens. This includes the use of sanitisers and short-term cold storage by some packing houses. There is no evidence in the literature that suggests any of these procedures mitigate symptomless infection. Therefore, it is not feasible to seek measures to reduce the risk of *V. inaequalis* during packing house processes.

Two options were evaluated in the New Zealand apple IRA in detail with a view to mitigating the unrestricted risk by reducing the probability of importation by sourcing fruit from: (i) pest free areas and (ii) pest free places of production. These options can equally be applied to apples from the US PNW states.

Option 1: Pest free areas

A pest free area, as described in ISPM No. 4: *Requirements for the establishment of pest free areas* (FAO 1996) would require systems to be put in place by APHIS to establish, maintain and verify that *V. inaequalis* does not occur within that area.

While the option of a pest free area is available, *V. inaequalis* has been reported in apple production areas of Washington, Oregon and Idaho (APHIS 2007a). Although apple scab caused by *V. inaequalis* is more common in areas of relatively high rainfall and high relative humidity, such as west of the Cascade Range, the disease outbreak can also occur in drier areas, such as central Washington, Hood River, and eastern and southern Oregon (Pscheidt 2008b). Extensive detection and delineating surveys, including inspection of alternative host plants would be required to confirm pest free areas. Similarly, the establishment and maintenance of pest free areas would need to be relevant to the biology of *V. inaequalis*, including its means of spread.

Infected nursery stock and apple fruit presents a pathway for establishment and spread of *V. inaequalis*. As there are no restrictions on the movement of planting stock or apple fruit within the US to stop the transfer of *V. inaequalis* from one area to another, maintenance of pest free areas may not be technically feasible except with continuous inspection and verification of freedom. Biosecurity Australia would consider any technical data forwarded by APHIS to support establishment of the pest free areas.

Option 2: Pest free places of production

An alternative option to mitigate the risk of *V. inaequalis* is to source apples from export orchards free of the disease, that is, establish pest free places of production as outlined in

ISPM No. 10: *Requirements for the establishment of pest free places of production and pest free production sites* (FAO 1999). A pest free place of production could be a place of production (an orchard managed as a single unit) or a production site (a designated block within an orchard), for which freedom from apple scab symptoms is established, maintained and verified by APHIS, and supported by the appropriate documentation.

While the option of pest free places of production is available, *V. inaequalis* has been reported from apple production areas of different climate characteristics in the exporting states. Therefore, extensive detection and delineating surveys, including inspection of alternative host plants would be required to confirm pest free places of production. Similarly, the establishment and maintenance of pest free places of production would need to be relevant to the biology of *V. inaequalis*, including its means of spread.

Infected nursery stock and apple fruit presents a pathway for establishment and spread of *V. inaequalis.* As there are no restrictions on the movement of planting stock or apple fruit within the US to stop the transfer of *V. inaequalis* from one area to another, maintenance of pest free places of production may not be technically feasible except with continuous inspection and verification of freedom. Biosecurity Australia would consider any technical data forwarded by APHIS to support establishment of the pest free places of production.

The objective of these measures is to reduce the probability of entry, establishment and spread for *V. inaequalis* to at least 'very low'. The overall probability of entry would then be reduced to 'very low'. Subsequently, the overall probability of entry, establishment and spread would be reduced to 'very low'. When this was combined with the 'moderate' estimate of consequences, the restricted risk for *V. inaequalis* achieved Australia's ALOP.

5.1.2 Operational system for the maintenance and verification of phytosanitary status

A system of operational procedures is necessary to maintain and verify the phytosanitary status of mature fresh apple fruit from the US PNW states: Washington, Oregon and Idaho. This is to ensure that the proposed risk management measures have been met and are maintained.

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 apple fruit from Washington, Oregon and Idaho would include the following:

Registration of export orchards

The objectives of this proposed procedure are to ensure that:

- Apple fruit is sourced only from APHIS-registered export orchards producing export quality fruit, as the pest risk assessments are based on existing commercial production practices
- Export orchards from which apple fruit is sourced can be identified. This is to allow traceback 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 apple fruit for export to Australia.

All export orchards (entire orchard) or orchard blocks (an identified part of an orchard) supplying apples for export to Australia must be registered with APHIS in winter before the start of each apple season. This is to allow the inspection for symptoms of fire blight and European canker to take place for the production season.

Growers must provide APHIS with sufficient detail that clearly identifies the boundaries of the orchard or orchard block. This may be identified by maps or physical landmarks that can be used to define boundaries. Growers must retain copies of orchard descriptions/maps for audit purposes.

APHIS must allocate each export orchard or orchard block a unique registration number to enable traceback.

Growers/packing houses must have approved documented systems, including appropriate records, in place ensuring that apples destined for Australia are harvested only from orchards or orchard blocks that are registered for Australia.

Growers must provide access to registered orchard or orchard blocks for the purpose of monitoring/surveillance for compliance with the requirements for freedom from specified disease symptoms and arthropods.

APHIS would be responsible for ensuring that export apple growers are aware of pests of quarantine concern to Australia, field sanitation and control measures. The hygiene of export orchards must be maintained by appropriate pest management options that have been approved by APHIS to manage pests of quarantine concern to Australia. Registered growers would be required to keep records of control measures for auditing purposes. If required, the details of the pest control program would need to be provided to DAFF by APHIS before trade commenced.

Orchard inspection

Requirements for registered orchards/blocks to be inspected for fire blight and European canker have been considered in the New Zealand apple IRA (Biosecurity Australia 2006a). These requirements can equally be applied to this IRA for apples from the US Pacific Northwest states.

Fire blight

Orchards will be inspected at an inspection intensity that would, at a 95% confidence level, detect visual symptoms if shown by 1% of the trees. This inspection should take place between 4–7 weeks after flowering when conditions for development of fire blight disease are likely to be optimal. APHIS must provide details of the proposed inspection methodology, including an analysis showing that the methodology will achieve the required efficacy, in advance of commencement of exports. This analysis must address practical issues such as visibility of symptoms in the tops of trees, the inspection time needed and the number of trees to be inspected to meet the efficacy level, and training and certification of inspectors. The proposed system will need to be approved before the commencement of trade.

The detection of any visual symptoms of fire blight would result in the suspension of the orchards/blocks for the season.

Any evidence of pruning or other activities carried out before the inspection that could constitute an attempt to remove or hide symptoms of fire blight may result in the suspension of the orchard/block for the season.

European canker

Risk management for European canker is based on establishing that export orchards/blocks are pest-free places of production. The requirements are:

- Orchards/blocks are inspected for symptoms of European canker after leaf fall and before winter pruning.
- Orchards/blocks in areas less conducive for the disease are inspected for symptoms by walking down every row and visually examining all trees on both sides of each row.
- Areas more conducive for the disease are inspected using the procedure above combined with inspection of the upper limbs of each tree using ladders (if needed).
- Detection of European canker would result in suspension of exports in that orchard/block for the season. Reinstatement would require eradication of the disease, confirmed by inspection.

Registration of packing house and auditing of procedures

The objectives of this proposed procedure are to ensure that:

- Apple fruit is sourced only from APHIS registered packing houses processing export quality fruit, as the pest risk assessments are based on existing commercial packing activities.
- Reference to the packing house and the orchard source (by name or a number code) are clearly stated on cartons destined for export of mature fresh apple fruit to Australia for traceback and auditing purposes.

All apples for export to Australia must be processed by registered packing houses.

All packing houses intending to export apple fruit to Australia will have to be registered with APHIS before commencement of harvest each season. APHIS must allocate each export packing house a unique registration number to enable traceback. The list of registered packing houses must be kept by APHIS and provided to AQIS prior to exports commencing, with updates provided if packing houses are added or removed from the list.

Each packing house must have an approved documented system for traceability, including record keeping of receival receipts, orchard and/or orchard block registration numbers, storage, packing and load-out records.

APHIS would be responsible for ensuring that packing house operators are aware of pests of quarantine concern to Australia, packing house sanitation and control measures. Registered packing house operators would be required to keep records of control measures for auditing purposes. If required, the details of the pathogen control program would need to be provided to DAFF by APHIS before trade commenced.

APHIS will inspect packing houses during the packing and storage of export apples to monitor and verify that the necessary requirements are met, including measures to prevent contamination of fruit and packing materials with quarantine pests and other regulated articles.

APHIS will conduct audit checks on registered packing houses to monitor the measures taken to prevent mixing or substituting apples destined for export to Australia with other apples.

APHIS must immediately suspend exports from packing houses found to be non-compliant and must notify AQIS of the suspension.

Suspended packing houses may only be reinstated for processing of apples for export to Australia when APHIS and AQIS are satisfied that non-compliance issues have been adequately addressed.

APHIS must make available to AQIS, on request, information on its supervisory activities in relation to packing houses.

Disinfection and/or disinfestation

Disinfection treatment of apples in the packing house is a mandatory requirement. The operational procedures based on the use of chlorine have been considered in the New Zealand apple IRA (Biosecurity Australia 2006a). These procedures can equally be applied to apples from the US PNW states.

All apples for export to Australia must be completely immersed in a water solution containing a minimum of 100 ppm available, free chlorine for a minimum of one minute.

Packing houses must have a documented system approved by APHIS for measuring the available chlorine and pH levels in the water and ensuring that the available chlorine levels do not fall below 100 ppm. This system is subject to audit by AQIS.

The pH must be kept between 5 and 6.

The level of available chlorine in the water must be maintained at or above the required level. The available chlorine and pH must be monitored and adjusted as required at the start of packing each day and at least every two hours throughout the packing processes.

Records of all chlorine monitoring, top-up and pH levels, including when water is replaced, must be maintained and available for audit.

Packing houses must have an approved system in place to limit the build-up in the chlorine treatment tank of extraneous organic matter, including leaves, stems, twigs, bark, grass, weeds, soil, clay, slime, or any other material that would interfere with the chlorine treatment.

Other agents may be as effective as chlorine. APHIS would need to submit supporting documentation on efficacy and maintenance of active concentrations for other agents for approval by AQIS.

Packing houses must ensure that all grading and packing equipment that comes in direct contact with apples is cleaned and disinfected using an approved disinfectant, e.g. sodium hypochlorite solution, immediately before each Australian packing run. Maintenance of good hygiene on the packing line is normal practice in the US. However, this must be documented and is subject to audit by APHIS and AQIS.

Packaging and labelling

The objectives of this proposed procedure are to ensure that:

- Apple fruit proposed for export to Australia is not contaminated by quarantine pests or regulated articles. Regulated articles are defined as any items other than apple fruit. This may include leaf material, woody plant material, weeds, weed seeds, or any other contaminants, often referred to as ‘trash’.

- Unprocessed packing material (which may vector pests identified as not on the pathway and pests not known to be associated with apple fruit) is not imported with the apple fruit.
- All wood material used in packaging of apple fruit complies with the AQIS conditions, e.g. those in "*Cargo containers: quarantine aspects and procedures*" (AQIS 2009).
- All cartons are labelled with the orchard/block registration number, packing house registration number and date of packing.
- Palletised product is identified by attaching a uniquely numbered pallet card to each pallet or part pallet to enable traceback to registered orchards/blocks and packing houses.
- The pre-cleared status of apple fruit is clearly identified by pallet card number.
- Lots which are rejected are withdrawn from the Australian program. Failed lots are identified with an appropriate label or sticker and be kept separate from other passed product awaiting inspection.

Specific conditions for storage and movement

The objective of this proposed procedure is to ensure that the phytosanitary status of the product is maintained during storage and movement.

Packed product and packaging is to be protected from pest contamination during and after packing, during storage and during movement between locations (that is, packing house to cool storage/depot, to inspection point, to export point). Product for export to Australia that has been inspected and certified by APHIS must be maintained in secure conditions that will prevent mixing with fruit for domestic consumption or for export to other destinations. Security of the consignment is to be maintained until release from quarantine in Australia.

Arrangements for secure storage and movement of produce are to be developed by APHIS in consultation with Biosecurity Australia/AQIS.

Declaration of pest status in the Pacific Northwest

For pests listed in Table 4.1b, due to the current lack of their records from the PNW, their importation risk is currently considered to be 'extremely low' and the overall risk associated with these pests is currently considered to achieve Australia's ALOP. There is no evidence of official control measures in place to prevent the spread of these pests into the PNW. Therefore, prior to each year of trade, APHIS will be required to provide a declaration that pests listed in Table 4.1b are still not present in the US PNW states. If a declaration is not provided, Biosecurity Australia reserves the right to review the import policy, which may include the institution of management measures to address risks associated with these pests.

Pre-export phytosanitary inspection and certification

The objective of this proposed procedure is to provide formal documentation to AQIS verifying that the relevant measures have been undertaken offshore.

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 (ISPM) No. 7: *Export Certification Systems* (FAO 1997).

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 have been established will result in the loss of the relevant pest status. Records of the interceptions made during these inspections (live quarantine pests, dead quarantine pests 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.

Each phytosanitary certificate is to contain the following information:

- Reference to the shipping container number and container seal number, or flight number
- Full description of the consignment, including registered packing house number, and registered orchard/block number/s.
- Additional declaration: 'The apples in this consignment have been produced in the US PNW states in accordance with the conditions governing the entry of mature fresh apple fruit from the US PNW states to Australia.'

Pre-clearance and on-arrival phytosanitary inspection by AQIS

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

A phytosanitary inspection of lots covered by each phytosanitary certificate issued by APHIS will be undertaken by AQIS either in the US (mandatory or voluntary) as a pre-clearance, or on arrival of the consignment in Australia. The inspection will be conducted using the standard AQIS inspection protocol for the type of commodity using optical enhancement where necessary. The sample size for inspection of apple fruit is given below.

Consignment size	Sample size
1–450 apples	100 per cent of the consignment
451–1000 apples	450 apples
1001 apples or more	600 apples

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.

Requirement for pre-clearance

It is recommended that, at least for the initial trade, the quarantine measures operate through a standard pre-clearance arrangement with AQIS officers being directly involved. The need for pre-clearance would be reassessed after experience had been gained following significant trade.

Under these arrangements AQIS officers would be involved in orchard inspections for European canker and fire blight, in direct verification of packing house procedures, and in fruit inspection. The involvement of AQIS officers in pre-clearance would also facilitate a rigorous audit of other arrangements including registration procedures, standard commercial practice, traceability, and handling export fruit in a secure manner.

Under the pre-clearance arrangement, on-arrival procedures would provide verification that the consignment received was the pre-cleared consignment and that the integrity of the consignment had been maintained.

Verification of documents and inspection on arrival where pre-clearance is not used

It is recommended that, at least for initial trade, pre-clearance be used (see above). However, it is possible that this requirement may change in the future. This section sets out the provisions that would apply to shipments that do not undergo pre-clearance.

AQIS will undertake a documentation-compliance examination for consignment verification purposes, followed by inspection before release from quarantine. The following conditions will apply:

- The importer must have a valid import permit.
- The shipment must have a phytosanitary certificate that identifies registered orchards/blocks and registered packing houses and bears the additional declaration.
- No land bridging of consignments will be permitted unless the goods have cleared quarantine.
- Any shipment with incomplete documentation or certification that does not conform to conditions may be refused entry, with the option of re-export or destruction. AQIS would notify APHIS immediately of such action, if taken.
- Subject to the specific risk management measures used, consignments will be subject to appropriate inspection by AQIS.

Actions for non-compliance

Where inspection lots are found to be non-compliant with requirements, remedial action must be taken. The remedial actions 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 determined 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 (if quarantine pests are detected during on-arrival inspection)
- destruction of the consignment (if quarantine pests are detected during on-arrival inspection)

or

- treatment of the consignment and re-inspection to ensure that the pest risk has been addressed (if quarantine pests are detected during either preclearance or on-arrival inspection).

Separate to the corrective measures mentioned above, there may be other breach actions necessary depending on the specific pest intercepted and the risk management strategy put in place against that pest in the protocol.

If product continually fails inspection, Biosecurity Australia/AQIS reserves the right to suspend the export program and conduct an audit of the risk management systems in Washington, Oregon and/or Idaho. 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.

Movement of fruit into Western Australia

State legislation in Western Australia currently prohibits the importation of apples from other States and Territories in Australia because of the presence of *Venturia inaequalis*, which causes apple scab, within the apple production areas of eastern Australia and the lack of suitable risk management measures to prevent the introduction of this pathogen into Western Australia.

To maintain Western Australia's regional freedom from apple scab, the IRA team is proposing that apples from the US PNW states should not be exported into Western Australia, unless pest free areas and/or pest free places of production for *V. inaequalis* can be established, verified and maintained as outlined earlier in the management for *V. inaequalis* section. However, if suitable risk management measures were to be developed for apple scab, importation of apples from the US PNW states to Western Australia would require the application of risk management measures for *Cydia pomonella*, *Grapholita molesta*, *Mucor piriformis* and *M. racemosus* as outlined in earlier sections of this report.

5.2 Responsibility of competent authority

APHIS is the designated NPPO under the International Plant Protection Convention (IPPC).

The NPPO's responsibilities include:

- inspecting plants and plant products moving in international trade
- issuing certificates relating to phytosanitary condition and origin of consignments of plants and plant products
- ensuring that all relevant agencies participating in this program meet the proposed service and certification standards and proposed work plan procedures
- ensuring that administrative processes are established to meet the requirements of the program.

5.2.1 Use of accredited personnel

Operational components and the development of risk management procedures may be delegated by APHIS to an accredited agent under an agency arrangement as appropriate. This delegation must be approved by AQIS and will be subject to the requirements of the pre-clearance system. APHIS is responsible for auditing all delegated risk management procedures.

Orchard inspections must be undertaken by APHIS or persons accredited by APHIS. Accredited persons must be assessed and audited as being competent in the recognition of disease symptoms of concern in the field. Accredited persons may include APHIS officers, agency staff, plant pathologists, commercial crop monitors/scouts, or other accredited persons. The accrediting authority must provide APHIS with the documented criteria upon which accreditation is based and this must be available for audit by APHIS and AQIS. AQIS will audit these systems before commencement of trade.

5.3 Review of processes

5.3.1 Audit of protocol

Prior to the first season of trade, a representative from Biosecurity Australia and AQIS will visit areas in the US PNW states that produce apples for export to Australia. They will audit the implementation of agreed import conditions and measures including registration, operational procedures and fumigation facilities.

5.3.2 Review of policy

Biosecurity Australia reserves the right to review the import policy after the first year of trade or when there is reason to believe that the pest and phytosanitary status either in the US or in the US PNW states has changed. The pre-clearance arrangement requirement may be reviewed after initial substantial trade.

APHIS must inform Biosecurity Australia/AQIS immediately on detection in Washington, Oregon or Idaho of any new pests of apples that are of potential quarantine concern to Australia. For example, Mediterranean fruit fly (*Ceratitis capitata*), Mexican fruit fly (*Anastrepha ludens*), oriental fruit fly (*Bactrocera dorsalis*) and *Botrytis mali* have not been detected in any of the exporting states and ongoing nationwide surveys are being conducted. Should any of these pests be detected in any of the exporting states, APHIS must immediately advise Biosecurity Australia and AQIS of the changed pest status.

5.4 Uncategorised pests

If an organism is detected on mature fresh apple fruit, either during the pre-clearance inspection in the US or on-arrival in Australia, that has not been categorised, it will require assessment by Biosecurity Australia to determine its quarantine status and if phytosanitary action is required. Assessment is also required if the detected species was categorised as not likely to be on the import pathway. If the detected species was categorised as on the pathway but assessed as having an unrestricted risk that achieves Australia's ALOP due to the rating likelihood of importation, then it would require reassessment. The detection of any pests of quarantine concern not already identified in the analysis may result in remedial action and/or temporary suspension of trade while a review is conducted to ensure that existing measures continue to provide the appropriate level of protection for Australia.

6 Conclusion

The findings of this draft IRA report are based on a comprehensive analysis of relevant scientific literature. Biosecurity Australia considers that the risk management measures proposed in this draft IRA report will provide an appropriate level of protection against the pests identified in this risk analysis. A range of risk management measures may be suitable to manage the risks associated with mature fresh apple fruit from the US PNW states. Biosecurity Australia will consider any other measures suggested by stakeholders that would achieve Australia's ALOP.

Appendices

Appendix A Initiation and categorisation for phytosanitary pests for mature fresh apple fruit from US[17]

Initiation (columns 1 – 3) identifies the pests of apple that have the potential to be on mature fresh apple fruit produced in the Pacific North West States using commercial production and packing procedures.

Pest categorisation (columns 4 - 7) identifies which of the pests with the potential to be on mature fresh apple fruit are quarantine pests for Australia and require pest risk assessment.

The steps in the initiation and categorisation processes are considered sequentially, with the assessment terminating at the first 'No' for columns 3, 5 or 6 or 'Yes' for column 4.

Details of the method used in this IRA are given in Section 2: Method for pest risk analysis

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
DOMAIN BACTERIA						
Class Alphaproteobacteria						
Order Rhizobiales						
Rhizobium radiobacter (Beijerinck & van Delden 1902) Young *et al.* 2001 Synonym[19]: *Agrobacterium tumefaciens* (E.F. Smith & Townsend 1907) Conn (1942) [Rhizobiaceae] Hairy root; crown gall	Yes. CA, CT, central states, DC, ID, MD, New England States, NY, PA, TX (Bradbury 1986).	No. Causes hairy root and crown gall disease (Bradbury 1986).	Not assessed	Not assessed	Not assessed	No
Order Rhodospirillales						
Acetobacter aceti (Pasteur 1864) Beijerinck 1898 Synonym: *Acetobacter liquefaciens* (Asai 1935) De Ley and Frateur, 1974 [Acetobacteraceae] Pink disease	Yes. *Acetobacter aceti* is ubiquitous in the environment, existing in soil, water, flowers, fruit and on honeybees (United States Environmental Protection Agency 1997).	Yes. *Acetobacter aceti* causes pink disease of pineapple and may also produce rot in apples and pears (Bradbury 1986; United States Environmental Protection Agency 1997).	Yes. Australia (Bradbury 1986). The organism is widely distributed in nature (Bradbury 1986).	Not assessed	Not assessed	No

[17] This Appendix table does not represent a comprehensive list of all the pests associated with the entire plant of the commdity being assessed. Reference to soilborne nematodes, soilborne pathogens, wood borer pests, root pests or pathogens, and secondary pests have not been listed or have been deleted from the table, as they are not directly related to the export pathway of fresh apple fruit and would be addressed by Australia's current approach to contaminating pests.

[18] For list of US states, see Appendix E.

[19] Synonyms are provided when the current scientific name differs from that provided by APHIS or when literature supporting pest categorisation is found under a different scientific name.

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Acetobacter pasteurianus (Hansen 1879) Beijerinck 1916 [Acetobacteraceae] Bacterial brown rot	Yes. Disease in apple has been observed in the US (Bradbury 1986).	Yes. Causes a bacterial brown rot of apples and pears in the US (Bradbury 1986).	Yes. *Acetobacter pasteurianus* has not been reported from apples or pears in Australia. However, the bacterium is present in Australian wines (Drysdale and Fleet 1989).	Not assessed	Not assessed	No
Class Gammaproteobacteria						
Order Pseudomonadales						
Pseudomonas cichorii (Swingle 1925) Stapp 1928 [Pseudomonadaceae] Bacterial blight of endive	Yes. AL, CA, eastern states, FL, GA, IL, MT, NY, western states. Apple is a host (Bradbury 1986).	Yes. Causes rots of apple fruit (Bradbury 1986).	Yes. Qld, Vic., WA (APPD 2009) and NSW (Bradbury 1986).	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Pseudomonas syringae pv. *papulans* (Rose 1917) Dhanvantari 1977 [Pseudomonadaceae] Blister spot	Yes. AR, eastern states, IL, IN, MI, MO, NY, PA (Bradbury 1986); VA (Smith 1944).	Yes. Small dark brown to purple lesion are produced on the fruit, and tiny cankers or rough bark on branches (Vanneste and Yu 2006; Bradbury 1986; Dhanvantari 1969).	No records found. Has never been recorded in New Zealand or Australia (Vanneste and Yu 2006).	Yes. The pathogen was for a long time limited to eastern North America and the province of Ontario in Canada. It has since been found in British Columbia, Canada, and more recently in Italy, France and Germany (Vanneste and Yu 2006). *Pseudomonas syrinagae* pv. *papulans* overwinters in buds, leaf scars and diseased fruit on the orchard floor (Burr 1990). The bacterium can survive and multiply on leaves, wood and weeds in the orchard without causing any symptoms (Celetti 2005). Bacteria disperse via water splash onto the fruit and infect through fruit pores or lenticels (Celetti 2005). Fruit are most susceptible from 2–6 weeks after petal fall and symptoms may not appear until 2–3 months later (Celetti 2005). Incidence of the disease is relatively low in dry weather (Burr 1990). The disease can also be transmitted via budwood (Vanneste and Yu 2006).	Yes. Blister spot is an important disease of the apple cultivar Mutsu in the northeastern US, Canada and Italy (Kerkoud *et al.* 2002; Burr and Hurwitz 1979). It is of economic concern on this cultivar (Burr 1990). In wet weather growing seasons, nearly 100% of the fruit (cultivar Mutsu) can become infected (Ellis *et al.* 2000). Blister spot is also occasionally found on other cultivars (Burr 1990, Celetti 2005). The bacterium infests fruit, leaves, leaf petioles, shoots (Ellis *et al.* 2000) and bark (Dhanvantari 1969). The foliar phase generally causes no economic damage on mature trees but can be of concern in nurseries where it may restrict terminal growth. The bacterium induces lesions on the fruit skin (Ellis *et al.* 2000). Fruit lesions are superficial and render the crop unmarketable for fresh market (Burr and Hurwitz 1979). Streptomycin is currently used to control the bacteria but streptomycin-resistant *Pseudomonas syringae* pv. *papulans* has been recovered from Mutsu fruit in Michigan (Jones *et al.* 1991).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Pseudomonas syringae pv. *syringae* van Hall (1902) [Pseudomonadaceae] Bacterial blight; Bacterial canker or blast	Yes. Reported in many areas of North America (Bradbury 1986; Burr and Katz 1984).	Yes. Lesions may appear on fruit (Bradbury 1986).	Yes. WA (APPD 2009); NSW, Qld, SA, NT, Tas., Vic., WA (Bradbury 1986).	Not assessed	Not assessed	No
Order Enterobacteriales						
Erwinia amylovora (Burrill 1882) Winslow *et al.* 1920, emend. Hauben *et al*. 1998 [Enterobacteriaceae] Fire blight	Yes. Every region of the US. Spread northward from CA into ID, OR and WA early in the 1900s (Bonn and van der Zwet 2000).	Yes. Fruit sourced from infected orchards have the potential to carry epiphytic bacteria (Hale *et al.* 1987) but endophytic infections in fruit are rare (van der Zwet *et al.* 1990).	No. *Erwinia amylovora* was detected on *Cotoneaster* in the Melbourne Royal Botanic Garden in 1997 and its eradication was confirmed by national survey (Rodoni *et al.* 1999; Jock *et al.* 2000).	Yes. Fruit sourced from infected orchards have the potential to carry epiphytic bacteria (Hale *et al.* 1987). The bacterium is disseminated by rain or insects (Beer 1990). Suitable hosts, including apple and pear, are present in Australia. Fire blight has first been reported in England in the late 1950s and has since spread through much of Europe and the Mediterranean area (Beer 1990) indicating its potential for spread.	Yes. A significant economic pest that has caused serious devastation to the world's apple, pear and ornamental plantings (Vanneste 2000; Bonn 1999). A single severe outbreak can disrupt orchard production for several years (Vanneste 2000).	Yes
Class Mollicutes						
Phytoplasmas						
Apple chat fruit phytoplasma Apple chat fruit; apple small fruit	Yes. Present in US. *Malus* is reported as the only host (Nemeth 1986).	Yes. Some apple cultivars develop fruit symptoms (EPPO 1978; Nemeth 1986; Seemüller 1990a).	No records found.	No. No method of transmission other than budding and grafting has been proven (Seemüller 1990a; Nemeth 1986; EPPO 1978). Circumstantial evidence that chat fruit spreads naturally in orchards, probably from tree to tree by root grafting and/or an unidentified vector (Cropley 1989; Nemeth 1986).	Not assessed	No
Apple rubbery wood phytoplasma Rubbery wood; flat limb	Yes. MI, MO, NY, WA (CMI 1975).	Uncertain. Most apple cultivars do not show symptoms. Fruit size can be affected (Seemüller, 1990b).	Yes. (Seemüller 1990b; CMI 1975); Tas. (Sampson and Walker 1982); Vic. (Washington and Nancarrow 1983); NSW (Letham 1995).	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
DOMAIN EUKARYA						
ANIMALIA						
ARTHROPODA: Arachnidia: Acari						
Order Acariformes						
Aculus schlechtendali (Nalepa, 1891) [Eriophyidae] Apple rust mite	Yes. ID, OR, WA (APHIS 2007a).	Yes. Reported to feed primarily on the surface of leaves, turning them silver under high populations, while female mites usually overwinter beneath bud scales and bark (Ohlendorf 1991). *Aculus schlechtendali* was assessed as not on the fruit pathway for apples from New Zealand (Biosecurity Australia 2006a). However, APHIS (2007a) states that diapausing, overwintering deutogyne female mites may be transported on fruit.	Yes (Halliday 2000); present in WA (DAWA 2006).	Not assessed	Not assessed	No
Bryobia rubrioculus (Scheuten, 1857) [Tetranychidae] Brown apple mite; Bryobia mite; Brown almond mite	Yes. OR, WA (APHIS 2007a).	No. Immature stages feed on the underside of leaves while adults feed on both the upper and lower leaf surface; summer eggs are laid on twigs and along the midribs of leaves; during the warmest part of the day these mites shelter in woody parts of the tree (Ohlendorf 1991).	Not assessed	Not assessed	Not assessed	No
Cenopalpus pulcher (Canestrini & Fanzago, 1876) [Tenuipalpidae] Flat scarlet mite	Yes. OR (USDA-APHIS 2000a; Bajwa *et al*. 2001).	Yes. Prefers the lower leaf surface and moves to the buds for winter (Jeppson *et al*. 1975), females deposit eggs on the striations and natural indentations of leaves and fruits and have been observed feeding on leaves, soft twigs and fruits (Bajwa and Kogan 2003). In the west of England it was associated with quite severe russeting around the calyx and stalk ends of apples in 2006 (Green 2007).	No records found	Yes. An invasive species that is widely distributed in Europe, the Middle East, Central Asia, and North Africa (Jeppson *et al*. 1975; CABI 2007), India (Menon *et al*. 1971) and Iraq (Elmosa 1971) in a variety of environments with similarities to Australia.	Yes. *C. pulcher* is an important pest in apple and other fruit crops in Asia, Europe, Africa and North America (CABI 2007; NAPPO 2008).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Eotetranychus carpini borealis (Ewing, 1913) [Tetranychidae] Yellow spider mite	Yes. OR, WA (APHIS 2007a).	No. Congregates along the midribs and larger veins of foliage (APHIS 2007a), primarily on the lower leaf surface.	Not assessed	Not assessed	Not assessed	No
Eotetranychus pruni (Oudemans, 1931) [Tetranychidae] Spider mite	Yes. (Jeppson *et al*. 1975).	No. Feeds along veins on the undersurface of leaves (Jeppson *et al*. 1975).	Not assessed	Not assessed	Not assessed	No
Eotetranychus uncatus Garman, 1952 [Tetranychidae] Spider mite	Yes. Eastern United States and UT, CA (Jeppson *et al.* 1975).	No. Feeds on undersurface of leaves (Jeppson *et al*. 1975).	Not assessed	Not assessed	Not assessed	No
Panonychus ulmi (Koch, 1835) [Tetranychidae] European red mite	Yes. ID, OR, WA (APHIS 2007a).	Yes. Overwinters on trunk and collects around the calyces of apples during late July to August (APHIS 2007a) which coincides with the harvest period.	Yes (Halliday 1998; 2000); present in WA (DAWA 2006).	Not assessed	Not assessed	No
Tetranychus canadensis (McGregor, 1950) [Tetranychidae] Four spotted spider-mite; Hawthorn spider mite	Yes. Distributed throughout the US (Jeppson *et al*. 1975); widespread throughout eastern and southwestern US (Pritchard and Baker 1955). *Malus domestica* is listed as a host in US (Pritchard and Baker 1955).	No. Feeds on the undersurface of leaves; produces very little webbing (Jeppson *et al*. 1975).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Tetranychus mcdanieli McGregor, 1931 [Tetranychidae] McDaniel spider mite	Yes. ID, OR, WA (APHIS 2007a); UT, CA, MT, ND, MI, NY (Pritchard and Baker 1955). Apple listed as a host (Pritchard and Baker 1955).	Yes. Usually stays on leaves and overwinters on tree trunk. However, they can collect around the calyx in late July/August (APHIS 2007a).	No records found	Yes. Wide host range including deciduous tree fruits (apple (*Malus*), pear (*Pyrus*), apricot, sweet and sour cherry, peach, prune (*Prunus* spp.)), some field and vegetable crops (squash (*Cucurbita*), *Asparagus*, alfalfa (*Medicago sativa*), clover (*Trifolium*), and a number of weeds (mallow (*Malva*), milkweed (*Asclepias*), knotweed (*Polygonum*), ragweed (*Ambrosia*), mustard (*Brassica nigra*), dock (*Rumex*), wild buckwheat (*Fagopyrum esculentum*), wild lettuce (*Lactuca*)) (Hoyt and Beers 1993). Distributed across North America in environments similar to Australia (Roy *et al*. 2005) indicating a high potential for establishment and spread.	Yes. Feeds and lays eggs on buds and fruit. An economically important pest (Roy *et al*. 1999; 2005). Damage caused by this pest is very important, particularly when the hot and dry summer favours development of infestations (INRA 1997).	Yes
Tetranychus pacificus McGregor, 1919 [Tetranychidae] Pacific spider mite	Yes. ID, OR, WA (APHIS 2007a); CA (Pritchard and Baker 1955).	Yes. Tetranychid mites are principally feeders of new leaf growth, with 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 (APHIS 2007a). There have been numerous interceptions of species of this genus on fruit from New Zealand (PDI 2003).	No records found	Yes. Wide host range includes Australian domestic crops. Distributed in a variety of environments across North America with similarities to Australia (CABI 2007). This indicates a high potential for establishment and spread.	Yes. Damage caused by high populations feeding on leaves can adversely affect tree vitality and fruit size (CABI 2007).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Tetranychus turkestani (Ugarov & Nikolskii, 1937) Synonym: *Tetranychus atlanticus* McGregor, 1941 [Tetranychidae] Strawberry spider mite	Yes. ID, OR, WA (Pritchard and Baker 1952); throughout most of US particularly abundant in the west (Pritchard and Baker 1955). Apple listed as a host (Pritchard and Baker 1955).	Yes. Tetranychid mites are principally feeders of new leaf growth, with 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 (APHIS 2007a). There have been numerous interceptions of species of this genus on fruit from New Zealand (PDI 2003).	No records found	Yes. Wide host range, primarily on low-growing hosts such as cotton (*Gossypium*), alfalfa (*Medicago sativa*), beans (*Phaseolus*), clover (*Trifolium*), and strawberry (*Fragaria*); vegetables such as eggplant (*Solanum melongena*), and ornamentals such as privet (*Ligustrum*), violet (*Viola*), and sunflower (*Helianthus*). Apple (*Malus*), peach, plum (*Prunus* spp.), pear (*Pyrus*), walnut (*Juglans regia*) and lemon (*Citrus limon*) are also infested (Pritchard & Baker 1952; Bolland *et al*. 1998); widespread across North America (US and Canada) (Pritchard and Baker 1952) in a variety of environments with similarities to Australia indicating a high potential for establishment and spread.	Yes. Damage caused by high populations feeding on leaves can adversely affect tree vitality and fruit size (CABI 2007). Recognized in Washington, Oregon, Idaho, Utah and California as a dominant pest (Pritchard and Baker 1952) and acknowledged as an economically important pest in temperate climates (Bailly *et al*. 2004).	Yes
Tetranychus urticae Koch, 1836 [Tetranychidae] Two-spotted spider mite	Yes. ID, OR, WA (APHIS 2007a).	Yes. Usually found on leaves, but it can collect around the calyx (APHIS 2007a).	Yes (Halliday 1998; 2000); present in WA (DAWA 2006).	Not assessed	Not assessed	No
ARTHROPODA: Insecta						
Order Coleoptera						
Anametis granulata (Say, 1831) [Curculionidae] Gray snout beetle	Yes. MI, WI, SD, NE, IA, IN, WY, TX, NM (Parrott and Hodgkiss 1916; Beers *et al*. 2003).	No. Reported eating bark of small branches and twigs of apple trees, only causing slight injury (Parrott and Hodgkiss 1916; Campbell *et al*. 1989; Beers *et al*. 2003).	Not assessed	Not assessed	Not assessed	No
Anoplophora chinensis (Forster, 1771) [Cerambycidae] Black and white citrus longhorn	Yes. WA (CABI 2007).	No. Larvae of *Anoplophora* species develop in the phloem and xylem of living host tree trunks and branches (Lingafelter and Hoebeke 2002).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Anthonomus quadrigibbus Say, 1831 Synonym: *Tachypterellus consors* (Dietz, 1891) [Curculionidae] Apple curculio	Yes. Recorded from every US state except NV and WY (Burke and Anderson 1989). CT to NC and west as far as NM (Brooks 1910); principally an apple pest which attacks apple fruit resulting in dwarfed and misshapen fruit (Metcalf *et al*. 1962; CABI 2007).	Yes. Is primarily an apple pest (CABI/EPPO 1997a). Adults are known to feed on flower buds, blossoms and fruitlets once they have set (Burke and Anderson 1989). Eggs are deposited in cavities made in maturing fruit; larvae feed primarily on the seeds; pupation occurs in the fruit while still on the tree; adults emerge and feed for a short time before seeking over-wintering sites (Burke and Anderson 1989).	No records found	Yes. Associated with a wide range of plants in the Rosaceae although apples (*Malus*) and *Crataegus* species are the usual host plants all of which occur in Australia and distributed in a wide range of environments across North America (Burke and Anderson 1989) with similarities to those found across Australia. Adults are strong fliers, dispersing actively in the spring, seeking the most suitable hosts (CABI 2007).	Yes. Destructive to cultivated apples and pears (Brooks 1910). According to Metcalf *et al*. (1962) it can inflict more than 50% crop losses. It caused serious damage to cherries in northern Colorado in 1945 resulting in the rejection of crop of cherries by government institution (Hoerner and List 1952).	Yes
Anthonomus signatus Say, 1831 [Curculionidae] Strawberry bud weevil	Yes. Widespread east of the Rocky Mountains (CABI/EPPO 1997f). The Campbell *et al*. (1989) reference applies to Canada. There are no recent reports for this species being associated with apple fruit in the Pacific Northwest.	No. Adults and larvae feed on leaves and flower buds. Eggs are laid in buds which wilt and droop, subsequently falling off (CABI/EPPO 1997f).	Not assessed	Not assessed	Not assessed	No
Asynonychus cervinus (Boheman, 1840) Synonym: *Pantomorus cervinus* (Boheman, 1840) [Curculionidae] Fuller's rose weevil	Yes. OR, CA (CABI 2007).	Yes. Eggs are typically laid under stones, in bark crevices, inside calyx lobes of fruits (especially citrus fruit), or in curled dead leaves (CABI 2007); larvae develop in the soil, feeding on plant roots and adults feed on the leaves, buds or flowers of host plants (Gyeltshen and Hodges 2007).	Yes (APPD 2009); present in WA (DAFWA 2008).	Not assessed	Not assessed	No
Cercopedius artemisiae (Pierce, 1910) Synonym: *Cercopeus artemisiae* Pierce, 1910 [Curculionidae] Lesser sagebrush weevil	Yes. WA, MT (Yothers 1916; Beers 2004).	No. Adults are reported to eat apple buds of young fruit trees and feed on sap from newly cut shoots; it is a diurnal feeder and will drop to the ground if disturbed (Beers 2004) also reported to feed on leaves (Yothers 1916).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Chrysobothris femorata (Olivier, 1790) [Buprestidae] Flatheaded apple-tree borer	Yes. OR, WA (APHIS 2007a).	No. Eggs are laid in bark crevices or under bark scales, larvae chew through the bark and feed in the phloem and surface of the sapwood (Solomon 1995); larva bores into the trunk and does not occur on fruit (APHIS 2007a).	Not assessed	Not assessed	Not assessed	No
Chrysobothris mali Horn, 1886 [Buprestidae] Pacific flathead borer	Yes. WA (Smith 2001). Widely distributed throughout western North America west of the Rocky Mountains from California to British Columbia and Manitoba (Fisher 1942; Bright 1987).	No. Eggs are usually deposited in bark crevices or depressions (Burke 1919, 1929). Larvae feed in shallow mines in the inner bark and outer wood of the host tree (Solomon 1995).	Not assessed	Not assessed	Not assessed	No
Cleonidius canescens (LeConte, 1875) [Curculionidae] Weevil	Yes. CO, UT (Yothers 1916).	No. Reported destroying buds of young apple (and peach) trees in Colorado and Utah (Yothers 1916; Beers *et al*. 2003).	Not assessed	Not assessed	Not assessed	No
Cleonidius poricollis (Mannerheim, 1843) Synonyms: *Cleonus lobigerinus* Casey, 1891; *Cleonus kirbyi* Casey, 1891 [Curculionidae] Weevil	Yes. WA (Yothers 1916).	No. Reported being especially destructive to apricot buds (Yothers 1916; Beers *et al*. 2003).	Not assessed	Not assessed	Not assessed	No
Cleonidius quadrilineatus (Chevrolat, 1873) [Curculionidae] Four-lined loco weevil	Yes. WA (Yothers 1916).	No. Reported causing minor damage to apple buds (Yothers 1916; Beers *et al*. 2003).	Not assessed	Not assessed	Not assessed	No
Conotrachelus anaglypticus (Say, 1831) [Curculionidae] Cambium curculio	Yes. FL, GA, IA, IL, IN, KS, MA, MI, NJ, TX, VA, WV (Brooks and Cotton 1924). OH (Neiswander 1961). Apple listed as a host (Beers *et al*. 2003).	No. Larvae usually feed under the bark of branches and trunks of various fruit and shade trees (Brooks and Cotton 1924). Larvae also recorded in soil feeding on interior of stem at the base of columbine (*Aquilegia* sp.) (Neiswander 1961).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Conotrachelus nenuphar Harris, 1841 [Curculionidae] Plum curculio	Yes. WA, UT (Beers *et al*. 2003). However, it is claimed that it is not known from Washington state or considered as a pest in that state (APHIS 2007a). A pest of apple production east of the Rocky Mountains (CABI/EPPO 1997g; Chouinard *et al*. 2002).	No. Adults feed on flowers, leaves and young fruits; eggs are laid in crescent-shaped areas on the apple skin; larvae bore through the apple causing infested fruits to drop prematurely and damage predisposes fruit to infection by brown rot; larvae leave the apple to pupate in the soil (CABI/EPPO 1997g; Douglas and Cowles 2008) and such immature or rotten fruit will not be harvested. While this is considered a serious pest (Douglas and Cowles 2008), infested fruit would prematurely drop well before harvest (Campbell *et al*. 1989). Additionally, damage to fruit would be easily detected and graded out.	Not assessed	Not assessed	Not assessed	No
Epicaerus imbricatus (Say, 1824) [Curculionidae] Imbricated snout beetle	Yes. US (Metcalf *et al*. 1962).	No. Adults reported eating out apple buds and chewing off newly forming fruitlets and leaves; eggs are laid on various plant leaves while larvae are found in the stems or on the roots of legumes or other field crops (Metcalf *et al*. 1962).	Not assessed	Not assessed	Not assessed	No
Evotus naso (LeConte, 1857) [Curculionidae]	Yes. WA (Yothers 1928).	No. Eats buds and leaves of apple trees; presumed native sagebrush feeder (Yothers 1928).	Not assessed	Not assessed	Not assessed	No
Harmonia axyridis (Pallas, 1773) [Coccinellidae] Harlequin ladybird	Yes. ID, OR, WA, CA (CABI 2007).	No. Adults and larvae are tree dwelling predators on aphids and scale insects in forests and orchards (Potter *et al*. 2005). Adults of the ladybirds would drop off when disturbed and any remaining larvae would be eliminated during packing house processing.	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Lepesoma nigrescens (Pierce, 1913) Synonyms: *Dyslobus nigrescens* (Pierce, 1913); *Melamomphus nigrescens* (Pierce, 1913) [Curculionidae] Weevil	Yes. WA (Yothers 1916; Yothers 1914 in Beers *et al*. 2003).	No. Reported destroying young buds of young apple (and peach) trees (Yothers 1916; Yothers 1914 in Beers *et al*. 2003).	Not assessed	Not assessed	Not assessed	No
Lepesoma tanneri (Van Dyke, 1933) Synonym: *Dyslobus tanneri* Van Dyke, 1933 [Curculionidae] Weevil	Yes. ID, OR, WA, CA, UT (Yothers 1916, 1941).	No. Adults reported eating or hollowing out apple buds and feeding on apple leaves (Yothers 1916; 1941).	Not assessed	Not assessed	Not assessed	No
Magdalis aenescens LeConte, 1876 [Curculionidae] Bronze appletree weevil	Yes. OR, WA (Beers *et al*. 2003); CA, MT, WA (Essig 1926).	No. Larvae bore and develop under the bark and into the wood of injured, dying and dead trees, twigs, branches, prunings and stumps of broad-leaved trees and conifers (Essig 1926); adults of other species of *Magdalis* feed on foliage (Furniss and Carolin 1977). Wood boring weevil associated with injured trees and canker of stems and trunks of apple trees (Treherne 1914).	Not assessed	Not assessed	Not assessed	No
Magdalis gracilis (LeConte, 1857) [Curculionidae] Black fruit tree weevil	Yes. WA (Beers *et al*. 2003); NM, NV, CA (Essig 1926). Apple recorded as host in western North America (Essig 1926) also listed as a weevil attacking fruit trees in Washington (Beers *et al*. 2003).	No. Larvae bore and develop in twigs and branches of broad-leaved trees and conifers; adults recorded eating holes in buds, flowers, leaves and young fruitlets of apple (Essig 1926); other species of *Magdalis* feed on foliage (Furniss and Carolin 1977).	Not assessed	Not assessed	Not assessed	No
Omias saccatus (LeConte, 1857) [Curculionidae] Sagebrush weevil	Yes. CA,, OR, WA (Yothers 1916).	No. Reported feeding on buds and leaves of 1–2 year old apple trees in 1911-12; probable native sagebrush feeder (Yothers 1916).	Not assessed	Not assessed	Not assessed	No
Ophryastes cinerascens (Pierce, 1913) [Curculionidae]	Yes. WA (Yothers 1916; Yothers 1914 in Beers *et al*. 2003).	No. Adults feed on the buds of 1–2 year old fruit trees (apple listed as a host) (Yothers 1916; Yothers 1914 in Beers *et al*. 2003).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Ophryastes geminatus (Horn, 1876) Synonym: *Eupagoderes geminatus* Horn, 1876 [Curculionidae] White bud weevil	Yes. CA, NV; fruit trees recorded as host in western North America (Essig 1926; Beers *et al*. 2003).	No. Recorded attacking buds of fruit trees in early spring (Essig 1926; Beers *et al*. 2003).	Not assessed	Not assessed	Not assessed	No
Otiorhynchus cribricollis Gyllenhal, 1834 [Curculionidae] Apple weevil	Yes. CA, AZ, NM, NV, TX (Warner and Negley 1976; CABI 2007).	No. Larvae are soil dwelling feeding on plant roots and adults feed on leaves/foliage (Warner and Negley 1976; Fisher and Learmonth 2007).	Not assessed	Not assessed	Not assessed	No
Otiorhynchus ligustici (Linnaeus, 1758) [Curculionidae] Alfalfa snout beetle	Yes. NY (Warner and Negley 1976; Claassen and Palm 1935; Beers *et al*. 2003).	No. Larvae feed on roots and adults observed feeding on apple (leaves), although alfalfa and clovers are primary hosts for reproduction (Claassen and Palm 1935; Beers *et al*. 2003).	Not assessed	Not assessed	Not assessed	No
Otiorhynchus meridionalis Gyllenhal, 1834 [Curculionidae] Lilac root weevil	Yes. ID, WA, also CA, MT, NV, NM, UT (Warner and Negley 1976).	No. Adults recorded feeding on apple leaves in eastern Washington (Beers *et al*. 2003).	Not assessed	Not assessed	Not assessed	No
Otiorhynchus ovatus (Linnaeus, 1758) [Curculionidae] Strawberry root weevil	Yes. WA (Beers *et al*. 2003); widespread across all US except AL, AZ, GA, KY, LA, MS, MO, OK, TN (Warner and Negley 1976).	No. Larvae feed on plant roots, and adults feed nocturnally on the foliage, buds and young shoots of fruit trees (Warner and Negley 1976; Garneau 2004a; Beers 2007a).	Not assessed	Not assessed	Not assessed	No
Otiorhynchus raucus (Fabricius, 1776) Synonym: *Brachyrhinus raucus* Fabricius, 1776 [Curculionidae]	Yes. OR (OISC 2004).	No. Larvae of *Otiorhynchus* species feed on the roots of plants while adults feed on foliage and young shoots of apple (Warner and Negley 1976; Beers *et al*. 2003; Beers 2007a).	Not assessed	Not assessed	Not assessed	No
Otiorhynchus singularis (Linnaeus, 1758) [Curculionidae] Clay-colored weevil, raspberry weevil	Yes. OR, WA (Warner and Negley 1976), also AZ, CA, CT, DC, IL, ME, MD, MA, MI, MT, NV, NH, NJ,NM, NY, NC, OH, RI, TX, UT, VT, VA, WI (Warner and Negley 1976), PA (Beers *et al*. 2003).	No. Larvae feed on the roots of plants while adults feed on foliage at night resulting in circular notches in the leaf margins usually of rosaceous plants (Murray 2008).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Otiorhynchus sulcatus (Fabricius, 1775) [Curculionidae] Black vine weevil	Yes. OR, WA (Warner and Negley 1976); ID (Beers *et al*. 2003); western US as far north as Alaska (Warner and Negley 1976).	No. Larvae feed on roots, and adults feed at night on the margins of foliage of a wide range of host plants (Warner and Negley 1976; Garneau 2004b); apple fruit petioles (Beers *et al*. 2003).	Not assessed	Not assessed	Not assessed	No
Panscopus aequalis (Horn, 1876) [Curculionidae] Weevil	Yes. WA, CA, MT, UT, WY (Yothers 1914, 1916); CA, UT, WY (Beers 2004).	No. Adults feed upon unfolded terminal or centre buds of 1 year-old apple trees; also feeds on sap oozing from freshly cut twigs (Yothers 1914, 1916; Beers *et al*. 2003).	Not assessed	Not assessed	Not assessed	No
Paraptochus sellatus (Boheman, 1859) [Curculionidae] Apricot leaf weevil	Yes. CA,, OR, WA (Essig 1926; Beers *et al*. 2003).	No. Feeds on buds and leaves of apple (Essig 1926; Beers *et al*. 2003).	Not assessed	Not assessed	Not assessed	No
Phyllobius oblongus (Linnaeus, 1758) [Curculionidae] Brown leaf weevil	Yes. NY, CT, MI, WI (O'Brien and Wibmer 1982; Hanson and Walker 2004; Pinski *et al*. 2005).	No. Larvae feed on roots while adults feed along leaf margins in spring disappearing by midsummer (Hanson and Walker 2004).	Not assessed	Not assessed	Not assessed	No
Polydrusus impressifrons (Gyllenhal, 1834) [Curculionidae] Leaf weevil	Yes. CT, MI, NY, OH (Parrott and Glasgow 1916; Sleeper 1957).	No. Adults eat foliage, especially leaf margins while some bud feeding occurs on other non-tree fruit hosts; larvae feed upon tree roots (Parrott and Glasgow 1916).	Not assessed	Not assessed	Not assessed	No
Polyphylla decemlineata (Say, 1823) [Scarabaeidae] Ten-lined June beetle	Yes. WA (Beers *et al*. 1993a; Smith 2001).	No. Eggs are deposited in the soil; larvae feed on decaying vegetable matter and the roots of many broadleaf trees and some conifers; adults feed on foliage (Beers *et al*. 1993a; Natural Resources Canada 2008a).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Popillia japonica Newman, 1838 [Scarabaeidae] Japanese beetle	Yes. Present in OR, WA (NAPIS 2008a). Widespread east of the Mississippi River, outbreaks west of the Mississippi River are usually eradicated before establishment (APHIS 2009).	No. Larvae feed on plant roots; adult feeding results in skeletonisation of host plant leaves, with damage being more severe on *Malus* (apple) leaves (Fleming 1972; Gyeltshen and Hodges 2005).	Not assessed	Not assessed	Not assessed	No
Pseudanthonomus crataegi (Walsh, 1867) [Curculionidae] Apple weevil, Hawthorn weevil	Yes. IL, WV (Brooks 1910; Beers *et al.* 2003).	No[20]. Adults feed on apple fruit particularly around the stem and calyx end and leaves. They fall off to the ground when disturbed. Larvae feed inside apple fruit that have ceased to grow and either fallen to the ground or remain as mummies on the tree; larvae are unable to survive in juicy, growing fruit (Brooks 1910) and thus will not be present in harvested fruit. No apple records from modern times could be found!	Not assessed	Not assessed	Not assessed	No
Rynchaenus pallicornis (Say, 1831) Synonym: *Rhynchaenus pallicornis* (Say, 1831) [Curculionidae] Apple flea weevil	Yes. MO and IL to eastern NY and south to Ohio River (Metcalf *et al*. 1962).	No. Adults eat holes in newly opening leaves and buds of apple trees in spring, eggs are laid along leaf midribs, while larvae mine apple leaves resulting in a mine starting near centre of leaf and extending to small blister-like cells at the leaf margin (Metcalf *et al*. 1962).	Not assessed	Not assessed	Not assessed	No
Sciopithes obscurus Horn, 1876 [Curculionidae] Obscure root weevil	Yes. OR, WA, CA (Essig 1926; Beers *et al*. 2003).	No. Larvae feed on roots (NWIPM 2008) while adults feed on apple leaves causing notching; eggs are laid on leaf tips (Gerdeman *et al.* 2005); recorded feeding on the opening buds and new foliage of fruit trees (Essig 1926).	Not assessed	Not assessed	Not assessed	No

[20] Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Scolytus rugulosus (Müller, 1818) [Curculionidae: Scolytinae] Shothole borer	Yes. OR, WA, CA (Wood 1982; Brunner 2004; APHIS 2007a; Walker 2008).	No. Eggs are laid at the interface of the bark and wood; adults and larvae mine the inner bark (phloem-cambial region) on twigs, branches or trunks of host trees (Dreistadt *et al*. 2004). Adults and larvae bore and mine broken or unthrifty limbs and branches of host trees (Wood 1982).	Not assessed	Not assessed	Not assessed	No
Sitona californius (Fahraeus, 1840) Synonym: *Sitona apacheana* (Casey, 1888) [Curculionidae]	Yes. WA (Yothers 1916; Beers *et al*. 2003).	No. Larvae feed on root nodules (Rudgers and Hoeksema 2003). Adults eat the buds of young apple trees (Yothers 1916). *Sitona* adults feed on leaves making semi-circular notches around the lamina (INRA 1997).	Not assessed	Not assessed	Not assessed	No
Tychius picirostris (Fabricius, 1787) Synonym: *Miccotrogus picirostris* (Fabricius, 1787) [Curculionidae] Clover seed weevil	Yes. OR, WA (MacNay 1954; Beers *et al*. 2003).	No[21]. The only mention of attack on apple was non-economic (MacNay 1954; Beers *et al*. 2003). No apple records from modern times could be found. Clovers are the primary host of this weevil (Campbell *et al*. 1989). Larvae feed on seeds of clover (Hirnyck and Downey 2005).	Not assessed	Not assessed	Not assessed	No
Xyleborinus saxesenii (Ratzeburg, 1837) [Curculionidae: Scolytinae] Lesser shot-hole borer	Yes. OR (Cramer 2005), WA (Brunner 2004); *Malus communis* / *Malus domestica* listed as host (Wood and Bright 1992).	No. Eggs are laid in tunnels bored into the wood by females; adults and larvae feed on the inner bark and wood of the trunk and branches of host plants (Wood 1982; Brunner 2004; Cramer 2005).	Not assessed	Not assessed	Not assessed	No
Xyleborus dispar (Fabricius, 1792) [Curculionidae: Scolytinae] Pear blight beetle	Yes. ID, OR, WA, CA (Wood 1982).	No. Adults and larvae bore and mine injured limbs and boles (5-20 cm diameter or larger) of host trees (Wood 1982).	Not assessed	Not assessed	Not assessed	No

[21] Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Xylosandrus germanus (Blandford, 1894) [Curculionidae: Scolytinae] Black timber bark beetle	Yes. OR, CA (LaBonte *et al*. 2005).	No. Adults and larvae bore and mine unthrifty, cut or broken branches, boles and stumps of host trees (Wood 1982).	Not assessed	Not assessed	Not assessed	No
Order Diptera						
Dasineura mali Keiffer, 1904 [Cecidomyiidae] Apple leafcurling midge; apple leaf midge	Yes. WA, present since 1994 (Antonelli and Glass 2005; LaGasa 2008).	Yes. Although there is no mention of *Dasineura mali* larvae or pupae occurring on apple fruit in Antonelli and Glass (2005), larvae have been recorded pupating in the calyces and stem ends of apple fruit in New Zealand (Smith and Chapman 1995; MAFNZ 2000).	No records found	Yes. Host range restricted to cultivated apples and crabapples (*Malus* spp.) which are widespread in southern Australia. Distributed across a range of environments in North America, New Zealand and Europe with similar climatic and environmental conditions to Australia (CABI 2007).	Yes. Apple tree shoots damaged and tree growth retarded resulting in decreased fruit yield in Europe and New Zealand (Tomkins *et al*. 1994; Smith and Chapman 1995).	Yes
Anastrepha ludens (Loew, 1873) [Tephritidae] Mexican fruit fly	No. Occasional incursions in California, Texas and Arizona (Weems *et al*. 2004). Apple (*Malus domestica*) is listed as an incidental minor host (CABI 2007).	No[22].	Not assessed	Not assessed	Not assessed	No
Bactrocera dorsalis (Hendel, 1912) [Tephritidae] Oriental fruit fly	No. Incursions in California are eradicated (APHIS 2006). Apple (*Malus domestica*) is listed as a major host (CABI 2007).	No[23].	Not assessed	Not assessed	Not assesed	No

[22] *Anastrepha ludens* is the most cold tolerant of the *Anastrepha* species (Sequeira *et al*. 2001) and has been found as far north as San Francisco in California. The occasional presence of this pest in California is not considered justification that the pest is likely to be found on apple fruit sourced from the Pacific Northwest. However, the maintenance of area freedom from fruit flies will be required unless other quarantine measures are imposed.

[23] The occasional presence of this pest is not considered justification that the pest is likely to be found on apple fruit sourced from the Pacific Northwest. The maintanence of area freedom for these fruit flies will be required unless other quarantine measures are imposed

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Ceratitis capitata (Wiedemann, 1824) [Tephritidae] Mediterranean fruit fly	No. Established in Hawaii (Mau and Martin Kessing 2007), and is considered a transient species in California and Florida. Incursions are subject to eradication efforts (APHIS 2006). Apple is listed as a host (White and Elson-Harris 1992).	No[24].	Not assessed	Not assessed	Not assessed	No
Rhagoletis pomonella (Walsh, 1867) [Tephritidae] Apple maggot	Yes. ID, OR, WA (Beers *et al*. 1996; APHIS 2007a).	Yes. Native to North America where apple and hawthorn fruits are preferred hosts (Caprile *et al*. 2006).	No records found	Yes. Since apple maggot has a wide host range including apricot, cherry, plum, (*Prunus* spp.), pear (*Pyrus*), wild rose (*Rosa* spp.), *Pyracantha* and *Cotoneaster*, and it originally fed on the fruit of wild hawthorn (*Crataegus* sp.) but has since switched to cultivated apples (*Malus*) (Weems and Fasulo 2007) it is likely that apple maggot may be able to adapt to other host plants in the future (Beers *et al*. 1996). Distributed in a variety of environments across North America with similarities to Australia (CABI 2007) and adults are capable of flight (Weems and Fasulo 2007) thus indicating a potential for establishment and spread.	Yes. Eggs are laid in fruit; maggots feed on pulp ultimately resulting in soft, rotten fruit that is unmarketable and completely unusable for any purpose (Cornell Cooperative Extension 2000; CABI 2007). A quarantine area has been declared in western Washington making it illegal to carry backyard or non-commercial tree fruit out of western Washington or across county lines (Beers *et al*. 1996). Efficacious alternative control tactics for this pest are generally lacking (Myers *et al*. 2008).	Yes

[24] The occasional presence of this pest is not considered justification that the pest is likely to be found on apple fruit sourced from the Pacific Northwest. The maintanence of area freedom for these fruit flies will be required unless other quarantine measures are imposed

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Order Hemiptera						
Acrosternum hilare (Say, 1832) [Pentatomidae] Green stink bug	Yes. CA, ID, OR, WA, AR, NC, SC, KS, IL, VA, SC, FL, TX, AZ, UT, ME, NH, VT, MA, RI, CT (McPherson and McPherson 2000).	No. Although reported as occasionally feeding on apple fruit (Mundinger and Chapman 1932) they are highly active insects that are considered to be present on the fruit for short feeding periods only. They are also easily disturbed.and would be removed from the pathway during harvesting and post-harvest operations.	Not assessed	Not assessed	Not assessed	No
Aphis gossypii Glover, 1877 [Aphididae] Cotton aphid, Melon aphid	Yes. Widespread in US including ID, OR, WA (CABI 2007).	No. Prefers to feed on the undersides of young leaves causing infested leaves to curl downwards and appear wrinkled or reddened (CABI 2007). *Malus domestica* listed as a minor host. No evidence that this pest is associated with fruit.	Yes. NSW, Qld, SA, Tas., Vic. (Hollis & Eastop 2005), WA (DAFWA 2008).	Not assessed	Not assessed	No
Aphis pomi DeGeer, 1773 [Aphididae] Green apple aphid	Yes. ID, OR, WA (APHIS 2007a).	No. Causes damage to newly-formed fruit, fruit bud clusters, leaves, and stems however, it does not hibernate (as eggs) in orchards and it is not an issue on mature apple fruit (APHIS 2007a).	Not assessed	Not assessed	Not assessed	No
Aphis spiraecola Patch, 1914 [Aphididae] Apple aphid, Spirea aphid	Yes. WA (Beers *et al*. 1993b; Lowery *et al*. 2006).	No. Eggs are laid on smooth twigs and watersprouts; adults prefer to feed on undersides of leaves, on growing shoot tips or the shoot stem although high populations can result in direct feeding on developing fruits [immature apples] (Beers *et al*. 1993b).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Boisea rubrolineata (Barber, 1956) Synonym: *Leptocoris rubrolineatus* Barber, 1956 [Rhopalidae] Western boxelder bug	Yes. WA (Anthon 1993a), OR (Cox 2004).	No. Primary host is boxelder, but also attack apple fruit causing dimples and deformations on fruit (Anthon 1993a). 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 and packinghouse operations.	Not assessed	Not assessed	Not assessed	No
Campylomma verbasci (Meyer-Dür, 1843) [Miridae] Campylomma bug	Yes. WA (APHIS 2007a).	No. Overwinters as eggs in bark (APHIS 2007a) and hatches around bloom. Nymphs feed on blossom calyxes and developing fruit causing dimpling and fruit deformity (Reding and Alston 1997; Simone 2004) however, they are highly active insects that 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 and post-harvest operations.	Not assessed	Not assessed	Not assessed	No
Ceresa alta Walker, 1851 Synonyms: *Stictocephala bisonia* Kopp & Yonke, 1977; *Ceresa bubalus* (Fabricius, 1794); *Stictocephala bubalus* (Caldwell, 1949) [Membracidae] Buffalo treehopper	Yes. OR, WA (APHIS 2007a).	No. Eggs are laid in bark of current season's growth to one-year old wood; does not occur on apple fruit (APHIS 2007a). The impact to fruit trees is only reported as a result of damage to twigs.	Not assessed	Not assessed	Not assessed	No
Chrysomphalus aonidum (Linnaeus, 1758) [Diaspididae] Circular scale	Yes. CA, AL, FL, GA, MS, MO, TX (Watson 2005; Miller and Gimpel 2009d); apple listed as a minor host for this species (CABI 2007).	Yes. Leaf-infesting species, but in high-density infestations may spread to fruits, stems and trunks (Futch *et al*. 2001; Watson 2005).	Yes. NSW, Qld, NT (APPD 2009); present in WA (DAWA 2006).	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Diaspidiotus ancylus (Putnam, 1878) [Diaspididae] Putnam scale	Yes. Widespread in 31 US states (CA, AL, AZ, CO, CT, DE, DC, FL, GA, IL, IN, IA, KS, KY, LA, MD, MS, MO, MT, NJ, NY, NC, OH, OK, PA, RI, SC, TN, TX, UT, VA, WV) (Miller and Gimpel 2009e); apple listed as a minor host for this species (Kozár 1990; CABI 2007).	No. Found on leaves, branches and trunk (Watson 2005). High population densities may cause branch dieback (Watson 2005; Polavarapu *et al*. 2000).	Not assessed	Not assessed	Not assessed	No
Diaspidiotus perniciosus (Comstock, 1881) Synonym: *Quadraspidiotus perniciosus* (Comstock, 1881) [Diaspididae] San Jose scale; Californian scale	Yes. OR, WA (CABI 2007).	Yes. Found on the fruit, leaves, bark (CABI 2007); on apple fruit the settled scale insects cause red blotches (haloes) and early settlement and feeding may cause pitting of the fruit surface (Ohlendorf 1991; CABI 2007).	Yes (Donaldson and Tsang 2002); present in WA (DAWA 2006); NSW, Qld, Tas., Vic. (APPD 2009).	Not assessed	Not assessed	No
Dysaphis plantaginea Passerini, 1860 [Aphididae] Rosy apple aphid	Yes. ID, OR, WA (APHIS 2007a).	No. Does not overwinter on fruit and is not associated with mature apple fruit (APHIS 2007a). These aphids migrate from apple trees to weed hosts in late June to early July and therefore would not be associated with harvested apples (Reding *et al*. 1997).	Not assessed	Not assessed	Not assessed	No
Dysmicoccus brevipes (Cockerell, 1893) [Pseudococcidae] Pineapple mealybug	Yes. CA, FL, LA (CABI 2007; Ben-Dov 2009f).	No. Inhabits the base of host plants such as the lower portions of stems and exposed roots of grasses and herbaceous plants, the butts of pineapple plants, and the lower stalks of sugar cane (Mau *et al*. 2007b). Apple (*Malus sylvestris*) listed as a host (Ben-Dov 2009f). No evidence that this pest is associated with fruit in the PNW.	Yes. NSW, NT, Qld, WA (Williams 1985; CABI 2007; Ben-Dov 2009f), WA (DAFWA 2008).	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Edwardsiana rosae (Linnaeus, 1758) [Cicadellidae] Rose leafhopper	Yes. OR, WA (APHIS 2007a).	No. Does not occur on fruit; leafhoppers are highly active insects that would take evasive action when disturbed (APHIS 2007a) and therefore would not be associated with harvested apples. This species overwinters as eggs on the stem of roses moving in the second and third generations to the tree fruit host to feed on leaves (Beers and Elsner 1993b).	Not assessed	Not assessed	Not assessed	No
Empoasca fabae (Harris, 1841) [Cicadellidae] Potato leafhopper	Yes. Gulf coast states and mid-Atlantic region - VA (Pfeiffer *et al*. 1999).	No. Feeds on vascular tissue of growing shoot tips such as young apple tree leaves (Pfeiffer *et al*. 1999).	Not assessed	Not assessed	Not assessed	No
Empoasca maligna (Walsh, 1862) [Cicadellidae] Apple leafhopper	Yes. ID, OR, WA (APHIS 2007a).	No. Feed on leaves, does not occur on fruit (APHIS 2007a). Overwinters in the egg stage under loose bark and during summer feeds on foliage (Insectidentification.net 2004).	Not assessed	Not assessed	Not assessed	No
Epidiaspis leperii (Signoret, 1869) [Diaspididae] European pear scale	Yes. CA, CT, MD, MT, NJ, NY, OK, PA, RI (Miller and Gimpel 2009f); twigs, branches, trunk (Gill 1997).	No. Does not infest fruit or leaves; often found sheltering under lichens on the bark; it prefers walnut, stone and pome fruit trees (Gill 1997). Causes pitting of young stems of apples and may cause distortion of branches (CABI 2007).	Not assessed	Not assessed	Not assessed	No
Eriosoma lanigerum (Hausmann, 1802) [Aphididae] Woolly apple aphid	Yes. ID, OR, WA (APHIS 2007a).	Yes. Found on trunk and branches occasionally found on fruit stems and calyx end of apples (APHIS 2007a).	Yes. ACT, NSW, Tas., Vic. (Hollis and Eastop 2005); present in WA (DAWA 2006; APPD 2009).	Not assessed	Not assessed	No
Eulecanium tiliae (Linnaeus, 1758) [Coccidae] Nut scale, Brown gooseberry scale	Yes. CA, RI (CABI 2007; Ben-Dov 2009g), PNW (Gill 1988).	No. Early nymphal stages occur on leaves, returning in autumn to overwinter as late instar nymphs on twigs (Gill 1988). Apple (*Malus domestica*, *M. pumila*) listed as host (Ben-Dov 2009g).	Yes. Tas. (CSIRO 2005; DPIW 2008b).	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Euschistus conspersus Uhler, 1897 [Pentatomidae] Stink bug	Yes. WA (APHIS 2007a).	No. Eggs laid on the undersides of leaves of various weed hosts (Krupke 2007; Krupke and Brunner 2008). They are highly active insects that 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 and post-harvest operations.	Not assessed	Not assessed	Not assessed	No
Fieberiella florii (Stål, 1864) [Cicadellidae] North American leafhopper; Privet leafhopper	Yes. OR, CA (Swenson 1974).	No. Overwinter as nymphs on crabapple and apple or as eggs on deciduous fruit trees (Van Steenwyk *et al*. 2006). Not associated with the mature fruit pre-harvest. Prefers to feed on leaves and branches, not fruit (Swenson 1974).	Not assessed	Not assessed	Not assessed	No
Halyomorpha halys (Stål, 1855) [Pentatomidae] Brown marmorated stink bug	Yes. DE, MD, NJ, PA, SC, WV and OR (LaBonte 2005; CABI 2007).	No. Eggs are laid on the undersides of leaves; adults and nymphs are sap suckers that are known to feed on apple fruit (Gyeltshen *et al*. 2008). However, nymphs and adults are considered to be present on fruit for short feeding periods only, are easily disturbed, and are unlikely to remain on the fruit when disturbed during harvesting and packing house processes.	No records found	Not assessed	Not assessed	No
Hyalopterus pruni (Geoffroy, 1762) [Aphididae] Mealy plum aphid	Yes. Pacific Northwest (Beers *et al*. 1993c).	No. Overwintering eggs are laid in crevices on twigs; feed on the undersides of leaves causing leaves to curl; migrate from tree fruits to summer hosts, which include weeds, ornamental plants and vegetables before returning to fruit hosts in autumn to lay eggs (Beers *et al*. 1993c). However, there is no evidence that the aphids are directly associated with the fruit.	Yes. Qld, SA, Vic., Tas. (Hollis & Eastop 2005), no records for WA.	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Lepidosaphes ulmi (Linnaeus, 1758) [Diaspididae] Oystershell scale; Mussell scale	Yes. ID, OR, WA (APHIS 2007a; CABI 2007). California widespread and common (Gill 1997).	Yes. Fruit, twigs, leaves (APHIS 2007a). Usually found on the bark of trunk and branches and on fruit (less often on leaves) (Watson 2005).	Yes (Donaldson and Tsang 2002); present in WA (DAFWA 2008); NSW, Tas., WA (APPD 2009).	Not assessed	Not assessed	No
Lopholeucaspis japonica (Cockerell, 1897) [Diaspididae] Japanese baton shaped scale	Yes. CT, DE, DC, MD, NJ, NY, PA, RI, VA (Miller and Gimpel 2009a).	Yes. On bark of branches and trunk, rarely on leaves and fruits (Watson 2005). Adults may be found in cracks; large populations can cause premature leaf fall and branch dieback (Germain 2005).	No. Found many years ago (1914) in Northern Territory but not established (CABI/EPPO 1997c; CABI 2007).	Yes. A polyphagous species recorded on 50 plant genera in 31 plant families (Miller and Gimpel 2009a) including cultivated *Malus* species (Watson 2005). Easily dispersed by wind, birds, or fruit pickers (Williams and Watson 1988).	Yes. Attacks all citrus severely and trees are killed by heavy infestations (CABI 2007). Caused serious problems on satsumas (*Citrus unshiu*), mandarins (*Citrus reticulata*) and lemons (*C. limon*) in Azerbaijan and Georgia (CABI 2007).	Yes
Lygus elisus Van Duzee, 1914 [Miridae] Lucerne plant bug	Yes. Pacific northwest (Anthon 1993b).	Yes. Adults feed on developing apple flower buds in spring and then leave the fruit trees soon after petal fall to feed on weed hosts or other crops; females deposit eggs in young fruit causing shallow pitting and deformity (Anthon 1993b).	No records found	Yes. Polyphagous bug feeding on *Medicago sativa* (alfalfa), *Melilotus officinalis* (sweet clover), *Verbascum* spp. (mullein), *Salsola tragus* (Russian thistle), *Bassia* spp. (smotherweed), *Conyza* spp. (horseweed), *Brassica spp.* (wild mustards), *Ambrosia psilostachya* (western ragweed), *Chrysothamnus* spp. (rabbitbrush) and *Artemisia* spp. (sagebrush) that will also attack apples, pears, peaches and apricots but do not reproduce on these hosts (Anthon 1993b). Distributed throughout the US and southern Canada (Anthon 1993b) in a variety of environments with similarities to Australia, suggesting a potential for establishment and spread.	Yes. Nymphs and adults suck plant juices from host plants; lygus bugs cause their most serious damage by feeding on fruit causing round pits or irregularly-shaped depressions in apple (Caprile *et al*. 2009), small bluish-green spots or split areas resulting in misshapen nectarines (Bentley and Day 2006) leading to reduced marketability and severe economic losses in some years (Bentley and Day 2006).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Lygus hesperus Knight, 1917 [Miridae] Western tarnished plant bug	Yes. Pacific northwest (Anthon 1993b).	Yes. Adults feed on developing apple flower buds in spring and then leave the fruit trees soon after petal fall to feed on weed hosts or other crops; females deposit eggs in young fruit causing shallow pitting and deformity (Anthon 1993b).	No records found	Yes. Polyphagous bug feeding on same hosts as *L. elisus* but prefers *Kochia scoparia* (Mexican fireweed) (Anthon 1993b). Distributed throughout the US and southern Canada (Anthon 1993b) in a variety of environments with similarities to Australia, suggesting a potential for establishment and spread.	Yes. Nymphs and adults suck plant juices from host plants; lygus bugs cause their most serious damage by feeding on fruit causing round pits or irregularly-shaped depressions in apple (Caprile *et al*. 2009), small bluish-green spots or split areas resulting in misshapen nectarines (Bentley and Day 2006) leading to reduced marketability and severe economic losses in some years (Bentley and Day 2006).	Yes
Lygus lineolaris (Palisot de Beauvois, 1818) [Miridae] Tarnished plant bug	Yes. Pacific northwest (Anthon 1993b).	Yes. Adults feed on developing apple flower buds in spring and then leave the fruit trees soon after petal fall to feed on weed hosts or other crops; females deposit eggs in young fruit causing shallow pitting and deformity (Anthon 1993b).	No records found	Yes. A polyphagous bug with three generations a year and a partial fourth in the Pacific northwest (Anthon 1993b) that will also attack apples, pears, peaches and apricots but do not reproduce on these hosts (Anthon 1993b). Distributed throughout the US and southern Canada (Anthon 1993b) in a variety of environments with similarities to Australia, suggesting a potential for establishment and spread.	Yes. Nymphs and adults suck plant juices from leaves, flower buds, flowers and seeds often leading to premature fruit drop or causing irregularly-shaped depressions, shallow pitting and deformity in apple fruit, peaches and nectarines leading to reduced marketability (Anthon 1993b; Bentley and Day 2006; Caprile *et al*. 2009). Known to cause economic losses in apples in Idaho (Colt *et al*. 2001).	Yes
Metcalfa pruinosa (Say, 1830) [Flatidae] Frosted moth bug	Yes. Common in eastern North America: AZ, AR, CA, CT, DE, FL, GA, IL, IN, IA, KS, KY, LA, MD, MA, MI, MN, MS, MO, NE, NJ, NY, NC, OH, PA, RI, TN, TX, VA and not recorded from the Pacific Northwest (CABI 2007).	No. Overwinters as eggs inserted in woody tissue or under tree bark (Wilson & McPherson, 1981); moving to leaves and stems in May (CABI 2007). Adults are easily disturbed, and are unlikely to remain on the fruit when disturbed during harvesting and packing house processes.	No records found	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Myzus persicae (Sulzer, 1776) [Aphididae] Peach green aphid	Yes. WA (Capinera 2008), ID, OR (CABI 2007). Apple (*Malus domestica*) listed as a major host (CABI 2007).	Yes. Highly polyphagous, includes apple as a summer host usually feeding on older or senescing leaves; overwinter as eggs laid in crevices around axillary buds, timing emergence with swelling of flower buds (CABI 2007; Capinera 2008).	Yes. NSW, NT, Qld, Vic., Tas. (APPD 2009); present in WA (DAWA 2006).	Not assessed	Not assessed	No
Parlatoria oleae (Colvée, 1880) [Diaspididae] Olive scale	Yes. AZ, CA, DE, MD (Miller and Gimpel 2009b). Apple is listed as a major host (CABI 2007).	Yes. Attacks all parts of the host plant, except the roots, (Watson 2005); feeds on fruit (CABI 2007).	Yes. Qld, NSW (Donaldson and Tsang 2002; CABI 2007; Miller and Gimpel 2009b); not present in WA (DAWA 2006).	Yes. Wide host range including many horticultural crops and its presence in Qld and NSW suggests potential for establishment and spread in Western Australia (CABI 2007).	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).	Yes[WA]
Parlatoria pergandii Comstock, 1881 [Diaspididae] Chaff scale	Yes. AL, CA, CT, DC, FL, GA, HI, IL, IN, KS, LA, MD, MA, MS, MO, NJ, NY, NC, OH, OK, PA, SC, TX, VA (Miller and Gimpel 2009c); WA (Miller and Davidson 1990). Apple is listed as a minor host (CABI 2007).	Yes. Found mainly on leaves, but sometimes also on bark, twigs and fruit (Watson 2005). It is primarily a citrus pest and has a decided shade preference, commonly being found on fruits often in the inner, shady part of the canopy (Watson 2005).	Yes. NSW, Qld (APPD 2009); not present in WA (DAWA 2006).	Yes. Restricted host range most commonly found on *Citrus* (Williams and Watson 1988) and already established in Queensland (Smith *et al*. 1997); easily dispersed by wind and plant material (Williams and Watson 1988).	Yes. Causes green spots on fruit making them unsuitable for the fresh fruit market (Cartwright and Browning 2008). Listed as a serious and widespread pest (Miller and Davidson 1990).	Yes[WA]
Parthenolecanium corni (Bouché 1844) [Coccidae] European fruit lecanium scale; brown scale; plum scale	Yes. WA (Smith 2001).	No. Crawlers feed on leaves and return to twigs and branches before autumn (Gill 1988). Sucks plant juices from leaves and twigs. They settle mostly on the underside of leaves, especially along the veins during spring moving back to the twigs in autumn (Henderson 2001).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Phenacoccus aceris (Signoret, 1875) [Pseudococcidae] Apple mealybug	Yes. OR, WA (Beers 2007b, 2008).	Yes. Eggs are found on the trunk, twigs or leaves of apple; crawlers disperse to leaves, twigs, leaf axils and fruit to feed; it can also directly infest and feed on fruit often in the calyx region (Beers 2007b, 2008).	No records found	Yes. A very broad host range, including all deciduous fruit and nut trees (apple (*Malus*), pear (*Pyrus*), apricot, cherry, plum (*Prunus* spp.), hazelnut (*Corylus*), small fruit (grape (*Vitis vinifera*), currant, gooseberry (*Ribes* spp.), blueberry (*Vaccinium*)) many shade trees (maple (*Acer*), oak (*Quercus*), birch (*Betula*), willow (*Salix*), ash (*Fraxinus*), linden (*Tilia*), elm (*Ulmus*), rowan (*Sorbus*)) and various ornamentals (*Cotoneaster*, *Pyracantha*, *Spirea*, hawthorn (*Crataegus*) and quince (*Cydonia oblonga*)) (Beers 2007b). All of these plants are widely distributed in Australia. It is present in US states where climatic conditions similar to those in Australia exist. Second instar nymphs overwinter in cocoons under bark or in bark cracks in colder northern regions (Beers 2007b). It is likely that this species could establish in Australia.	Yes. Apple mealybug is a known vector of little cherry virus 2, a virus (Raine *et al*. 1986; Beers 2008) which is regulated in British Columbia. The virus has been widespread and devastating in Kootenay (British Columbia) cherry growing region (Beers 2007b; Rott and Jelkmann 2001). It is also a known vector of Grapevine leafroll-associated virus-1 and -3 (GLRaV-1 and -3) in France and Italy where it is considered as becoming a serious pest (Sforza *et al*. 2003).	Yes
Pseudococcus calceolariae (Maskell, 1879) [Pseudococcidae] Citrophilus mealybug; Scarlet mealybug	Yes. CA (Ben-Dov 2009b). Apple is listed as a major host (CABI 2007).	Yes. Found on citrus and apple fruit; occurring on the aerial parts of the host plant (Cox 1987).	Yes. Qld, NSW, SA, Tas. (APPD 2009); not present in WA (DAWA 2006).	Yes. Wide host range recorded from hosts in 40 plant families (Ben-Dov 2009b) most of which occur in Australia. It is present in US states where climatic conditions similar to those in Australia exist. It is likely that this species could establish in Western Australia.	Yes. This mealybug is a highly polyphagous species, reported as a pest of citrus and grapevines (CABI 2007).	Yes[WA]

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Pseudococcus comstocki (Kuwana, 1902) [Pseudococcidae] Comstock's mealybug	Yes. CA, CT, DE, DC, GA, IL, IN, LA, MD, MA, MI, NH, NJ, NY, OH, PA, SC, VA, WV (Ben-Dov 2009c). On apple fruit (Spangler and Agnello 1991).	Yes. Congregates on older branches, pruning scars, node, branch base, and can be found inside calyx of apple fruit (Spangler and Agnello 1991).	No records found	Yes. Known to damage several agricultural crops including banana (*Musa*), pear (*Pyrus*), lemon (*Citrus limon*), apricot, cherry peach (*Prunus* spp.) and mulberry (*Morus*) all of which are grown in Australia. It is believed to be of Asian origin, possibly indigenous to Japan. It has been recorded from a number of countries throughout the world, indicating it has the ability to adapt to new environments (CABI 2007).	Yes. Occasionally a serious pest in apple, pear and citrus orchards. It is known to damage several agricultural crops including banana (*Musa*), pears (*Pyrus*), lemon (*Citrus limon*), apricot, cherry, peach (*Prunus* spp.), *Catalpa* and mulberry (*Morus*) and is also damaging to several ornamental and shade trees (CABI 2007). In New York state, Weires (1984) reported that losses from the Comstock mealybug were $9.32 and $3.58/ha for Red Delicious and McIntosh apples, respectively. Honey dew excreted by crawlers is a substrate for sooty moulds growing on fruit surface. Contaminant for fruit processing (Spangler and Agnello 1991).	Yes
Pseudococcus longispinus (Targioni Tozzetti, 1867) [Pseudococcidae] Long tailed mealybug	Yes. AL, CA, CT, FL, IL, IN, IA, KS, MD, MA, MI, MO, NJ, NY, NC, PA, TN, TX, WA, WI (CABI 2007; Ben-Dov 2009h).	No. Adult females occur exposed on the foliage or twigs of the host plant (Tenbrink *et al*. 2007). Apple (*Malus pumila*) listed as a host (Ben-Dov 2009h).	Yes. All states (Williams 1985; Malipatil & Wainer 2007); WA (DAFWA 2008).	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Pseudococcus maritimus (Ehrhorn, 1900) [Pseudococcidae] Grape mealybug Williams (1985) states that *Ps. maritimus* is not known to occur in Australia but is a misidentification for *Ps. affinis*, *Ps. calceolariae* and *Ps. longispinus*, while on the other hand Williams and Granara de Willink (1992) state that *Ps. maritimus* is common in Australia and the USA. According to Gimpel and Miller (1996) there are no correct records of *Ps. maritimus* outside the New World.	Yes. ID, OR, WA (APHIS 2007a; Ben-Dov 2009d).	Yes. Feeding occurs primarily on the leaves, but adult females migrate to the trunk for oviposition (Ben-Dov 2009d). Recognised as a sporadic pest of minor importance, the second generation of this pest in each season may be associated with fruit (Burts and Dunley 1993). Eggs are usually laid in crevices in the bark but some may be laid in the calyx end of apple fruit (Ohlendorf 1991).	No records found	Yes. Wide host range on many cultivated and ornamental plants from 44 families (Ben-Dov 2009d) most of which occur throughout Australia; present in Washington, Oregon and Idaho (APHIS 2007a; Ben-Dov 2009d), where climatic 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 reduces the marketability of fruit.	Yes
Pseudococcus viburni (Signoret, 1875) [Pseudococcidae] Obscure mealybug; Californian mealybug	Yes. WA, OR, CA, AL, CT, DE, DC, GA, IL, IN, IA, MD, MA, MI, MO, NJ, NY, NC, OH, PA, SC, UT, VA, WV, WI (Ben-Dov 2009e); apple listed as a host (CABI 2007).	Yes. Lives mainly on the bark of apple and pear trees. Their feeding on the sap does not cause economic damage but when they move onto the fruit, mealybugs become a major quarantine pest. They are found particularly at the calyx and stem end of apple fruit (HortResearch 1999).	Yes. Qld, NSW, SA, Tas., WA (APPD 2009); present in WA (DAWA 2006).	Not assessed	Not assessed	No
Rhopalosiphum insertum (Walker, 1849) Cited as *Rhopalosiphum fitchii* (Sanderson, 1920) in list (APHIS 2007a) [Aphididae] Apple grain aphid; Apple-grass aphid	Yes. ID, OR, WA (Carroll and Hoyt 1986; APHIS 2007a).	No. Leaves and fruit (Carroll and Hoyt 1986). Generally found early in the season but is not associated with mature fruit at harvest (APHIS 2007a). In autumn, males and parthenogenetic viviparous females return to and preferentially spread on the underside of old apple leaves (they never move to young shoots). Winter eggs are laid on old wood of apple trees (INRA 1997).	Not assessed	Not assessed	Not assessed	No
Stictocephala basalis (Walker, 1851) Synonym: *Ceresa basalis* Walker, 1851 [Membracidae] Dark-coloured treehopper	Yes. OR, WA (APHIS 2007a).	No. Eggs are laid in bark of current season's growth to one-year old wood; does not occur on apple fruit (APHIS 2007a).	Not assessed	Not assessed	Not assessed	No

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Typhlocyba pomaria McAtee, 1926 [Cicadellidae] White apple leafhopper	Yes. ID, WA (Hogmire and Beavers 1998; APHIS 2007a).	No. Overwinters as eggs laid in one to five-year-old wood that give rise to the generation that lays its eggs into leaf petioles and midribs (Beers and Elsner 1993a; Hogmire and Beavers 1998). They are highly active insects that fly when disturbed and would not be associated with post-harvest fruit (Hogmire and Beavers 1998; APHIS 2007a). It is primarily a nuisance pest at harvest (APHIS 2007a).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Order Hymenoptera						
Ametastegia glabrata (Fallén, 1808) [Tenthredinidae] Dock sawfly	Yes. OR, WA (APHIS 2007a).	Yes. After feeding larvae seek out hollow stems, soft wood or fruit into which they bore to form pupal cells, including fruit of apples (Malipatil *et al*. 1995).	Yes. Vic. (Malipatil *et al*. 1995) – recent introduction probably widespread in Victoria; not present in WA (DAWA 2006).	Yes. Host range includes herbaceous plants particularly belonging to the Polygonaceae (*Rumex*, *Polygonum*, *Rheum*) and Chenopodiaceae (*Chenopodium*) (Benson 1952; Smith 1979). It is widely distributed across temperate Europe, the Mediterranean region east to Siberia and North America (Smith 1979) as well as introduced into Chile (Carrillo *et al.* 1990) and Australia (Malipatil *et al.* 1995) suggesting it has a potential to establish and spread in Western Australia.	Yes. The major damage by this sawfly is caused by the mature larvae tunnelling into raspberry (*Rubus*) canes and fruit (such as apples growing above sawfly host plants) in search of pupation sites (Naumann *et al.* 2002). Since apples are a suitable pupation site, the dock sawfly has gained status as an economic pest (Smith 1979).	Yes [WA]
Caliroa cerasi Linnaeus, 1758 [Tenthredinidae] Pear and cherry slugworm	Yes. ID, OR, WA (CABI 2007).	No. Eggs are laid under the leaf surface; larvae feed on the upper and lower surfaces of leaves; pupae are found in silken cocoons in the soil (MacQuarrie 2004).	Not assessed	Not assessed	Not assessed	No
Order Lepidoptera						
Acleris minuta (Robinson, 1869) Synonym: *Peronea minuta* (Robinson, 1869) [Tortricidae] Yellow headed fireworm	Yes. Occurs over most of the USA east of the 100th meridian; apple listed as a host plant (Oregon State University 2005).	No. Larvae feed on the terminal leaves of rosaceous host plants especially *Malus* and *Prunus*, tying the leaves together as they feed (Schwarz *et al.* 1983). Eggs are laid on the bark of apple trees (Weatherby and Hart 1984).	Not assessed	Not assessed	Not assessed	No
Acleris holmiana (Linnaeus, 1758) Synonym: *Croesia holmiana* (Linnaeus, 1758) [Tortricidae] Golden leafroller	Yes. WA (LaGasa 1996).	No. Larvae feed on leaves (LaGasa 1996). The larva spins several leaves together from which it feeds on the surrounding leaves. It lives on a range of rosaceous trees including apple (*Malus*) (Kimber 2009; De Prins and Steeman 2008).	Not assessed	Not assessed	Not assessed	No

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Agrotis ipsilon (Hufnagel, 1766) Synonym: *Agrotis ypsilon* Godman & Salvin, 1889 [Noctuidae] Black cutworm	Yes. Pacific northwest (Berry 1998 in Hollingsworth 2008; Antonelli *et al*. 2000); ID, OR, WA; *Malus domestica* recorded as a host (CABI 2007).	No. Eggs are deposited on foliage. Larvae feed on the leaves, stems and roots of seedlings. Pupation occurs at a depth of 3–12 cm underground (Capinera 2006). The larvae remain hidden in the soil during the day and feed at night (Antonelli *et al*. 2000).	Not assessed	Not assessed	Not assessed	No
Archips argyrospila (Walker, 1863) [Tortricidae] Fruit tree leafroller	Yes. OR, WA (APHIS 2007a).	Yes. A native American species whose larvae primarily feed on the lower surface of leaves usually in groups (Brunner 1993; APHIS 2007a). Larvae can damage fruit throughout the growing season causing fruit drop or deep scarring and severe deformation (Brunner 1993).	No records found	Yes. Wide host range including apricot, cherry, plum, prune (*Prunus* spp.), pear (*Pyrus*), apple (*Malus*), quince (*Cydonia*), raspberry, loganberry, blackberry, (*Rubus*), currant, gooseberry (*Ribes* spp.), English walnut (*Juglans regia*), ash (*Fraxinus*), box elder (*Acer negundo*), elm (*Ulmus*), locust (*Robinia*), oak (*Quercus*), poplar (*Populus*), willow (*Salix*) and rose (*Rosa*), and distributed across North America in environments similar to those found in Australia, suggesting a potential for establishment and spread (Caprile *et al*. 2006; Bentley and Day 2006, Pickel *et al*. 2006; Deland *et al*. 1993).	Yes. Larvae feed on leaves, buds and fruit resulting in fruit loss and reducing marketability due to deep scarring and severe deformation of stone fruit (Bentley and Day 2006, Pickel *et al*. 2006; Berry 1998 in Hollingsworth 2008) or apples with shallow cavities or deep bronze-coloured scars with roughened, netlike surfaces (Caprile *et al*. 2006).	Yes
Archips fuscocupreanus Walsingham, 1900 [Tortricidae] Apple tortrix	Yes. WA, CT, MA, NY, NJ, RI, (Maier 2007a); CT, MA (Maier 2003).	No. Egg masses are laid on the trunk and branches of trees. The young larvae feed on developing leaves while later instar larvae eat the flowers and occasionally young fruit (Maier 2003, 2007a). It is not a pest of actual fruit and transport of larvae with apple fruit is unlikely (CABI 2007).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Archips podana (Scopoli, 1763) [Tortricidae] Great brown twist moth, Large fruit tree tortrix	Yes. WA (LaGasa *et al*. 2003; NAPIS 2008b).	Yes. An introduced European species. Attacks leaves and buds early in the season while later in the season, early instar larvae can cause skin damage to mature fruits (Dickler 1991). Eggs are laid in batches on the upper surface of leaves and larvae taken into apple stores continue to feed on the fruit (Cuthbertson and Murchie 2005). Third instar larvae hibernate in a cocoon at the base of the leaves or at a branch axil (INRA 1997).	No records found	Yes. Wide host range feeding on the foliage, flowers and fruit of a wide variety of deciduous trees, including apple (*Malus*), pear (*Pyrus*), plum, cherry, apricot (*Prunus* spp.), blackthorn (*Prunus spinosa*), black currant (*Ribes nigrum*), raspberry (*Rubus*), hop (*Humulus lupulus*), rhododendron (*Rhododendron*), rose (*Rosa*) and occasionally conifers (INRA 1997; Kimber 2009). It is an introduced species widely distributed across Europe, Canada, and US with environments similar to those found in Australia that suggests a potential for establishment and spread (Safonkin and Triseleva 2005; CABI 2007).	Yes. Larval feeding on fruit reduces marketability (CABI 2007).	Yes
Archips rosana (Linnaeus, 1758) Synonym: *Archips rosanus* (Linnaeus, 1758) [Tortricidae] European leafroller	Yes. OR, WA (Berry 1998 in Hollingsworth 2008; APHIS 2007a).	Yes. A native American species whose larvae primarily feed on foliage but also on fruit (Brunner 1993). Eggs are deposited on bark of host plants; feeding on apple results in the formation of russeted, badly misshapen and unmarketable fruit (Meijerman and Ulenberg 2000). Early instar larvae cause skin damage to mature fruits (Dickler 1991) and fruits in contact with leaves are nibbled quite deeply in May and June in Europe (INRA 1997).	No records found	Yes. Wide host range the primary hosts being apple (*Malus*), pear (*Pyrus*), hawthorn (*Crataegus*), cherry, plum (*Prunus* spp.) currant (*Ribes*) as well as privet (*Ligustrum*) and widely distributed across Europe and localised areas in North America with environments similar to those in Australia suggesting a potential for establishment and spread (CABI 2007; Brunner 1993).	Yes. Larvae feed in the buds resulting in fruit loss and, later, within spun leaves or a (longitudinally) rolled leaf, also on blossoms and young fruitlets reducing marketability due to surface feeding damage (Brunner 1993; CABI 2007). Damage is frequent on apple and pear; incisions on the bud peduncle lead to premature drop and feeding on fruit can be quite deep resulting in markedly deformed fruits (INRA 1997).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Argyresthia conjugella (Zeller, 1839 [Yponomeutidae] Apple fruit moth	Yes. WA (LaGasa 2008).	Yes. Eggs laid on surface of fruit (Carter 1984). Larvae tunnel through apple fruit causing sunken, discoloured patches on the skin, sometimes attacking pips and hollowing them out; pupates in cocoon under loose bark or amongst leaf-litter on the ground (Carter 1984; Kimber 2009).	No records found	Yes. Principal hosts are apple (*Malus*) and rowan (*Sorbus aucuparia*) which are present throughout temperate Australia; widely distributed across temperate Europe to Siberia and Japan as well as introduced and established in North America with environments similar to those in Australia suggesting a potential for establishment and spread (Carter 1984; Nazari 2003).	Yes. Larvae tunnel through fruit of apple resulting in sunken, discoloured patches on the skin and causing the fruit to rot (Carter 1984) resulting in crop losses or reduced marketability and subsequent economic loss to growers.	Yes
Argyrotaenia franciscana (Walsingham, 1879) Synonym: *Argyrotaenia citrana* (Fernald, 1889); *Eulia citrana* (Fernald, 1889); *Argyrotaenia kearfotti* Obraztsov, 1961 [Tortricidae] Orange tortrix, Tortrix citrana	Yes. OR, WA, CA, apple is a recorded host (as *A. citrana*) (Berry 1998 in Hollingsworth 2008).	Yes. Larvae are known as apple skinworms because of their surface feeding habit which causes fruit scarring (Zalom and Pickel 1988). An occasional pest in apple orchards. Larvae feed on the surface of fruit, where they leave shallow, irregular scars. Generally they feed within a fruit cluster; occasionally they tie a leaf to the fruit's surface and feed under it (Caprile *et al*. 2006).	No records found	Yes. Wide host range including raspberry, blackberry, boysenberry, loganberry, youngberry, blueberry, salmonberry (*Rubus* spp.), apple (*Malus*), peach, apricot (*Prunus* spp.), grape (*Vitis vinifera*) and weeds such as pigweed (*Portulaca oleracea*) and lambsquarter (*Chenopodium album*) and localised to Pacific Northwest states with similar environments being found in Australia (Caprile *et al*. 2006; Heppner 2004; Berry 1998 in Hollingsworth 2008), indicating a potential for establishment and spread.	Yes. Larvae of this leafroller feed on developing buds and leaves of cane fruits, tree fruits, ornamental and florist crops; larvae are known to bore into the base of berries to feed on the fruit tissues making the berries unacceptable for fresh market and processing (Berry 1998 in Hollingsworth 2008). Orange tortrix is an important pest on apples as well as many other fruit crops, for example avocado, in the western United States (Zalom and Pickel 1988; Walker and Welter 2004; Phillips *et al*. 2009). In apple orchards even fairly low population densities can result in significant fruit damage making the fruit unmarketable (Walker and Welter 2001).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Argyrotaenia velutinana (Walker, 1863) [Tortricidae] Redbanded leafroller	Yes. MA, MI, NY, NC, PA, VA, WV (CABI 2007).	Yes. Larvae usually skeletonise the underside of leaves, folding and webbing the leaf together. Second and third generation larvae may feed on the fruit surface often concealed beneath a white web or attached leaf for protection. Larvae may also attack the fruit at the calyx or stem end or where two fruit touch (North Carolina State University 2007).	No records found	Yes. Wide host range, larvae feeding on cherries, peaches, plums (*Prunus* spp.), grapes (*Vitis vinifera*), spruces (*Picea* spp.), as well as vegetables (CABI 2007). It is distributed across Northeast US and Canada with environments similar to those in Australia indicating a potential for establishment and spread.	Yes. Redbanded leafroller is one of several leafrollers that are important pests of apple orchards in North America with the potential to cause significant economic loss to commercial fruit growers (Fadamiro 2004a). Covell (1984) states that *Argyrotaenia velutinana* is "the most serious pest of apple trees, eating fruits and foliage."	Yes
Choreutis pariana (Clerck, 1759) Synonym: *Eutromula pariana* (Clerck, 1759) [Choreutiidae] Apple-and-thorn skeletonizer	Yes. OR, WA (APHIS 2007a).	No. Larvae feed on underside of leaf first before moving to feed on the upper leaf surface; it does not occur on apple fruit (APHIS 2007a).	Not assessed	Not assessed	Not assessed	No
Choristoneura rosaceana (Harris, 1841) [Tortricidae] Oblique-banded leafroller	Yes. OR, WA (APHIS 2007a).	Yes. A native North American species that usually feeds on the lower surface of leaves usually in groups (Fadamiro 2004b; APHIS 2007a) and occasionally larvae may eat portions of young fruit causing damaged fruit to abort or are deeply scarred and severely deformed (Brunner 1993). First instar larvae crawl to protected locations including under the calyx of a fruit after hatching (Gilligan and Epstein 2009).	No records found	Yes. Wide host range and distributed across North America in similar environments to Australia suggesting a potential for establishment and spread (Wilkinson *et al*. 2004; Bentley and Day 2006; Caprile *et al*. 2006; Pickel *et al*. 2006; CABI 2007; Coates *et al*. 2009).	Yes. Major pest of apple worldwide (CABI 2007); larval feeding results in scarring and distorted fruit reducing marketability and severe attack can result in young fruit aborting (Brunner 1993; Wilkinson *et al.* 2004; Bentley and Day 2006; Caprile *et al*. 2006; Pickel *et al*. 2006; Coates *et al*. 2009). Not previously considered an important pest as cover sprays provided effective control, but insecticide resistance has dictated a need for specific control measures (Fadamiro 2004b).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Cydia pomonella (Linnaeus, 1758) [WA,] [Tortricidae] Codling moth	Yes. ID, OR, WA (APHIS 2007a).	Yes. Larvae bore internally in apple fruit (APHIS 2007a).	Yes (Nielsen *et al*. 1996); absent from WA (DAWA 2006).	Yes. Main hosts are apple and pear. Larvae are known to be polyphagous and apart from apple (*Malus*) and pear (*Pyrus*), they can also feed on cherry, nectarine, prune (*Prunus* spp.) and walnut (*Juglans regia*) (CABI 2007). These hosts are widespread in Western Australia. It has been reported from the eastern states including Tasmania and South Australia. However, several outbreaks have occurred in Western Australia and have been successfully eradicated, indicating that climatic conditions are suitable for its establishment in Western Australia.	Yes. Codling moth is a well known pest of apples as well as pear and walnut (CABI 2007). Larvae damage developing shoots and fruit. Severe damage can occur causing a reduction in marketability of fruit (Caprile *et al*. 2006; Lacey *et al*. 2006)	Yes [WA]
Datana ministra (Drury, 1773) [Notodontidae] Yellow-necked caterpillar	Yes. OR, WA (APHIS 2007a).	No. Feed on leaves (APHIS 2007a). Major host is roundleaf serviceberry (*Amelanchier sanguinea*) and doesn't occur on apple fruit (APHIS 2007a).	Not assessed	Not assessed	Not assessed	No
Enarmonia formosana (Scopoli, 1763) [Tortricidae] Cherry bark tortrix	Yes. OR, WA (LaGasa 1996; Tanigoshi *et al*. 2000; Breedveld and Tanigoshi 2007).	No. Larvae attack the bark of older trees boring between the bark and cambium of several rosaceous trees including apple (*Malus*) (LaGasa 1996; Breedveld and Tanigoshi 2007).	Not assessed	Not assessed	Not assessed	No
Euproctis chrysorrhoea (Linnaeus, 1758) [Lymantriidae] Brown-tail moth	Yes. Reduced to two coastal enclaves in MA, ME (Elkinton *et al.* 2006); apple listed as a host (CABI 2007).	No. Eggs are laid on the underside of leaves and larvae feed on the leaves of host plants (Maine Department of Conservation 2008).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Graphiphora augur (Fabricius, 1775) [Noctuidae] Double dart moth	Yes. Transcontinental from Alaska to Newfoundland and the northern United States, southward in the Rockies to New Mexico and on the Pacific coast to Northern California (Lafontaine and Wood 1997; Fauske 2007); apple listed as a minor host (CABI 2007).	No. Larvae feed on leaves of trees and shrubs (Mazzei *et al*. 2009; Kimber 2009; Fauske 2007).	Not assessed	Not assessed	Not assessed	No
Grapholita molesta (Busck, 1916) [WA,] Synonym: *Cydia molesta* Busck, 1916 [Tortricidae] Oriental fruit moth	Yes. WA, AR, CA, GA, MI, MO, NY, NC, OH, PA, VA (Botha *et al*. 2006).	Yes. Eggs are laid on the underside of leaves, on stems, or smooth-skinned fruit; summer cocoons may be found on fruit, in axils of twigs, under pieces of bark, and on the ground under loose debris (Botha *et al*. 2006). Larvae bore into the apple fruit (Myers *et al.* 2006a, b, c, 2007).	Yes (Nielsen *et al*. 1996); absent from WA (DAWA 2006).	Yes. Wide host range, distributed globally, present in all Australian states except WA and NT suggesting a potential for establishment and spread (Barcenas *et al*. 2005; Bentley and Day 2006; CABI 2007; Gencsoylu *et al*. 2006).	Yes. Serious international pest especially of peaches, nectarines and apricots (Rothschild and Vickers 1991; CABI 2007) and in recent years its incidence on apples has increased (Botha *et al*. 2006). Attacks on fruits considerably reduce their quality and, therefore, their market value (Botha *et al*. 2006) and since Oriental fruit moth can cause economic damage at relatively low population densities (Botha *et al*. 2006), it would have significant consequences if it was introduced into Western Australia.	Yes [WA]
Grapholita packardi Zeller, 1875 Synonym: *Cydia prunivora* (Walsh, 1868) [Tortricidae] Cherry fruitworm	Yes. WA (Barcenas *et al.* 2005); OR, WA (CABI 2007).	Yes. Larvae are internal fruit feeders of apples and pears in North America (Barcenas *et al.* 2005).	No records found.	Yes. Wide host range, distributed across the US and localised in Canada in environments similiar to Australia, suggesting a potential for establishment and spread (Barcenas *et al*. 2005; CABI 2007).	Yes. A pest in Pacific Northwest blueberry fields that can cause up to 25% of the berries to be destroyed or rendered unmarketable (DeFrancesco 2004).	Yes

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Grapholita prunivora (Walsh, 1868) Synonym: *Cydia prunivora* (Walsh, 1868) [Tortricidae] Lesser appleworm	Yes. OR, WA (APHIS 2007a).	Yes. Larvae bore internally in apple fruit which may result in some fruit drop; larvae pupate in the ground (APHIS 2007a).	No records found	Yes. Hosts include apple (*Malus*), stone fruit (*Prunus* spp.), service berries (*Amelanchier*), pears (*Pyrus*), roses (*Rosa*), hawthorns (*Crataegus*) and elms (*Ulmus*) all of which are widespread in Australia; distributed across USA and Canada in environments similar to Australia, suggesting a potential for establishment and spread (Barcenas *et al*. 2005; CABI 2007).	Yes. Larvae eat fruit by hollowing out superficial galleries under the skin, which remains intact at first, but then wrinkles, turns brown and ampoules form where excrement accumulates. The ampoules usually form in the calyx end of the fruit, but they may also be found near the peduncle or around the apple (CABI 2007). This obviously results in the fruit being unmarketable.	Yes
Hedya nubiferana (Haworth, 1811) Synonym: *Hedya dimidioalba* (Retzius, 1783) [Tortricidae] Green budworm	Yes. WA (LaGasa 1996), OH (Rings 1992).	Yes. Overwintering larvae feed on opening leaf and blossom buds and may also bore into new branch tips (LaGasa 1996). Eggs are usually laid on leaves, rarely on fruits which are seldom damaged by larval feeding (Ovsyannikova and Grichanov 2008c). The caterpillar hibernates overwinter in bud axils or cracks in tree bark and it pupates inside a cocoon in a rolled-up leaf (INRA 1997).	No records found	Yes. Polyphagous pest of rosaceous fruit trees and bushes including apple (*Malus*), pear (*Pyrus*), quince (*Cydonia oblonga*), apricot, cherry, sweet cherry, plum (*Prunus* spp.), rowan (*Sorbus* sp.), hawthorn (*Crataegus*), raspberry (*Rubus*), *Cotoneaster*, and roses (*Rosa*) (Ovsyannikova and Grichanov 2008c) all of which are widespread in Australia; distributed across western Europe, European Russia, Asia Minor, Iraq, Iran, Transcaucasus, Urals, Kazakhstan, mountains of Turkmenistan and western Siberia, introduced to the US and Canada (Ovsyannikova and Grichanov 2008c; CABI 2007) in environments similar to Australia, suggesting a potential for establishment and spread.	Yes. Pest of gardens in the south of European Russia and in the Caucasus, larvae destroy buds and flower buds of several economic crops including apple (*Malus*), apricot, cherry, plum (*Prunus* spp.), pear (*Pyrus*), raspberry (*Rubus*) as well as roses (*Rosa*) (Ovsyannikova and Grichanov 2008c). Young larvae nibble the skin of late apples which encourages the growth of moulds and rotting of the fruit which obviously results in the fruit being unmarketable (INRA 1997).	Yes
Hemithea aestivaria (Hübner, 1799) [Geometridae] European common emerald	Yes. WA (LaGasa 1996).	No. Larva feeds on apple leaves (LaGasa 1996; Duncan 2007; Kimber 2009).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Hyalophora cecropia (Linnaeus, 1758) [Saturniidae] Cecropia silkmoth	Yes. WA. Nova Scotia and ME south to FL, west across southern Canada and the eastern United States to the Rocky Mountains (Opler *et al*. 2009).	No. Eggs are laid on on both sides of the leaves of small host trees or shrubs; larvae feed on the leaves of various trees and shrubs including apples (*Malus*) (Fauske 2002; Opler *et al*. 2009).	Not assessed	Not assessed	Not assessed	No
Hyphantria cunea (Drury, 1770) [Arctiidae] Fall webworm	Yes. OR, WA (APHIS 2007a).	No. Feeds on leaves of apple (APHIS 2007a). Eggs are usually deposited on the underside of leaves and larvae pupate in the soil or bark cracks (Douce 2003).	Not assessed	Not assessed	Not assessed	No
Lacanobia subjuncta (Grote & Robinson, 1868) [Noctuidae] Lacanobia fruitworm	Yes. WA (APHIS 2007a); OR, WA (Doerr *et al*. 2005).	Yes. Larvae feed directly on fruit by excavating holes (Doerr and Brunner 2007). Young larvae feed on the shoots sometimes resulting in defoliation while older larvae also feed on fruit (Bell *et al*. 2007; Riedl and Hilton 2007; APHIS 2007a).	No records found	Yes. Wide host range feeding on a variety of plants including row crops, shrubs, trees and several weed species (dandelion (*Taraxacum*), bindweed (*Convolvulus*), mallow (*Malva*)) (Doerr *et al*. 2005; Landolt 1998). Occurs in North America in environments similar to Australia, suggesting a potential for establishment and spread.	Yes. Although fruit injury is incidental to foliage feeding it can be quite severe in orchards where the densities are high (Doerr and Brunner 2007) resulting in loss of production and reduction in fruit marketability.	Yes
Lithophane antennata (Walker, 1858) [Noctuidae] Green fruitworm	Yes. WA (APHIS 2007a).	No. Larvae feed on leaves and fruit (APHIS 2007a; Riedl and Hilton 2007). Although reported to feed on fruit causing superficial or deep holes into the fruits of apple (Rings 1973), this species overwinters as adults and lay 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 (Rings 1973) and would therefore not be associated with fruit during harvest.	Not assessed	Not assessed	Not assessed	No
Lymantria dispar (Linnaeus, 1758) Synonym: *Porthetria dispar* (Linnaeus, 1758) [Lymantriidae] European gypsy moth	Yes. Northeastern US (ME, VT, NH, MA, CT, RI, NY, NJ, PA, MI, VA, WV, MD) (Liebhold 2003). *Malus* is listed as a host (CABI 2007; Kimoto and Duthie-Holt 2007).	No. Eggs are laid on tree trunks and the underside of branches. The larvae are foliage feeders (GISD 2006).	Not assessed	Not assessed	Not assessed	No

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Lymantria monacha (Linnaeus, 1758) [Lymantriidae] Nun moth	No. NY, formerly present but now absent (CABI 2007).	No. Larvae are foliage feeders (Keena 2003). Eggs are normally laid in the bark crevices of trees (Humphreys and Allen 2002).	Not assessed	Not assessed	Not assessed	No
Lyonetia prunifoliella Hübner, 1796 Synonym: *Lyonetia speculella* Clemens, 1862 [Lyonetiidae] Apple leaf miner	Yes. Ranges from Ontario south to VA and west to British Columbia and WA, south to CA, TX and possibly NM (Schmitt *et al*. 1996); CT, WV (CABI 2007).	No. Larvae mine the leaves of various roseaceous trees including apple (*Malus*), forming blotch mines (Kimber 2009; Schmitt *et al*. 1996).	Not assessed	Not assessed	Not assessed	No
Malacosoma americanum (Fabricus, 1793) [Lasiocampidae] Eastern tent caterpillar	Yes. Widespread in the eastem part of the United States as far west as the Rocky Mountains (CABI/EPPO 1997h).	No. Eggs are laid on twigs and the larvae are foliage feeders only (Hyche 1996; CAB/EPPO 1997h).	Not assessed	Not assessed	Not assessed	No
Malacosoma disstria Hübner, 1822 [Lasiocampidae] Forest tent caterpillars	Yes. OR, WA (APHIS 2007a).	No. Feeds on leaves and doesn't overwinter on fruit (Meeker 2001; APHIS 2007a).	Not assessed	Not assessed	Not assessed	No
Mamestra configurata Walker, 1856 [Noctuidae] Bertha armyworm	Yes. ID (APHIS 2007a)	No. Eggs are laid in masses on the underside of leaves of crop plants and weeds (Berry 1998 in Hollingsworth 2008). Larvae feed on buds and leaves, chewing holes in buds and ragged holes out of leaves; also feed on growing tips, particularly on small apple trees or on the lower branches of large apple trees (Berry 1998 in Hollingsworth 2008).	Not assessed	Not assessed	Not assessed	No
Operophtera bruceata (Hulst, 1886) [Geometridae] Bruce spanworm	Yes. Occurs throughout the north eastern United States from New England to the Great Lakes (Maine Department of Conservation 2000). Rarely recorded from apple (CABI 2007; Robinson *et al*. 2008) and no evidence was found to suggest that this pest is associated with apple fruit in the Pacific Northwest.	No. Eggs laid in bark crevices, under loose flakes or in lichens (Natural Resources Canada 2008b). Larvae feed on the opening buds and expanding leaves causing the foliage to be skeletonised (Maine Department of Conservation 2000; Natural Resources Canada 2008b).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Operophtera brumata (Linnaeus, 1758) [Geometridae] Winter moth	Yes. OR (Kimberling *et al*. 1986); WA (LaGasa 1996); OR, WA, MS, RI, NH, ME, CT (Childs *et al*. 2007).	No. Eggs are laid in clusters on tree trunks and branches, in bark crevices, under bark scales and loose lichen. Larvae feed on buds (by tunnelling into apple buds just before or at bud break), expanding leaf clusters, leaves, and blossoms from early spring until June; damage to blossoms and developing fruit produces a high percentage of distorted fruit; larvae leave fruit to pupate underground long before fruit reaches maturity (LaGasa 1996; INRA 1997; Childs *et al*. 2007).	Not assessed	Not assessed	Not assessed	No
Orgyia antiqua (Linnaeus, 1758) [Lymantriidae] Rusty (European) tussock moth	Yes. OR, WA (APHIS 2007a).	No. Larvae feed externally on leaves, sometimes causing complete defoliation of shrubs and trees; cocoons are spun in chinks of bark, amongst leaves, or in crevices in walls (CABI 2007). Rarely feeds on fruit and doesn't overwinter on fruit (APHIS 2007a). Considered a surface feeder of fruit that would be excluded during routine harvest and post-harvest quality control procedures undertaken in the orchard and within the packinghouse.	Not assessed	Not assessed	Not assessed	No
Orgyia leucostigma (J. E. Smith, 1797) [Lymantriidae] White-marked tussock moth	Yes. Widely distributed throughout eastern North America, as far west as TX and CO (Hyche 1999); MD (Medina and Barbosa 2002); FL (Foltz 2004); AL (Hyche 1999).	No. Egg masses are laid on the female moth's empty cocoons attached to the trunk and branches of the host plants, while the larvae feed on leaves (Foltz 2004).	Not assessed	Not assessed	Not assessed	No
Orthosia hibisci (Guenée, 1852) [Noctuidae] Speckled green fruitworm	Yes. WA (Howell 1993).	No. Eggs laid on tree leaves; reported to feed at first on buds, then later on flowers, leaves and fruit although prefer fruiting spurs; in summer mature larvae drop to the ground to pupate in the soil (Howell 1993) and therefore not present in fruit at harvest time.	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Ostrinia nubilalis (Hübner, 1796) Synonym: *Pyrausta nubilalis* Meyrick, 1890 [Pyralidae] European corn borer	Yes. MA, NY, has spread as far west as the Rocky Mountains and south to the Gulf Coast states (Capinera 2000).	Yes. Larvae bore into the apple fruit. Fruit infested with larvae can produce no noticeable injury (Weires and Straub 1982; Straub *et al.* 1986). The females lay eggs on well-irrigated plants such as apple (CABI 2007).	No records found	Yes. A very wide host range including all robust herbaceous plants such as corn (*Zea mays*), potato (*Solanum tuberosum*), snap (*Phaseolus vulgaris*) and lima beans (*Phaseolus lunatus*), buckwheat (*Fagopyrum esculentum*), grain corn (*Z. mays*), hop (*Humulus lupulus*), oat (*Avena sativa*), pearl millet (*Pennisetum glaucum*), barley (*Hordeum vulgare*) and soybean (*Glycine max*), flowers such as *Aster*, *Cosmos*, *Dahlia*, *Gladiolus*, *Zinnia* and hollyhock (*Alcea rosea*), as well as many common weeds (*Amaranthus* spp., *Bidens* spp., *Echinochloa* sp., *Panicum* spp., and *Polygonum* spp., *Rumex* spp., *Xanthium* spp.) etc. (Weires and Straub 1982; Capinera 2000; CABI 2007). An introduction from Europe that has spread across the USA and Canada in environments similar to Australia, suggesting a potential for establishment and spread (CABI 2007).	Yes. In Mediterranean region, the caterpillar's presence leads to a weakening of the plant which results in a reduction of the weight of grains, the losses reaching up to 30%. Serious damage may occur once the population in a maize field reaches one caterpillar per plant at harvest (INRA 1997).	Yes
Pandemis cerasana (Hübner, 1786) Synonym: *Pandemis ribeana* (Hübner, 1796) [Tortricidae] Barred fruit tree tortrix	Yes. WA (LaGasa 1996).	No. Larvae essentially feed on leaves (INRA 1997; Evans 1970) and eggs are laid on the upper surface of leaves (Evans 1970). Larvae feed on blossoms and immature apple fruitlets producing blemished fruit (LaGasa 1996). Larvae have been reported feeding on rosaceous fruit especially apple causing damaged ovaries to fall down and fruits to be deformed or rotten (Ovsyannikova and Grichanov 2008a). Infested immature apple fruit exhibit visible round holes 5–10 mm in diameter (CABI 2008).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Pandemis heparana (Denis & Schiffermüller, 1775) [Tortricidae] Dark fruit tree tortrix	Yes. WA (LaGasa 1996).	Yes. Eggs are laid on the upper side of the leaves (Ovsyannikova and Grichanov 2008b). Larvae mostly feed on leaves, but flower and fruit feeding can cause loss or blemished fruit (LaGasa 1996). In Europe larvae are reported to feed on the epidermis and pulp of fruit causing particularly serious damage in summer (INRA 1997).	No records found	Yes. Host range includes fruit bearing Rosaceae particularly apple (*Malus*) and pear (*Pyrus*) (INRA 1997); found throughout a wide range of agro-ecological zones in western Europe, across Russia to Mongolia, China, Japan and introduced to North America (Ovsyannikova and Grichanov 2008b) in environments similar to Australia, suggesting a potential for establishment and spread.	Yes. In Russia caterpillars destroy up to 26-66% of ovaries in addition to plenty of leaf rosettes and flower buds; injured apples partly rot on trees and an important pest on numerous fruit crops (Ovsyannikova and Grichanov 2008b). Apple fruit is particularly susceptible to rotting especially during storage of the attacked fruit (INRA 1997).	Yes
Pandemis pyrusana Kearfott, 1907 [Tortricidae] Pandemis leafroller	Yes. ID, OR, WA (APHIS 2007a).	Yes. An historical pest of apples and also reported from various stone fruit. Principally a leaf feeder, that also causes damage to fruits (Berry 1998 in Hollingsworth 2008). Some larvae may eat portions of young fruit causing damaged fruit to abort or become deeply scarred and severely deformed (Brunner 1993). Eggs laid in masses on the upper surfaces of leaves and on fruit, economic damage is caused by feeding between clusters of fruit (Gilligan and Epstein 2009).	No records found	Yes. Wide host range including wild plants such as cottonwood (*Populus* spp.), rose (*Rosa*), willow (*Salix*), dogwood (*Cornus*), hawthorn (*Crataegus*), antelope brush (*Purshia glandulosa*), big-leaf maple (*Acer macrophyllum*), chokecherry (*Prunus virginiana*), lupine (*Lupinus*) and alder (*Alnus*) as well as apple (*Malus*) and cherry (*Prunus* spp.) (Brunner 1993); widely distributed across North America in environments similar to Australia, suggesting a potential for establishment and spread (Jones *et al*. 2005; Caprile *et al*. 2006).	Yes. Larvae eat holes in fruit and leaves causing reduction in fruit marketablity. It is a key pest of apple (Jones *et al.* 2005; Caprile *et al*. 2006; Dunley *et al*. 2006).	Yes
Pasiphila rectangulata (Linnaeus, 1758) Synonym: *Chloroclystis rectangulata* (Linnaeus, 1758) [Geometridae] Green pug moth	Yes. WA (Ferguson and Mello 1996; LaGasa 1996, 2008).	No. Larvae eat buds, flowers and leaves of apple from March to June; damage to blossoms causes considerable deformation of fruit (Ferguson and Mello 1996; LaGasa 1996; Maier 2007b).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Peridroma saucia (Hübner, 1808) Synonym: *Lycophotia saucia* Hübner, 1808 [Noctuidae] Pearly underwing	Yes. OR (West and Miller 1989); WA (Rock and Waynick 1975).	No. Although larvae have been reported feeding on apple fruit (Rock and Waynick 1975), they feed at night and remain under surface debris or loose dirt at the base of host plants during the day (Mau *et al*. 2007a). They are one of the few cutworm species that climb the host plant to feed during the night (North Carolina State University 1982) and would therefore not be associated with fruit during harvest.	Not assessed	Not assessed	Not assessed	No
Phyllonorycter blancardella (Fabricius, 1781) Synonym: *Lithocolletis blancardella* (Fabricius, 1781) [Gracillariidae] Spotted tentiform leafminer	Yes. OR, WA (Landry and Wagner 1995); northeastern US (El-Sayed *et al.* 2004).	No. Larvae are leaf miners of apple (*Malus* spp.) (Landry and Wagner 1995). The eggs are laid on the underside of leaves and the larvae feed on leaves (INRA 1997).	Not assessed	Not assessed	Not assessed	No
Phyllonorycter crataegella (Clemens, 1859) Synonym: *Lithocolletis crataegella* Clemens, 1859 [Gracillariidae] Apple blotch leafminer	Yes. Northeastern US (Green and Prokopy 1998). Western North American records remain unconfirmed and are probably erroneous (Landry and Wagner 1995).	No. Eggs are laid on the underside of leaves while larvae mine apple leaves (Landry and Wagner 1995; Green and Prokopy 1998).	Not assessed	Not assessed	Not assessed	No
Phyllonorycter elmaella Doganlar & Mutuura, 1980 [Gracillariidae] Western tentiform leafminer	Yes. ID, WA (Beers *et al*. 1993, 2007; APHIS 2007a). Pacific Coast region from from central Oregon to southern British Columbia (Landry and Wagner 1995).	No. Eggs are laid on the undersides of leaves while larvae mine apple leaves and pupate in fallen leaves; (Simone 2004; Beers *et al*. 2007); larvae do not feed on apple fruit (APHIS 2007a).	Not assessed	Not assessed	Not assessed	No
Phyllonorycter mespilella (Hübner, 1805) [Gracillariidae] Apple leafmining moth	Yes. OR, WA, CA, UT, NM (Landry and Wagner 1995; Varela *et al*. 1997).	No. Larvae mine the leaves of various apple cultivars and crabapples (*Malus* spp.) (Meristem Land and Science 2002) and other rosaceous plants (Borden *et al*. 1953; Landry and Wagner 1995).	Not assessed	Not assessed	Not assessed	No

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Platynota flavedana Clemens, 1860 [Tortricidae] Variegated leafroller; Rusty brown tortricid	Yes. VA (Pfeiffer *et al*. 1993); FL, KS, ME, TX, VA (CABI 2007); although ranging from Maine to North Carolina and west to Minnesota and Arizona it is predominantly a southern species (Hull *et al*. 1995a).	Yes. Eggs are deposited only on the top surfaces of leaves. Larvae feed on leaves from a shelter formed of two leaves tied together or on the fruit surface where a leaf is tied to a fruit (Hull *et al*. 1995a).	No records found	Yes. Wide host range and described as a general feeder, most common on low growing rosaceous hosts, e.g. strawberry (*Fragaria*). In addition to apple (*Malus*), it has also been found on azalea (*Rhododendron* spp.), blackberry, raspberry (*Rubus* spp.), clover (*Trifolium*), cotton (*Gossypium*), sunflower (*Helianthus* sp.), maple (*Acer*), peach (*Prunus*), rose (*Rosa*), sassafras (*Sassafras albidum*), and other plants (Hull *et al*. 1995a). Distributed from Maine to North Carolina and west to Minnesota and Arizona (Hull *et al*. 1995a) in environments similar to Australia. It is also developing resistance to organophosphorus insecticides (Hull *et al*. 1995a) suggesting a potential for establishment and spread.	Yes. Eats holes in fruit causing a reduction in fruit marketability. Early season feeding results in large corky scars and indentations on the fruit which often drop prematurely, while summer-feeding on developing fruit will result in downgrading of apples to juice quality (Solymár 2005) and subsequent economic impact on the grower.	Yes
Platynota idaeusalis (Walker, 1859) [Tortricidae] Tufted apple budworm	Yes. NC (Meissner *et al*. 2001); DE, GA, MI, NJ, NC, PA, VA, WV (CABI 2007).	Yes. Larvae feed on leaves from a shelter formed of two leaves tied together or on the fruit surface where a leaf is tied to a fruit. Late season second brood larvae drop to the ground during fruit harvest or with leaf fall to overwinter. Larvae occasionally enter the apple calyx and feed unnoticed within the seed cavity (Hull *et al*. 1995b).	No records found	Yes. Wide host range including the following major hosts: apple (*Malus*), pear (*Pyrus*), cherry, nectarine, peach (*Prunus* spp.) and a wide range of herbaceous plants found in the ground cover (Hull *et al*. 1995b), all of which occur in Australia. Widely distributed across eastern North America (Hull *et al*. 1995b) in environments similar to Australia, suggesting a potential for establishment and spread. First instar larvae disperse by crawling or ballooning (floating in the wind on a strand of silk) while adults are capable of unassisted flight (Hull *et al*. 1995b).	Yes. Leafrolling activity of the caterpillars has little economic impact on the fruit grower. However, feeding damage on apple fruit appears as tiny holes or irregular scarring or channeling of the apple surface or as an area of rot (Hull *et al*. 1995b), obviously reducing marketability. Generally, feeding injury does not reduce the grade of processing apples, but it can affect the rate of fruit drop and storageability of those apples by promoting decay, both of which can have an economic impact on the grower and processor (Hull *et al*. 1995b).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Platynota stultana Walsingham, 1884 [Tortricidae] Omnivorous leafroller	Yes. CA, AZ, FL, IL, MA, MI, TX, VA, Washington D.C. (Flaherty *et al*. 1992).	Yes. Larvae feed on leaves and on the surface of fruit, sometimes webbing one or more leaves to the fruit for protection. They chew shallow holes or grooves in the fruit surface, often near the stem end (Caprile *et al*. 2006).	No records found	Yes. Wide host range including grapes (*Vitis*), apricot, peach, plum, prune (*Prunus* spp.), avocado (*Persea americana*), berries (*Rubus* spp., celery (*Apium*), citrus (*Citrus* spp.), eggplant (*Solanum melongena*), lettuce (*Lactuca sativa*), melons (Cucurbitaceae), sorghum (*Sorghum*), strawberry (*Fragaria*), tomato (*Lycopersicon*), walnut (*Juglans*), carnation (*Dianthus caryophyllus*), *Chrysanthemum*, *Eucalyptus*, *Fuchsia*, geranium (Geraniaceae), rose (*Rosa*) as well as weeds such as California mugwort (*Artemesia douglasiana*), cheeseweed (*Malva parviflora*), horseweed (*Conyza canadensis*), lambsquarters (*Chenopodium album*), panicled willow herb (*Epilobium brachycarpum*) and pigweed (*Amaranthus* spp.) (Flaherty *et al*. 1992) most of which occur across Australia. This pest has two to four generations per year depending on climatic conditions (Caprile *et al*. 2006) suggesting an ability to survive conditions in Australia. Distributed across southern and northeast US, northern Mexico (Flaherty *et al*. 1992) in environments similar to Australia, suggesting a potential for establishment and spread.	Yes. Omnivorous leafroller is a major vineyard pest in California. It feeds on flowers and developing berries and feeding damage provides entry for secondary rot organisms that further damage clusters (Flaherty *et al*. 1992).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Pseudexentera mali Freeman, 1942 [Tortricidae] Pale apple leafroller	Yes. MI, MO, NY, OH, WI (Chapman and Lienk 1971; Miller 1986).	Yes. Eggs are laid in leaf scars and crevices on the fruit spurs (Chapman and Lienk 1971). Larvae feed on the growing tips of terminal buds before and up to three weeks after the end of the blossom period. It is primarily a bud and foliage feeder although young fruits are occasionally attacked (Chapman and Lienk 1971). As the leaves develop the larvae will web a leaf to the side of an apple or fruit cluster and feed on the surface of the apple (Braun and Craig 2008).	No records found	Yes. Host range includes domestic apple, crabapple (*Malus* spp.) and possibly hawthorn (*Crataegus* spp.) all of which occur across temperate Australia. It overwinters in the soil within a cocoon (Chapman and Lienk 1971) suggesting an ability to survive winter conditions in Australia. Distributed across temperate north-eastern US and south-eastern Canada (NS, ON, QC) (Miller 1986) in environments similar to Australia, suggesting a potential for establishment and spread.	Yes. Feeding on the terminal buds of young non-bearing trees significantly stunts or deforms the tree making good tree structure difficult to develop (Braun and Craig 2008). As the leaves develop the larvae will web a leaf to the side of an apple or fruit cluster and chew a vertical strip down the side of the apple (Braun 2004) leading to a reduction in fruit marketability.	Yes
Recurvaria nanella (Denis & Schiffermüller, 1775) [Gelechiidae] Lesser bud moth	Yes. WA (LaGasa 1996).	No. Larvae of this pest feed on leaves and blossoms of apple (*Malus*), in early spring (LaGasa 1996; Kimber 2009).	Not assessed	Not assessed	Not assessed	No
Rhopobota naevana (Hübner, 1814) Synonym: *Rhopobota unipunctana* (Haworth, 1811) [Tortricidae] Blackheaded fireworm moth; Holly bud moth	Yes. Pacific Northwest (OR) (Rosetta and Young 2007). Although larvae are known to attack cultivated apple and pear in Europe (Alford 1984) and are a known as a pest of cultivated cranberry in North America (Kachadoorian and Mahr 1991; Fitzpatrick 2006) and Russia (Volkova 1976), no evidence was found to suggest that this pest is associated with apple fruit in the Pacific Northwest.	No. Eggs are laid singly on the smooth bark of trunks and branches of host trees or on the underside of holly leaves; larvae feed in a webbed shelter of young leaves as well as unopened and opened flowers; larvae pupate in a cocoon spun in a folded leaf or amongst dead leaves or debris on the ground (Meijerman and Ulenberg 2000). Larvae destroy young leaves, flowers and, occasionally, newly set fruitlets; as well as destroying young lateral shoots (Alford 1984). They are not associated with mature fruit.	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Spilonota ocellana (Denis & Schiffermüller, 1775) [Tortricidae] Eyespotted bud moth	Yes. OR, WA (APHIS 2007a).	Yes. A silken feeding tube may be spun to the surface of apple fruit (APHIS 2007a) so the larvae may also feed on the fruit surface.	No records found	Yes. Wide host range, feeding on various wild hosts and many fruit crops including apple (*Malus*), pear (*Pyrus*), cherry, plum (*Prunus* spp.), blackberry and raspberry (*Rubus* spp.), apple (*Malus*) being its most consistent food source (Strickler and Whalon 1985). Occurs generally throughout the northern hemisphere (Europe and North America) in apple-growing regions in environments similar to Australia suggesting a potential for establishment and spread (CABI 2007).	Yes. Principally a pest of pears and apples where buds are attacked causing economic losses (Dickler 1991). Larval damage caused to apple and pear buds can reduce cropping considerably (INRA 1997).	Yes
Spodoptera frugiperda (J.E. Smith, 1797) Synonym: *Laphygma frugiperda* (J.E. Smith, 1797) [Noctuidae] Fall armyworm	Yes. CA and widespread east of the Rockies (Capinera 2005; CABI 2007); midwestern US (Burkness *et al.* 2002).	No. Although CABI (2007) lists apple (*Malus pumila*) as a minor host, no evidence was found to suggest that this pest is associated with apple fruit.	Not assessed	Not assessed	Not assessed	No
Swammerdamia pyrella (Villers, 1789) Synonym: *Swammerdamia pelicaria* (Retzius, 1783) [Yponomeutidae]	Yes. WA (LaGasa 1996, 2008).	No. Larvae feed on the upper surface of apple and hawthorn leaves during early to late summer (LaGasa 1996; Kimber 2009).	Not assessed	Not assessed	Not assessed	No
Synanthedon scitula (Harris, 1839) [Sesiidae] Dogwood borer	Yes. Distributed from southeastern Canada and New England, west to OH and MN, and south to TX (Hogmire 1997; Michigan State University 2000).	No. Eggs are laid singly in wounds and burr knots on apple trees; larvae develop in galleries beneath the tree bark (Hogmire 1997) or in burr knots (Michigan State University 2000).	Not assessed	Not assessed	Not assessed	No
Synanthedon myopaeformis (Borkhausen, 1789) [Sesiidae] Apple clearwing moth	Yes. WA (LaGasa 2008; NAPIS 2008c).	No. Recorded laying eggs in burr knots (Ateyyat 2006). Larvae bore deep sub-cortical galleries in tree trunks especially apple, often cutting into the phloem (INRA 1997).	Not assessed	Not assessed	Not assessed	No
Tischeria malifoliella Clemens, 1860 [Tischeriidae] Appleleaf trumpet miner	Yes. Common in eastern US (Byers 2006).	No. Larvae make trumpet shaped mines in upper surface of leaves (Byers 2006).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Xestia c-nigrum (Linnaeus, 1758) Synonym: *Amathes c-nigrum* (Linnaeus, 1758) [Noctuidae] Spotted cutworm; Setaceous Hebrew character	Yes. WA (Howell 1979; Howell and George 1979; Landolt 2000; Landolt and Hammond 2001).	No. Larvae feed on the buds when the tree is dormant but feed on the leaves and surface of fruit in the growing season (Howell and George 1979). Larvae feed at night, and then descend to the ground to hide during the day (CABI 2007) and would not be present at harvest.	Not assessed	Not assessed	Not assessed	No
Yponomeuta malinellus (Zeller, 1838) Synonym: *Hyponomeuta malinellus* (Zeller, 1838) [Yponomeutidae] Apple ermine moth	Yes. WA, OR (LaGasa 1996, 2008; Unruh *et al.* 2003).	No. Eggs are laid on the bark of apple trees (Antonelli *et al*. 1989). The web spinning larvae feed on apple leaves from April to June; fruit may also be deformed where it comes in contact with larval webs (LaGasa 1996; Kimber 2009). Pupal cocoons are arranged in a web beneath a leaf or twig (Kimber 2009).	Not assessed	Not assessed	Not assessed	No
Yponomeuta padella (Linnaeus, 1758) [Yponomeutidae] Cherry ermine moth; Orchard ermine	Yes. WA (LaGasa 1996).	No. Larvae feed on the leaves of apple (*Malus*) (LaGasa 1996; Kimber 2009).	Not assessed	Not assessed	Not assessed	No
Zeuzera pyrina (Linnaeus, 1761) [Cossidae] Leopard moth	Yes. Introduced probably from Europe now distributed mostly along the Atlantic seaboard from Philadelphia northward to MA (Solomon 1995). Also CT, DE, ME, MA, NH, NJ, NY, PA, RI, SD (NAPPO 2001).	No. Eggs are usually laid on the ground but also on young shoots, in branch forks and bark cracks (Ovsyannikova and Grichanov 2008d). Larvae bore into the tips of branches and shoots, then move downwards to attack the young parts of the tree (twigs, spurs, pouches, central veins and leaf peduncles). After further migration, the larvae then attack the larger branches and the trunk (INRA 1997).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Order Thysanoptera						
Frankliniella occidentalis (Pergande, 1895) Synonyms: *Euthrips tritici californicus* Moulton, 1911; *Frankliniella tritici maculata* Priesner, 1925; *Frankliniella tritici moultoni* Hood, 1914. [Thripidae] Western flower thrips	Yes. ID, OR, WA (CABI 2007).	Yes. Affect leaves, and inflorescence of the plants (Frantz and Fasulo 2008). It can be associated with apple fruit at harvest if the population and infestation is high (CABI 2007).	Yes. Occurs in every state (Mound 2008; DAWA 2006), but is absent from NT (DRDPIFR NT 2008) and under official control in Tasmania (DPIW 2008a).	Yes. A very broad host range including apple (*Malus*), geranium (Geraniaceae), *Chrysanthemum*, cotton (*Gossypium*), grapes (*Vitis vinifera*), and *Citrus* (CABI 2007; Frantz and Fasulo 2008). High reproductive rate with more than one generation per year (McDonald *et al*. 1998) and capable of unassisted flight (Pearsall 2002), suggests a potential for establishment and spread	Yes. A pest of several economically important crop species and a known vector of Tomato spotted wilt virus (TSWV) (CABI 2007; Frantz and Fasulo 2008).	Yes (For NT and Tas.)
Frankliniella tritici (Fitch, 1855) [Thripidae] Eastern flower thrips	Yes. ID (CABI 2007); CA (Hoddle *et al*. 2004). Mainly an eastern species distributed in AR, FL, GA, IL, KY, LA, MD, MS, MT, NJ, NY, NC, ND, OK, PA (CABI 2007).	Yes. Flowers (Frantz and Fasulo 2008) and young fruit (APHIS 2007a).	No records found	Yes. Wide host range including grasses, legumes, composites, crucifers as well as rose (*Rosa*) (Frantz and Fasulo 2008) 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 of several fruit crops and flowers, especially roses (*Rosa* spp.), in eastern United States (Nakahara 1997). This flower thrips is not known to be a vector of Tomato spotted wilt virus (TSWV) although the thrips is able to acquire the virus it does not move to the insects mouthparts, which is necessary for transmission (de Assis Filho *et al*. 2005). Feeds on leaves and flowers (Stavisky *et al.* 2002; University of Illinois 2004).	Yes
Retithrips syriacus Mayet, 1890 [Thripidae] Black vine thrips	Yes. Present in Florida as an introduction (APHIS 1997). Apple (*Malus domestica*) is listed as a host by (CABI 2007). However, there is no evidence that this species is associated with apple production in the Pacific Northwest.	No. Eggs are laid in the leaf tissue at both upper and lower surfaces. It prefers the lower leaf-surface on the majority of host plants however when infestation is heavy the upper surface is also attacked (CABI 2007).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
CHROMALVEOLATA						
Order Peronosporales						
Phytophthora cactorum (Lebert & Cohn) J. Schröt. [Pythiaceae] Phytophthora fruit rot	Yes. AR, CA, CT, FL, ID, ME, NC, NY, PA, SC, WA; US (Farr and Rossman 2009); ID, OR, WA (APHIS 2007a). Phytophthora fruit rot occurs sporadically and is of limited economic importance on apple in Washington and Oregon (Covey and Harris 1990).	Yes. *Phytophthora cactorum* causes post harvest fruit rot (Covey and Harris 1990; APHIS 2007a). It also causes canker at or below the ground line in the root-crown area (Jones and Sutton 1996). Zoospores may be splashed onto fruit and cause rot (Jones and Sutton 1996).	Yes. ACT, NSW, Qld, SA, Tas., Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Phytophthora cambivora (Petri) Buisman [Pythiaceae] Phytophthora root rot	Yes. CA, NC, NY, OR; US (Farr and Rossman 2009).	Yes. *Phytophthora cambivora* causes canker at or below the ground line in the root-crown area (Jones and Sutton 1996). Zoospores may be splashed onto fruit and cause rot (Jones and Sutton 1996).	Yes. NSW, Qld, SA, Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Phytophthora cryptogea Pethybr. & Laff. [Pythiaceae] Phytophthora root rot	Yes. CA, KY, NY; US (Farr and Rossman 2009).	Yes. *Phytophthora cryptogea* causes canker at or below the ground line in the root-crown area (Jones and Sutton 1996). Zoospores may be splashed onto fruit and cause rot (Jones and Sutton 1996).	Yes. ACT, NSW, Qld, SA, Tas., Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Phytophthora drechsleri Tucker [Pythiaceae] Crown rot; collar and root rot	Yes. AZ, CA; US (Farr and Rossman 2009).	Yes. Is primarily a root pathogen but also attacks ripening fruit of various crops (Farr and Rossman 2009).	Yes. ACT, NSW, Qld, SA, Tas., Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Phytophthora megasperma Drechsler [Pythiaceae] Phytophthora root rot	Yes. CA, NY; US (Farr and Rossman 2009).	No. Is primarily a root pathogen (CABI 2007). Has also been reported to cause crown rot of apple (Jeffers *et al.* 1982).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Phytophthora syringae (Berk.) Kleb. [Pythiaceae] Phytophthora fruit rot	Yes. NY; US (Farr and Rossman 2009).	Yes. Is a soilborne fungus affecting mostly roots and collar but can also infect fruit and cause rotting of fruit in storage. The fungus can also spread to adjacent healthy fruit (Snowdon 1990).	Yes. NSW (APPD 2009), SA (Cook and Dubé 1989), Vic. (Washington and Nancarrow 1983). No records for WA.	Yes. Its presence in NSW, SA and Victoria indicates potential for establishment and spread in WA.	No. Phytophthora fruit rot is of limited economic importance in the US and Canada even though *Phytophthora syringae* is widespread in these countries (Covey and Harris 1990). In states of Australia where it is recorded, it is of minor economic significance. *Phytophthora syringae* was assessed in the extension of existing policy for sweet oranges from Italy. Overall consequences were estimated as 'low'. Probability of distribution, establishment and spread were rated 'low', 'high' and high', respectively. Based on this existing pest risk assessment, even though probability of importation for US apples may be rated 'high', the overall probability of entry, establishment and spread would be 'low' and unrestricted risk would achieve Australia's ALOP.	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
DOMAIN FUNGI						
Order Agaricales						
Coprinopsis psychromorbida (Redhead & Traquair) Redhead, Vilgalys & Moncalvo Synonym: *Coprinus psychromorbidus* Redhead & Traquair [Psathyrellaceae] Coprinus rot	Yes. Found throughout the Pacific Northwest (Willett *et al.* 1989).	Yes. Causes postharvest fruit rot of apple (Spotts 1990c).	No records found	Yes. Is a low-temperature tolerant basidiomycete causing postharvest rot of apple and pear (Traquair 1987). Also infects cereals, grasses and legumes causing snow mold (Spotts 1990c). Hosts are available in Australia. The fungus grows best at 15ºC, but also readily grows at 2ºC (Gaudet and Sholberg 1990).	Yes. Economic losses due to decay of apples in controlled-atmosphere storage have been reported from British Columbia, Canada (Sholberg and Gaudet 1992). Has caused serious losses of stored d'Anjou pears in Oregon in 1979 (Spotts *et al.* 1981). On cereals, grasses and legumes, it causes snow mold (Spotts 1990c).	Yes
Maireina marginata (McAlpine) W.B. Cooke Synonym: *Cyphella marginate* McAlpine [Tricholomataceae]	Yes. OR, WA (Farr and Rossman 2009; Glawe 2009).	No. This fungus is known to occur on dead twigs and is not associated with the mature fresh harvested fruit of its hosts (Ginns and Lefebvre 1993; Farr and Rossman 2009).	Not assessed	Not assessed	Not assessed	No
Sclerotium rolfsii Sacc. Teleomorph: *Athelia rolfsii* (Curzi) C.C. Tu & Kimbr. [Anamorphic Cystostereaceae] Southern blight	Yes. CA, FL, KY, MD, NC, TX, VA (Farr and Rossman 2009).	No. This species affects the lower stems and roots of apple trees (Jones and Sutton 1996).	Not assessed	Not assessed	Not assessed	No
Order Capnodiales						
Cladosporium cladosporioides (Fresen.) G.A. De Vries Synonym: *Hormodendrum cladosporioides* (Fresen.) Sacc. [Anamorphic Davidiellaceae]	Yes. CA, WA, WV (Farr and Rossman 2009); WA (Glawe 2009).	Yes. A post harvest fruit rot (Farr *et al.* 1989; De Lucca 2007). The fungus enters the fruit through wounds or surface injuries and causes decay (De Lucca 2007).	Yes. ACT, NSW, NT, Qld, SA, Tas., Vic., WA (APPD 2009)	Not assessed	Not assessed	No
Cladosporium herbarum (Pers.:Fr.) Link Teleomorph: *Davidiella tassiana* (De Not.) Crous & U. Braun [Davidiellaceae] Cladosporium rot	Yes. ID, OR, WA (APHIS 2007a); CA, WA (Farr and Rossman 2009); WA (Glawe 2009).	Yes. This pathogen causes post harvest fruit rot (APHIS 2007a; Snowdon 1990).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2009).	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Colletogloeum sp. FG2.1 *Colletogloeum* sp. FG2.2 *Colletogloeum* sp. FG2.3 [Anamorphic Mycosphaerellaceae] Sooty blotch and flyspeck	Yes. Midwestern states (Batzer *et al.* 2005).	Yes. Isolated from apple fruit (Batzer *et al.* 2005).	No records found	Yes. Sooty blotch and flyspeck (SBFS), caused by a group of fungi, are late-season blemishes on the cuticle of apples and pears in humid regions worldwide (Batzer *et al.* 2005; Batzer *et al.* 2008). Environments with climates similar to these areas exist in various parts of Australia suggesting that fungi associated with SBFS have the potential to establish and spread in Australia.	Yes. Sooty blotch and flyspeck are two of the most common diseases of pome fruits in many moist, temperate growing regions of the world caused by a group of fungi. In the United States, the diseases are most severe on apples in the southeast, but they occur throughout the apple growing regions in the east and midwest. Although the diseases do not result in a yield loss, they cause considerable economic loss to growers because of reduced fruit quality (Sutton 1990b; Williamson and Sutton 2000). In the southeastern United States, virtually all of the apple crop would be affected each year if fungicides were not applied. Even with the use of fungicides, losses of 25% or more are reported in individual orchards in some years (Sutton 1990b).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Coniothecium sp. [Incertae sedis]	Yes. NM, WA (USDA-ARS 1960; Shaw 1973).	Yes. Causes secondary blister or cracking of fruit. The species associated with apple probably is *Coniothecium chomatosporum* Corda (USDA-ARS 1960). *Coniothecium chomatosporum* causes fruit russeting, cracking and dieback of branches and formation of stem cankers (Jindal and Sharma 2005). In England, C. *chomatosporum* is a common fungus on apple bark and in cracks on russeted apple fruit (Farr and Rossman 2009).	Yes. *Coniothecium chromatosporum* recorded on *Pyrus* (pear) in Vic. (APPD 2009). *Coniothecium chomatosporium* reported on *Pyrus* and *Malus* (apple) in Tas. (Sampson and Walker 1982). *Coniothecium* sp. recorded on *Pyrus* and *Malus* in NSW, Qld, Vic. and WA (Shivas 1989; APPD 2009).	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Dissoconium sp. DS1.1 *Dissoconium* sp. DS1.2 *Dissoconium* sp. DS2 *Dissoconium* sp. FG4 *Dissoconium* sp. FG5 [Anamorphic Mycosphaerellaceae] Sooty blotch and flyspeck	Yes. Midwestern states (Batzer *et al.* 2005).	Yes. Isolated from apple fruit (Batzer *et al.* 2005).	No records found	Yes. Sooty blotch and flyspeck (SBFS), caused by a group of fungi, are late-season blemishes on the cuticle of apples and pears in humid regions worldwide (Batzer *et al.* 2005; Batzer *et al.* 2008). Environments with climates similar to these areas exist in various parts of Australia suggesting that fungi associated with SBFS have the potential to establish and spread in Australia.	Yes. Sooty blotch and flyspeck are two of the most common diseases of pome fruits in many moist, temperate growing regions of the world caused by a group of fungi. In the United States, the diseases are most severe on apples in the southeast, but they occur throughout the apple growing regions in the east and midwest. Although the diseases do not result in a yield loss, they cause considerable economic loss to growers because of reduced fruit quality (Sutton 1990b; Williamson and Sutton 2000). In the southeastern United States, virtually all of the apple crop would be affected each year if fungicides were not applied. Even with the use of fungicides, losses of 25% or more are reported in individual orchards in some years (Sutton 1990b).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Heterosporium maculatum Klotzsch [Anamorphic Mycosphaerellaceae]	Yes. WA (Shaw 1973).	No[25]. Limited information available. Has been reported on decaying stems and leaves of monocotyledonous plants, also on apples (Farr *et al.* 1989). All of the reports of *H. maculatum* on apple in the US are based on a report from 1973 (Shaw 1973). Lack of recent records suggests that this pathogen is unlikely to be present on the importation pathway.	Not assessed	Not assessed	Not assessed	No

[25] Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Mycelia sterilia sp. RS1 Mycelia sterilia sp. RS2 [Anamorphic Mycosphaerellaceae] Sooty blotch and flyspeck	Yes. Midwestern states (Batzer *et al.* 2005).	Yes. Isolated from apple fruit (Batzer *et al.* 2005).	No records found	Yes. Sooty blotch and flyspeck (SBFS), caused by a group of fungi, are late-season blemishes on the cuticle of apples and pears in humid regions worldwide (Batzer *et al.* 2005; Batzer *et al.* 2008). Environments with climates similar to these areas exist in various parts of Australia suggesting that fungi associated with SBFS have the potential to establish and spread in Australia.	Yes. Sooty blotch and flyspeck are two of the most common diseases of pome fruits in many moist, temperate growing regions of the world caused by a group of fungi. In the United States, the diseases are most severe on apples in the southeast, but they occur throughout the apple growing regions in the east and midwest. Although the diseases do not result in a yield loss, they cause considerable economic loss to growers because of reduced fruit quality (Sutton 1990b; Williamson and Sutton 2000). In the southeastern United States, virtually all of the apple crop would be affected each year if fungicides were not applied. Even with the use of fungicides, losses of 25% or more are reported in individual orchards in some years (Sutton 1990b).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Mycosphaerella pomi (Pass.) Lindau Teleomorph: *Cylindrosporium pomi* C. Brooks [Anamorphic Mycosphaerellaceae] Brooks fruit spot	Yes. AR, eastern states, IA, MO, NC (Farr and Rossman 2009).	Yes. Infects apple fruit and leaves (Yoder 1990b). Causes dark spots on apple fruit and severe infection can lead to cracking (Snowdon 1990). Light infection of fruit is often not noticed at harvest (Sutton *et al.* 1987).	Yes. NSW, as *Cylindrosporium pomi* (APPD 2009). No records for WA.	Yes. The pathogen overwinters on leaf litter on ground of orchard. After storage, production of spores has been observed in fruit lesions (Sutton *et al.* 1987). Suitable hosts, including apple, are present in Australia.	No. Brooks fruit spot is a minor disease of apple throughout most of the eastern US (Sutton *et al.* 1987). It causes lesions on fruit and leaves. It is usually controlled adequately with fungicides (Yoder 1990b). This disease has also been reported from Canada, New Zealand and Germany (Atkinson 1971; Yoder 1990b). As the spots on apple fruit are shallow, it affects market value but not eating quality (Atkinson 1971). The pathogen is found in most apple-growing areas of New Zealand, but only occasionally. It is of no economic importance in New Zealand (Atkinson 1971). *Mycosphaerella pomi* also infects quince causing quince blotch (Yoder 1990b). *Mycosphaerella pomi* does not appear to be a pest of economic significance in the Southern Hemisphere, including New Zealand, and the State of New South Wales of Australia where it is reported. Based on this, it is not considered a potential quarantine pest for Australia (Biosecurity Australia 2006a).	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Passalora sp. FG3 [Anamorphic Mycosphaerellaceae] Sooty blotch and flyspeck	Yes. Midwestern states (Batzer *et al.* 2005).	Yes. Isolated from apple fruit (Batzer *et al.* 2005).	No records found	Yes. Sooty blotch and flyspeck (SBFS), caused by a group of fungi, are late-season blemishes on the cuticle of apples and pears in humid regions worldwide (Batzer *et al.* 2005; Batzer *et al.* 2008). Environments with climates similar to these areas exist in various parts of Australia suggesting that fungi associated with SBFS have the potential to establish and spread in Australia.	Yes. Sooty blotch and flyspeck are two of the most common diseases of pome fruits in many moist, temperate growing regions of the world caused by a group of fungi. In the United States, the diseases are most severe on apples in the southeast, but they occur throughout the apple growing regions in the east and midwest. Although the diseases do not result in a yield loss, they cause considerable economic loss to growers because of reduced fruit quality (Sutton 1990b; Williamson and Sutton 2000). In the southeastern United States, virtually all of the apple crop would be affected each year if fungicides were not applied. Even with the use of fungicides, losses of 25% or more are reported in individual orchards in some years (Sutton 1990b).	Yes
Peltaster fructicola E.M. Johnson, T.B. Sutton & Hodges [Anamorphic Mycosphaerellaceae] Sooty blotch complex	Yes. AL, MI, NC, PA, VA, WI (Farr and Rossman 2009).	Yes. Colonies of this pathogen are found on freshly picked apple fruit (Williamson *et al.* 2004; Johnson *et al.* 1997).	No records found	Yes. *Malus* is present in Australia. The pathogen overwinters on reservoir hosts and apple twigs and fruit. Spores are spread by wind and rain (Williamson and Sutton 2000).	Yes. Causes considerable loss due to reduced fruit quality (Williamson and Sutton 2000).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Peltaster sp. P2.1 *Peltaster* sp. P2.2 [Anamorphic Mycosphaerellaceae] Sooty blotch and flyspeck	Yes. Midwestern states (Batzer *et al.* 2005).	Yes. Isolated from apple fruit (Batzer *et al.* 2005).	No records found	Yes. Sooty blotch and flyspeck (SBFS), caused by a group of fungi, are late-season blemishes on the cuticle of apples and pears in humid regions worldwide (Batzer *et al.* 2005; Batzer *et al.* 2008). Environments with climates similar to these areas exist in various parts of Australia suggesting that fungi associated with SBFS have the potential to establish and spread in Australia.	Yes. Sooty blotch and flyspeck are two of the most common diseases of pome fruits in many moist, temperate growing regions of the world caused by a group of fungi. In the United States, the diseases are most severe on apples in the southeast, but they occur throughout the apple growing regions in the east and midwest. Although the diseases do not result in a yield loss, they cause considerable economic loss to growers because of reduced fruit quality (Sutton 1990b; Williamson and Sutton 2000). In the southeastern United States, virtually all of the apple crop would be affected each year if fungicides were not applied. Even with the use of fungicides, losses of 25% or more are reported in individual orchards in some years (Sutton 1990b).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Pseudocercospora sp. FS4 *Pseudocercospora* sp. FG1.1 *Pseudocercospora* sp. FG1.2 [Anamorphic Mycosphaerellaceae] Sooty blotch and flyspeck	Yes. Midwestern states (Batzer *et al.* 2005).	Yes. Isolated from apple fruit (Batzer *et al.* 2005).	No records found	Yes. Sooty blotch and flyspeck (SBFS), caused by a group of fungi, are late-season blemishes on the cuticle of apples and pears in humid regions worldwide (Batzer *et al.* 2005; Batzer *et al.* 2008). Environments with climates similar to these areas exist in various parts of Australia suggesting that fungi associated with SBFS have the potential to establish and spread in Australia.	Yes. Sooty blotch and flyspeck are two of the most common diseases of pome fruits in many moist, temperate growing regions of the world caused by a group of fungi. In the United States, the diseases are most severe on apples in the southeast, but they occur throughout the apple growing regions in the east and midwest. Although the diseases do not result in a yield loss, they cause considerable economic loss to growers because of reduced fruit quality (Sutton 1990b; Williamson and Sutton 2000). In the southeastern United States, virtually all of the apple crop would be affected each year if fungicides were not applied. Even with the use of fungicides, losses of 25% or more are reported in individual orchards in some years (Sutton 1990b).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Pseudocercosporella sp. RH1 *Pseudocercosporella* sp. RH2.1 *Pseudocercosporella* sp. RH2.2 [Anamorphic Mycosphaerellaceae] Sooty blotch and flyspeck	Yes. Midwestern states (Batzer *et al.* 2005).	Yes. Isolated from apple fruit (Batzer *et al.* 2005).	No records found	Yes. Sooty blotch and flyspeck (SBFS), caused by a group of fungi, are late-season blemishes on the cuticle of apples and pears in humid regions worldwide (Batzer *et al.* 2005; Batzer *et al.* 2008). Environments with climates similar to these areas exist in various parts of Australia suggesting that fungi associated with SBFS have the potential to establish and spread in Australia.	Yes. Sooty blotch and flyspeck are two of the most common diseases of pome fruits in many moist, temperate growing regions of the world caused by a group of fungi. In the United States, the diseases are most severe on apples in the southeast, but they occur throughout the apple growing regions in the east and midwest. Although the diseases do not result in a yield loss, they cause considerable economic loss to growers because of reduced fruit quality (Sutton 1990b; Williamson and Sutton 2000). In the southeastern United States, virtually all of the apple crop would be affected each year if fungicides were not applied. Even with the use of fungicides, losses of 25% or more are reported in individual orchards in some years (Sutton 1990b).	Yes
Ramularia magnusiana (Sacc.) Lindau [Anamorphic Mycosphaerellaceae]	Yes. Northwestern states, WA (Farr and Rossman 2009); WA (Glawe 2009).	No. Found on leaves causing leaf spot (Farr and Rossman 2009).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Ramularia sp. P5 [Anamorphic Mycosphaerellaceae] Sooty blotch and flyspeck	Yes. Midwestern states (Batzer *et al.* 2005).	Yes. Isolated from apple fruit (Batzer *et al.* 2005).	No records found	Yes. Sooty blotch and flyspeck (SBFS), caused by a group of fungi, are late-season blemishes on the cuticle of apples and pears in humid regions worldwide (Batzer *et al.* 2005; Batzer *et al.* 2008). Environments with climates similar to these areas exist in various parts of Australia suggesting that fungi associated with SBFS have the potential to establish and spread in Australia.	Yes. Sooty blotch and flyspeck are two of the most common diseases of pome fruits in many moist, temperate growing regions of the world caused by a group of fungi. In the United States, the diseases are most severe on apples in the southeast, but they occur throughout the apple growing regions in the east and midwest. Although the diseases do not result in a yield loss, they cause considerable economic loss to growers because of reduced fruit quality (Sutton 1990b; Williamson and Sutton 2000). In the southeastern United States, virtually all of the apple crop would be affected each year if fungicides were not applied. Even with the use of fungicides, losses of 25% or more are reported in individual orchards in some years (Sutton 1990b).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Xenostigmina sp. P3 *Xenostigmina* sp. P4 [Anamorphic Mycosphaeriallaceae] Sooty blotch and flyspeck	Yes. Midwestern states (Batzer *et al.* 2005).	Yes. Isolated from apple fruit (Batzer *et al.* 2005).	No records found	Yes. Sooty blotch and flyspeck (SBFS), caused by a group of fungi, are late-season blemishes on the cuticle of apples and pears in humid regions worldwide (Batzer *et al.* 2008; Batzer *et al.* 2005). Environments with climates similar to these areas exist in various parts of Australia suggesting that fungi associated with SBFS have the potential to establish and spread in Australia.	Yes. Sooty blotch and flyspeck are two of the most common diseases of pome fruits in many moist, temperate growing regions of the world caused by a group of fungi. In the United States, the diseases are most severe on apples in the southeast, but they occur throughout the apple growing regions in the east and midwest. Although the diseases do not result in a yield loss, they cause considerable economic loss to growers because of reduced fruit quality (Sutton 1990b; Williamson and Sutton 2000). In the southeastern United States, virtually all of the apple crop would be affected each year if fungicides were not applied. Even with the use of fungicides, losses of 25% or more are reported in individual orchards in some years (Sutton 1990b).	Yes
Zygophiala jamaicensis E.W. Mason [Anamorphic Mycosphaerellaceae] Sooty blotch and flyspeck	Yes. CA (Farr and Rossman 2009); midwestern states (Batzer *et al.* 2005).	Yes. Isolated from apple fruit (Batzer *et al.* 2005).	Yes. WA (APPD 2009).	Not assessed	Not assessed	No
Zygophiala cryptogama Batzer & Crous [Anamorphic Mycosphaerellaceae] Sooty blotch and flyspeck	Yes. IA (Batzer *et al.* 2008); midwestern states (Batzer *et al.* 2005).	Yes. Isolated from apple fruit (Batzer *et al.* 2005; Batzer *et al.* 2008).	No records found	Yes. Sooty blotch and flyspeck (SBFS), caused by a group of fungi, are late-season blemishes on the cuticle of apples and pears in humid regions worldwide (Batzer *et al.* 2005; Batzer *et al.* 2008). Environments with climates similar to these areas exist in various parts of Australia	Yes. Sooty blotch and flyspeck are two of the most common diseases of pome fruits in many moist, temperate growing regions of the world caused by a group of fungi. In the United States, the diseases are most severe on apples in the southeast,	Yes
Zygophiala tardicrescens Batzer & Crous [Anamorphic Mycosphaerellaceae] Sooty blotch and flyspeck	Yes. IA (Batzer *et al.* 2008); midwestern states (Batzer *et al.* 2005).	Yes. Isolated from apple fruit (Batzer *et al.* 2005; Batzer *et al.* 2008).	No records found			

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Zygophiala wisconsinensis Batzer & Crous [Anamorphic Mycosphaerellaceae] Sooty blotch and flyspeck	Yes. WI (Batzer *et al.* 2008); midwestern states (Batzer *et al.* 2005).	Yes. Isolated from apple fruit (Batzer *et al.* 2005; Batzer *et al.* 2008).	No records found	suggesting that fungi associated with SBFS have the potential to establish and spread in Australia. Some fungi of the SBFS have a very wide range of hosts. For example, the host plants of *Z. jamaicensis* include 120 species in 44 families of seed plants including *Malus* throughout temperate and tropical regions (reviewed in Batzer *et al.* 2008).	but they occur throughout the apple growing regions in the east and midwest. Although the diseases do not result in a yield loss, they cause considerable economic loss to growers because of reduced fruit quality (Sutton 1990b; Williamson and Sutton 2000). In the southeastern United States, virtually all of the apple crop would be affected each year if fungicides were not applied. Even with the use of fungicides, losses of 25% or more are reported in individual orchards in some years (Sutton 1990b).	
Order Chaetothyriales						
Leptodontium elatius (G. Mangenot) De Hoog [Anamorphic Herpotrichiellaceae] Sooty blotch	Yes. IL, NC, NY (Johnson *et al.* 1997).	Yes. Isolated from apple fruit (Johnson *et al.* 1997).	Yes. Qld, WA (CABI 2004).	Not assessed	Not assessed	No
Order Diaporthales						
Cytospora ambiens Sacc. Teleomorph: *Valsa ambiens* (Pers.: Fr.) Fr. [Anamorphic Valsaceae]	Yes. North central, northeastern and western states, IA, OK, OR (Farr and Rossman 2009); OR (Zeller 1927; Glawe 2009).	No. Found on wood and dying twigs (Farr and Rossman 2009).	Not assessed	Not assessed	Not assessed	No
Cytospora leucostoma Sacc. Teleomorph: *Leucostoma persoonii* (Nitschke) Höhn. Synonym: *Valsa leucostoma* (Pers.: Fr.) Fr. [Anamorphic Valsaceae] Leucostoma canker	Yes. North central states, northeastern states and western states, ID, MI, OK, WA (Farr and Rossman 2009); ID, WA (Glawe 2009).	No. Causes a wilt and dieback of scaffold limbs and the central leader. Cankers form on limbs and trunk (Jones 1990a).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Phomopsis prunorum (Cooke) Grove Teleomorph: *Diaporthe perniciosa* Marchal & E. J. Marchal [Anamorphic Valsaceae] Phomopsis canker; Phomopsis fruit decay	Yes. AR, CA, central states, NC, OH, OR, VA, western states (Farr and Rossman 2009); OR, WA (Glawe 2009).	Yes. Causes affected fruit to decay in storage (Rosenberger 1990e).	Yes. NSW, Qld, SA, Tas., WA (APPD 2009).	Not assessed	Not assessed	No
Valsa ceratosperma (Tode:Fr.) Maire Anamorph: *Cytospora sacculus* (Schwein.: Fr.) Gvrit. Synonyms: *Valsa americana* Berk. & M.A. Curtis [Valsaceae] Valsa canker	Yes. GA (Farr and Rossman 2009). NJ, WA (EPPO 2004; CABI/EPPO 2005).	No. Affects the bark of apple trees (Sakuma 1990b). The disease is transmitted via plants for planting and wood (EPPO 2004).	Not assessed	Not assessed	Not assessed	No
Valsa cincta (Fr.:Fr.) Fr. Anamorph: *Cytospora cincta* Sacc. Synonyms: *Leucostoma cinctum* (Fr.:Fr.) Höhn. (variant spelling: *Leucostoma cincta* (Fr.:Fr.) Höhn.) [Valsaceae] Leucostoma canker and dieback	Yes. MI, WI, as *Leucostoma cinctum* (Farr and Rossman 2009).	No. Occurs on wood of apple trees (Jones 1990a).	Not assessed	Not assessed	Not assessed	No
Valsa papyriferae (Schwein.) Cooke Synonym: *Valsella papyriferae* (Schwein.) Berl. & Voglino [Valsaceae]	Yes. OR (Farr and Rossman 2009; Glawe 2009).	No. Was found on winter-injured bark of apple in OR (Farr *et al.* 1989; Zeller 1927).	Not assessed	Not assessed	Not assessed	No
Valsella melastoma (Fr.) Fuckel Synonym: *Valsa melastoma* Fr. [Valsaceae]	Yes. IA, MI, WA (Farr and Rossman 2009); WA (Glawe 2009).	No. Found on limbs of apple (Farr *et al.* 1989).	Not assessed	Not assessed	Not assessed	No
Order Dothideales						
Aureobasidium pullulans (de Bary) G. Arnaud Synonym: *Pullularia pullulans* (de Bary) Berkhout [Anamorphic Dothioraceae]	Yes. OR, WA (Farr and Rossman 2009; Glawe 2009).	Yes. Can cause storage decay of apple fruit (Rist and Rosenberger 1995). Can also cause russet of apple fruit (Matteson Heidenreich *et al.* 1997).	Yes. All states and territories (APPD 2009).	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Diplodia mutila (Fr.:Fr.) Mont. Teleomorph: *Botryosphaeria stevensii* Shoemaker Synonym: *Sphaeropsis malorum* (Berk.) Berk. [Anamorphic Botryosphaeriaceae] Diplodia canker	Yes. CA, MT, OR, WA (Farr *et al.* 1989); CA, OR (Farr and Rossman 2009); CA, MT, OR, WA (Farr and Rossman 2009); OR, WA, as *Physalospora mutila* (Glawe 2009).	Yes. Causes black rot (Farr *et al.* 1989).	Yes. ACT, NSW, SA, Vic., WA (APPD 2009)	Not assessed	Not assessed	No
Diplodia sarmentorum (Fr.:Fr.) Teleomorph: *Otthia spiraeae* (Fuckel) Fuckel [Anamorphic Botryosphaeriaceae]	Yes. OR (Farr and Rossman 2009; Glawe 2009).	No. Found on limbs of apple (Farr *et al.* 1989).	Not assessed	Not assessed	Not assessed	No
Diplodia seriata De Not. Teleomorph: *Botryosphaeria obtusa* (Schwein.) Shoemaker Synonym: *Physalospora obtusa* (Schwein.) Cooke [Anamorphic Botryosphaeriaceae] Black rot	Yes. Eastern, central and western states; AR, CA, CT, GA, ID, MI, MS, OK, OR, VA, WA (Farr and Rossman 2009).	Yes. Infects fruit, leaves and wood of apple (Sutton 1990d).	Yes. ACT, NSW, Qld, Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Dothichiza sp. [Anamorphic Dothioraceae]	Yes. WA (Shaw 1973).	No[26]. All of the reports of *Dothichiza* sp. on apple in the US are based on a report from 1973 (Shaw 1973). This report does not specify whether *Dothichiza* sp. was found on apple fruit. Lack of recent records suggests that it is unlikely to be present on the importation pathway. *Dothichiza* spp. are not known as pests of apple fruit.	Not assessed	Not assessed	Not assessed	No

[26] Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Epicoccum granulatum Penz. [Anamorphic Dothideales]	Yes. WA, WV (Adams and Tamburo 1957; USDA-ARS 1960; Shaw 1973).	No[27]. Causes fruit rot (Heald and Ruehle 1931; Adams and Tamburo 1957). All reports of *E. granulatum* on apple in the US are based on reports prior to 1974 (Adams and Tamburo 1957; USDA-ARS 1960; Shaw 1973). Lack of recent records suggests that it is unlikely to be present on the importation pathway. *Epicoccum* spp. are primarily saprophytes or opportunistic pathogens on several hosts (Bruton *et al.* 1993).	Not assessed	Not assessed	Not assessed	No
Epicoccum nigrum Link Synonym: *Epicoccum purpurascens* Ehrenb. [Anamorphic Ascomycetes]	Yes. WA, WV (Farr *et al.* 1989).	Yes. Causes fruit rot (Farr *et al.* 1989).	Yes. ACT, NSW, Qld, Vic., WA, Tas. (APPD 2009).	Not assessed	Not assessed	No
Fusicoccum aesculi Corda Teleomorph: *Botryosphaeria dothidea* (Moug.:Fr.) Ces. & De Not. [Anamorphic Botryosphaeriaceae] White rot	Yes. AR, CA, FL, GA, NC, VA (Farr and Rossman 2009).	Yes. Infects fruit and wood of apple (Biggs 1997; Sutton 1990a).	Yes. NSW, Qld, Vic., WA (Cunnington *et al.* 2007; APPD 2009).	Not assessed	Not assessed	No
Fusicoccum pyrorum Chupp & Clapp [Anamorphic Botryosphaeriaceae]	Yes. OR (Zeller 1929; Shaw 1973).	No. Causes canker of apple (Farr *et al.* 1989). Found on die-back twigs of apple (Zeller 1929). Produces cankers on branches and trunk of apple, and is not known to infect apple fruit under natural conditions (Chupp and Clapp 1923).	Not assessed	Not assessed	Not assessed	No

[27] Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Neofusicoccum ribis (Slippers, Crous & M.J. Wingf.) Crous, Slippers & A.J.L. Phillips Teleomorph: *Botryosphaeria ribis* Grossenb. & Duggar Synonym: *Botryosphaeria berengeriana* De Not. [Anamorphic Botryosphaeriaceae] White rot	Yes. Eastern, central and southern states; GA, OK, WA, WV (Farr and Rossman 2009); WA (Glawe 2009).	Yes. Infects apple fruit causing fruit rot (Snowdon 1990).	Yes. ACT, NSW, Qld, Vic., WA (APPD 2009), NSW (Cunnington *et al.* 2007).	Not assessed	Not assessed	No
Otthia amica Sacc., E. Bommer & M. Rousseau [Incertae sedis]	Yes. WA (Shaw 1973).	No[28]. Limited information available. Unknown symptom on apple (Farr *et al.* 1989). All of the reports of *O. amica* on apple in the US are based on a report from 1973 (Shaw 1973). Lack of recent records suggests that this pathogen is unlikely to be present on the importation pathway.	Not assessed	Not assessed	Not assessed	No

28 Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Peltaster sp. CS1 [Anamorphic Dothioraceae] Sooty blotch and flyspeck	Yes. Midwestern states (Batzer *et al.* 2005).	Yes. Isolated from apple fruit (Batzer *et al.* 2005).	No records	Yes. Sooty blotch and flyspeck (SBFS), caused by a group of fungi, are late-season blemishes on the cuticle of apples and pears in humid regions worldwide (Batzer *et al.* 2008; Batzer *et al.* 2005). Environments with climates similar to these areas exist in various parts of Australia suggesting that fungi associated with SBFS have the potential to establish and spread in Australia.	Yes. Sooty blotch and flyspeck are two of the most common diseases of pome fruits in many moist, temperate growing regions of the world caused by a group of fungi. In the United States, the diseases are most severe on apples in the southeast, but they occur throughout the apple growing regions in the east and midwest. Although the diseases do not result in a yield loss, they cause considerable economic loss to growers because of reduced fruit quality (Sutton 1990b; Williamson and Sutton 2000). In the southeastern United States, virtually all of the apple crop would be affected each year if fungicides were not applied. Even with the use of fungicides, losses of 25% or more are reported in individual orchards in some years (Sutton 1990b).	Yes
Phyllosticta arbutifolia Ellis & G. Martin Synonym: *Phyllosticta solitaria* Ellis & Everh. [Anamorphic Botryosphaeriaceae] Apple blotch	Yes. Central and western states; AL, FL, IA, LA, MS, NC, OK, TX, WA (Farr and Rossman 2009); WA (Glawe 2009).	Yes. Can be present on leaves, buds, twigs and fruit (Gardner 1923; Yoder 1990a). This pathogen can survive for nine months on apple seedlings stored at 1-2°C (McClintock 1930).	No records found	Yes. The hosts of *P. arbutifolia* are restricted to *Crataegus*, *Malus* and *Pyrus* species (Farr *et al.* 1989). These hosts are widely available in Australia. The fungus is disseminated by water splash (Gardner 1923).	Yes. Was formerly a major disease in the eastern US but today is rare in most commercial apple orchards. It damages fruit, leaves, buds, twigs and branches of susceptible apple cultivars causing defoliation and development of cankers on twigs and branches (Yoder 1990a).	Yes
Phyllosticta clypeata Ellis & Everh. [Anamorphic Botryosphaeriaceae]	Yes. OR (Farr and Rossman 2009; Glawe 2009).	No. Found on leaves, petioles and twigs (Farr *et al.* 1989).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Schizothyrium pomi (Mont. & Fr.) Arx Synonym: *Microthyriella rubi* Pter. [Schizothyriaceae] Flyspeck	Yes. CA, FL, MS, NC, OK, WA (Farr and Rossman 2009).	Yes. Infects fruit of apple (Sutton 1990b; Persley 1993).	Yes. NSW, WA as *Leptothyrium pomi* (APPD 2009), WA (Shivas 1989), Qld (Simmonds 1966).	Not assessed	Not assessed	No
Sphaeropsis pyriputrescens C.L. Xiao & J.D. Rogers [Anamorphic Botryosphaeriaceae] Sphaeropsis rot	Yes. WA (Farr and Rossman 2009; Xiao *et al.* 2004).	Yes. Was first reported on apple in Washington packing houses causing post-harvest fruit rot (Xiao *et al.* 2004). Sphaeropsis rot shows three types of symptoms: stem-end rot, calyx-end rot and more rarely skin rot (Kim and Xiao 2008). *Sphaeropsis pyriputrescens* also causes canker and twig dieback disease on apple and crabapple (Xiao and Boal 2005a).	No records found	Yes. Infection seems to occur in the orchard leading to fruit rot during storage (Kim and Xiao 2008; Xiao *et al.* 2004). The fungus can form spores on the surface of decayed fruit (Xiao and Rogers 2004). Suitable hosts are grown in Australia.	Yes. Sphaeropsis rot can cause economic losses due to fruit rotting in storage. It is an important postharvest disease in apple in Washington State and is widely distributed in all major apple growing regions in this state (Kim and Xiao 2008).	Yes
Order Erysiphales						
Oospora otophila Harz [Erysiphaceae]	Yes. WA (Shaw 1973).	No[29]. Limited information available. Unknown symptom on apple (Farr *et al.* 1989). All of the reports of *O. otophila* on apple in the US are based on a report from 1973 (Shaw 1973). Lack of recent records suggests that this pathogen is unlikely to be present on the importation pathway.	Not assessed	Not assessed	Not assessed	No
Phyllactinia guttata (Wallr.:Fr.) Lév. Anamorph: *Ovulariopsis moricola* Delacr. [Erysiphaceae]	Yes. On *Malus baccata* (Siberian crabapple) and *Malus fusca* (Oregon crabapple) in WA (Shaw 1958). On *Malus* (Shaw 1973).	No. Only reported on crabapple in 1958 with no later records on apple. No records found for *Malus domestica* (Farr and Rossman 2009).	Not assessed	Not assessed	Not assessed	No

[29] Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Podosphaera clandestina (Wallr.:Fr.) Lév. var. *clandestina* Anamorph: *Oidium crataegi* Grognot Synonym: *Podosphaera oxyacanthae* (DC.) de Bary [Anamorphic Erysiphaceae] Hawthorn powdery mildew	Yes. CA, ID, WA (Farr and Rossman 2009); ID, WA (Glawe 2009); CA, FL, ID, MS, SD, WA (Farr *et al.* 1989).	Yes. Infects leaves, shoots and fruit of cherry. (Grove 1995). May also infect apple fruit. However, *Malus* is not a major host (CABI 2007).	No. North American strain not present in Australia. *Podosphaera clandestina* recorded in Australia occurs only on *Crataegus* spp. (APPD 2009). Reported in WA on *Malus sylvestris* and *Pyrus communis* under the synonym *P. oxyacanthae* (Shivas 1989 citing Despeissis 1901), but these reports are erroneous. Despeissis (1901) reports on black spot of loquat.	Yes. Suitable hosts are present in Australia. Hosts include species of *Amelanchier*, *Crataegus*, *Cydonia*, *Diospyros*, *Holodiscus*, *Malus*, *Prunus*, *Pyracantha*, *Pyrus*, *Sanguisorba*, *Spiraea*, *Symphoricarpos* and *Vaccinium* (Farr *et al.* 1989). Wind disperses the fungus suggesting potential for spread (Grove 1998).	Yes. In stone fruit, fruit infections result in large economic losses (Grove 1995).	Yes
Podosphaera leucotricha (Ellis & Everh.) E.S. Salmon Anamorph: *Oidium mespili* Cooke [Erysiphaceae] Powdery mildew	Yes. ID, OR, WA, (APHIS 2007a; Glawe 2009); CA, FL, GA, ID, MO, NC, NM, OK, OR, WA (Farr and Rossman 2009).	Yes. It grows on the surface of leaves, shoots, twigs, blossoms and fruit of apple (Persley 1993).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Order Eurotiales						
Aspergillus clavatus Desm. [Anamorphic Trichocomaceae] Storage fruit rot	Yes. WV (Farr and Rossman 2009).	Yes. Found on fruit (Farr *et al.* 1989). *Aspergillus* spp. cause decay of stored apples (Rosenberger 1990b). Fruit rot caused by *Aspergillus* spp. is only associated with fruit stored under warm conditions (Snowdon 1990).	Yes. Qld, Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Aspergillus flavus Link:Fr. [Anamorphic Trichocomaceae] Aspergillus ear rot	Yes. Present in North America and apple is known to be a minor host (CABI 2007). Found on pear in the US, including in WA (Farr and Rossman 2009).	Yes. *Aspergillus* spp. cause decay of stored apples (Rosenberger 1990b).	Yes. ACT, NSW, Vic., Qld, WA (APPD 2009).	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Aspergillus sclerotiorum G.A. Huber [Anamorphic Trichocomaceae] Fruit rot	Yes. WA (Farr and Rossman 2009; Glawe 2009).	Yes. This fungus has been isolated from the surface of apple fruit. It causes decay of apples in storage, both at ordinary and cold-storage temperature (Huber 1933).	No records found	Yes. *Aspergillus* spp. are rapidly growing filamentous fungi or moulds that are ubiquitous to the environment and found worldwide (Keating 2001). They commonly grow in soil and moist locations and are among the most common moulds encountered on spoiled food and decaying vegetation, in compost piles and in stored hay and grain (Keating 2001). *Aspergillus sclerotiorum* is a common fungus in subtropical and tropical soils. It has been reported from soils in India, Israel, Pakistan, Brazil, Argentina, France, Germany and the Ukraine (Mycobank 2009). *Aspergillus sclerotiorum* disperses through dry spores by wind (EMLab P&K 2008) and is therefore likely to establish and spread.	No. This fungus is found on rotting apples and pears, tomato seedlings, *Crotalaria juncea* (Indianhemp) seed and peanuts (Kozakiewicz 1989). It produces the mycotoxin ochratoxin A which when present in mouldy feed causes serious liver damage in farm animals (Kozakiewicz 1989). However, no severe economic consequences have been reported for any of these hosts.	No
Penicillium aurantiogriseum Dierckx Synonyms: *Penicillium martensi* Biourge; *Penicillium puberulum* Bainier [Anamorphic Trichocomaceae]	Yes. WA (Farr and Rossman 2009; Glawe 2009).	Yes. *Penicillium* spp. cause blue mould of apple fruit in storage (Rosenberger 1990d). *Penicillium aurantiogriseum* is mainly found on cereals, but it can also be found on fresh and stored fruit and vegetables (Kozakiewicz 1992a).	Yes. NSW (APPD 2009). No records for WA.	Yes. Its presence in NSW indicates potential for establishment and spread in other parts of Australia.	No. *Penicillium aurantiogriseum* is mainly found on cereal, but it can also be found on fresh and stored fruit and vegetables. It is distributed worldwide with a preference for temperate climates (Kozakiewicz 1992a).	No
Penicillium aurantiogriseum var. *viridicatum* (Westling) Frisvad & Filt. Synonyms: *Penicillium olivinoviride* Biourge; *Penicillium viridicatum* Westling [Anamorphic Trichocomaceae]	Yes. CA, ID, OR, WA, WV (Farr and Rossman 2009; Glawe 2009).	Yes. *Penicillium* spp. cause blue mould of apples in storage (Rosenberger 1990d). *Penicillium viridicatum* is mainly associated with cereals (Kozakiewicz 1992b).	Yes. Vic.—as *P. viridicatum* (APPD 2009). No records for WA.	Yes. Its presence in Victoria indicates potential for establishment and spread in other parts of Australia.	No. *Penicillium viridicatum* is mainly associated with cereals and cereal products. It is distributed worldwide with a preference for temperate climates (Kozakiewicz 1992b).	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Penicillium expansum Link [Anamorphic Trichocomaceae] Blue mould	Yes. CA, IA, ID, OR, WA, WV (Farr and Rossman 2009); ID, OR, WA (APHIS 2007a).	Yes. This pathogen causes post harvest fruit rot (APHIS 2007a). Spores produced on damaged or fallen fruit on the orchard floor are blown by wind onto fruit on the trees (Persley 1993). Fruit rot can develop during grading or packing as a result of infection through damaged skin or an open calyx cavity (Persley 1993).	Yes. NSW, Qld, Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Penicillium verrucosum Dierckx [Anamorphic Trichocomaceae]	Yes. WA (Farr and Rossman 2009; Glawe 2009).	Yes. *Penicillium* spp. cause blue mould of apples in storage (Rosenberger 1990d).	Yes. ACT, NSW, Qld (Penrose and Davis 1978; APPD 2009). No records for WA.	Yes. Its presence in ACT, NSW and Qld indicates potential for establishment and spread in other parts of Australia.	No. *Penicillium verrucosum* is already widely distributed in foods and feedstuffs (Kozakiewicz 2003). It is not known to be a major economic pest of apple anywhere in the world.	No
Trichosporum sp. [Incertae sedis]	Yes. WA (Shaw 1958, 1973).	No[30]. All of the reports of *Trichosporum* sp. on apple in the US are based on reports from 1958 and 1973 (Shaw 1958, 1973). These reports do not specify whether it was found on apple fruit. Lack of recent records suggests that this pathogen is unlikely to be present on the importation pathway.	Not assessed	Not assessed	Not assessed	No

[30] Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Order Helotiales						
Botrytis cinerea Pers.:Fr. Teleomorph: *Botryotinia fuckeliana* (de Bary) Whetzel [Anamorphic Sclerotiniaceae] Grey mould	Yes. OR, WA (APHIS 2007a); northwestern states, CA, GA, NY, WA, WV (Farr and Rossman 2009).	Yes. Found on fruit and leaves (APHIS 2007a). Infected fruit often drop prematurely. If harvested, about 50% of the affected fruit decay from grey mould in storage (Rosenberger 1990g). Post harvest rot can develop at cold temperatures and has the ability to spread in storage (MAL 2007b). *Botrytis* diseases appear primarily as blossom blights and fruit rots but also as leaf spots and bulb rots in the field and in storage (Staats *et al.* 2005).	Yes. ACT, NSW, Qld, SA, Tas., Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Botrytis mali Rühle [Anamorphic Sclerotiniaceae]	Yes. WA (Ruehle 1931; Farr and Rossman 2009; Glawe 2009).	No[31]. Although *B. mali* can cause fruit rot (Farr *et al.* 1989; O'Gorman *et al.* 2005; O'Gorman *et al.* 2008), it has only been recorded in 1931 (Ruehle 1931) and not since (Pierson *et al.* 1971). Lack of recent records suggests that it is unlikely to be present on the importation pathway.	Not assessed	Not assessed	Not assessed	No
Cadophora malorum (Kidd & Beaumont) W. Gams Synonym: *Phialophora malorum* (Kidd & Beaumont) McColloch [Anamorphic Dermateaceae] Side rot	Yes. CA, IN, OR, PA, VA, WA, WV (Farr and Rossman 2009); WA, OR (Glawe 2009).	Yes. Infects fruit (Snowdon 1990).	Yes. WA, Tas. (APPD 2009).	Not assessed	Not assessed	No

[31] Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Cristulariella moricola (Hino) Redhead Teleomorph: *Grovesinia pyramidalis* M.N. Cline, J.L. Crane & S.D. Cline Synonym: *Sclerotinum cinnamomi* Sawada [Sclerotiniaceae] Zonate leaf spot	Yes. NC (Farr and Rossman 2009). Has been reported on apple in a nursery in Florida (Harada *et al.* 1990).	No. Affects leaves, not fruit (Harada *et al.* 1990).	Not assessed	Not assessed	Not assessed	No
Cryptosporiopsis corticola (Edgerton) Nannf. Synonym: *Myxosporium corticola* Edgerton [Anamorphic Dermateaceae]	Yes. IL, MI, NC, northeastern states, OK, OR, SD, WA (Farr and Rossman 2009); OR, WA (Glawe 2009).	No. A superficial bark canker (Zeller 1924; Farr and Rossman 2009) found more often on pear than apple (Zeller 1924). Not known to cause decay of fruit even when artificially inoculated (Zeller 1924). Not likely to be associated with mature fresh harvested fruit.	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Cryptosporiopsis curvispora (Peck) Gremmen Teleomorph: *Neofabraea malicorticis* H. Jacks. Synonym: *Pezicula malicorticis* (H. Jacks.) Nannf. [Anamorphic Dermateaceae] Anthracnose canker and bull's-eye rot	Yes. ID, WA (APHIS 2007a); CA, ID, IL, MA, ME, MT, OK, OR, WA (Farr and Rossman 2009). Prevalent in the Pacific Northwest (Grove 1990a), particularly in the wet areas west of the Cascades (Dugan *et al.* 1993).	Yes. Can infect fruit and cause fruit to rot in storage (Grove 1990a; Jones and Sutton 1996). Found on fruit (APHIS 2007a). This pathogen causes Bull's eye rot of stored apple fruit (Dugan 1993; Verkley 1999).	No records found	Yes. Fungal spores produced in the canker are spread by rain and wind. Infection occurs in fall. Fungal spores spread from limb cankers to maturing fruit, young limbs and twigs. Fungus fruiting bodies develop in the centre of spots on infected fruit (Pscheidt 2008c). Suitable hosts, particularly apple and pear, are grown in Australia.	Yes. Bull's eye rot is the most important post-harvest disease in Washington. It can cause serious economic losses due to rot occurring in storage (Smith 2001). The disease is severe in the high-rainfall areas west of the Cascades and British Columbia (Pscheidt 2008c). Severe outbreaks of bull's eye-rot occurred in Washington in 1985, 1987 and 1988 (Grove *et al.* 1992). This fungus rarely kills trees as the cankers are generally confined to small branches and twigs. Losses occur due to fruit rot that occurs after fruit has been in storage for several months (Grove 1990a). Bull's eye rot is a slow growing rot and does not commonly spread from fruit to fruit (Dugan 1993).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Cryptosporiopsis perennans (Zeller & Childs) Wollenw. Teleomorph: *Neofabraea perennans* Kienholz Synonym: *Pezicula perennans* (Kienholz) Dugan, R.G. Roberts & G.G. Grove [Anamorphic Dermateaceae] Perennial canker and bull's-eye rot	Yes. ID, ME, MT, OR, WA (Farr and Rossman 2009); ID, OR, WA, (Glawe 2009). Prevalent in the Pacific Northwest (Grove 1990a), particularly east of the Cascades where winters are cold and summers are dry and hot (Dugan *et al.* 1993).	Yes. This pathogen causes Bull's eye rot of stored apple fruit (Dugan 1993; Verkley 1999).	Yes. Vic. (Cunnington 2004; APPD 2009). No records for WA.	Yes. Its presence in Victoria indicates potential for establishment and spread in other parts of Australia. Fungus fruiting bodies develop in the centre of spots on infected fruit (Pscheidt 2008d). Perennial canker is often associated with the presence of the woolly apple aphid (*Eriosoma lanigerum*), injuries caused by low temperature and pruning wounds (Pscheidt 2008d). The woolly apple aphid is present in Australia (APPD 2009). The fungus can survive from one season to the next as conidia on canker surfaces or on the surface of infected fruit on the orchard floor (Grove *et al.* 1992). Cankers caused by *C. perennans* can grow for several years (Gariepy *et al.* 2005).	Yes. Bull's eye rot is the most important post-harvest disease in Washington. It can cause serious economic losses due to rot occurring in storage (Smith 2001). Severe outbreaks of bull's eye-rot occurred in Washington in 1985, 1987 and 1988 (Grove *et al.* 1992). The disease caused by this fungus rarely kills trees as the cankers are generally confined to small branches and twigs. Losses occur due to fruit rot which usually only occurs after fruit has been in storage for several months (Grove 1990a). Bull's eye rot is a slow growing rot and does not commonly spread from fruit to fruit in storage (Dugan 1993).	Yes[WA]
Monilinia fructicola (G. Winter) Honey Anamorph: *Monilia fructicola* L.R. Batra [Sclerotiniaceae] Brown rot	Yes. (Farr and Rossman 2009); ID, OR, WA (APHIS 2007a).	Yes. *Monilinia fructicola* causes brown rot of apple fruit (Jones 1990b). It infects blossoms, twigs and fruit (Farr and Rossman 2009).	Yes. ACT, NSW, Qld, SA, Tas., Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Monilinia laxa (Aderhold & Ruhland) Honey Anamorph: *Monilia cinerea* Bonord. [Sclerotiniaceae] Blossom blight	Yes. (Farr and Rossman 2009); ID, OR, WA (APHIS 2007a).	Yes. Found on fruit (APHIS 2007a). Causes fruit rot of apple (Jones 1990b; Snowdon 1990).	Yes. ACT, NSW, Qld, SA, Tas., Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Pezicula pruinosa Farl. [Dermateaceae]	Yes. OR, WA (Farr and Rossman 2009; Glawe 2009).	No. Found on twigs (Farr and Rossman 2009).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Phacidiopycnis piri (Fuckel) Weindlm. Teleomorph: *Potebniamyces pyri* (Berk. & Broome) Dennis [Anamorphic Potebniamyces] Phacidiopycnis rot	Yes. WA (Xiao *et al.* 2005; Kim and Xiao 2006).	Yes. Causes fruit rot on pears, but has also been observed on apples in WA (Xiao *et al.* 2005; Kim and Xiao 2006; Xiao 2006). It is also associated with a twig dieback and canker disease of apple and pear (DiCosmo *et al.* 1984; Xiao and Boal 2005b).	No records found	Yes. Infection of fruit with *Phacidiopycnis piri* occurs in the orchard and rot symptoms develop in storage (Xiao and Boal 2004). Infection can also spread from fruit to fruit in storage (Xiao and Boal 2004). At advanced stages of infection, the fungus forms pycnidia on the decayed area of the fruit (Xiao 2006). Suitable hosts are grown in Australia.	Yes. Phacidiopycnis rot is one of the major postharvest fruit rots in d'Anjou pears in Washington State causing economic losses due to fruit rotting in storage (Xiao and Boal 2004). It is much less common in apple (Xiao *et al.* 2005; Kim and Xiao 2006). *Phacidiopycnis piri* also causes twig dieback and canker disease of apple and pear (DiCosmo *et al.* 1984; Xiao and Boal 2005b).	Yes
Phacidiopycnis washingtonensis C.L. Xiao & J.D. Rogers [Anamorphic Potebniamyces] Speck rot	Yes. WA (Xiao *et al.* 2005; Kim and Xiao 2006).	Yes. Causes fruit rot, primarily stem-end rot and calyx-end rot, of apples in storage. It is also associated with twig dieback and canker disease of crabapple and dead twigs of pear (Xiao *et al.* 2005). Has been isolated from symptomless fruit. Infection of fruit seems to occur in the orchard (Kim and Xiao 2006).	No records found	Yes. When apple fruit were inoculated with the fungus one to two weeks before harvest, symptoms on fruit were first observed two to three months after harvest (Kim and Xiao 2006). The fungus forms spores on the surface of decayed fruit after an extended period in storage (Kim and Xiao 2006). Suitable hosts are grown in Australia.	Yes. Speck rot can cause economic losses due to fruit rotting in storage. Although this disease occurs sporadically, a few instances of severe losses caused by this disease in Washington State during 2004 and 2005 were observed (Kim and Xiao 2006).	Yes
Phlyctema vagabunda Desm. Teleomorph: *Neofabraea alba* (E.J. Guthrie) Verkley Synonym: *Pezicula alba* E.J. Guthrie [Anamorphic Dermateaceae] Ripe spot	Yes. WA (Farr and Rossman 2009; Glawe 2009); OR, WA (Gariepy *et al.* 2005).	Yes. The fungus forms lesions and rot on fruit (Snowdon 1990).	Yes; Tas., Vic., WA (Shivas 1989; APPD 2009).	Not assessed	Not assessed	No
Sclerotinia sclerotiorum (Lib.) de Bary [Sclerotiniaceae] Calyx end rot	Yes. WA (Farr and Rossman 2009).	Yes. Calyx end rot is a sporadic and minor disease of apple fruit (Hickey 1990b).	Yes. ACT, NSW, Qld, SA, Tas., Vic., WA (APPD 2009).	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Order Hymenochaetales						
Hyphoderma litschaueri (Burt) J. Erikss. & Å. Strid Synonym: *Corticium litschaueri* Burt [Hyphodermataceae]	Yes. ND, OR (Farr and Rossman 2009); OR (Glawe 2009).	No. Is associated with bark and wood (Ginns and Lefebvre 1993).	Not assessed	Not assessed	Not assessed	No
Order Hypocreales						
Cephalosporium carpogenum Rühle [Incertae sedis]	Yes. PA, WA (Farr and Rossman 2009); WA (Glawe 2009).	Yes. Causes decay of apple fruit in storage (Ruehle 1931; Fink 1958; Rosenberger 1990b).	No records found	Yes. *Cephalosporium carpogenum* is considered a weak parasite of apple fruit and found bordering insect marks or punctures. The fungus develops slowly and appears as small shallow spots around the damaged area (Ruehle 1931). The only known hosts are species of *Malus* and *Pyrus* (Glawe 2009).	No. Is considered to be a minor postharvest disease of apple and pear (Pierson *et al.* 1971; Rosenberger 1990b; Glawe 2009). Rarely found in apples from commercially tended orchards if the fruit are stored under modern cold storage conditions (Rosenberger 1990b).	No
Cylindrocarpon angustum Wollenw. [Anamorphic Nectriaceae]	Yes. OR (Shaw 1958, 1973; USDA-ARS 1960).	No. Found on bark (USDA-ARS 1960; Farr *et al.* 1989).	Not assessed	Not assessed	Not assessed	No
Cylindrocarpon candidum (Link) Wollenw. Teleomorph: *Neonectria coccinea* (Pers.:Fr.) Rossman & Samuels Synonym: *Nectria coccinea* (Pers.: Fr.) Fr. [Anamorphic Nectriaceae]	Yes. OR (Shaw 1973).	No[32]. It is a pathogen of *Fagus sylvatica* (beech) causing beech bark disease (Booth 1977). *Neonectria coccinea* occurs only in Europe and only on *Fagus* (Castlebury *et al.* 2006). Thus, the US apple reports and pest records are probably misidentifications. All of the reports of *Cylindrocarpon candidum* on apple in the US are based on a report from 1973 (Shaw 1973). Lack of recent records suggests that it is unlikely to be present on the importation pathway.	Not assessed	Not assessed	Not assessed	No

[32] Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Cylindrocarpon destructans (Zinssm.) Scholten Teleomorph: *Neonectria radicicola* (Gerlach & L. Nilsson) Mantiri & Samuels Synonym: *Nectria radicicola* Gerlach & L. Nilsson [Anamorphic Nectriaceae] Storage rot	Yes. MA, MD, WA (Farr and Rossman 2009).	No. Found in soil, associated with roots (Farr *et al.* 1989). Attacks roots and seedlings of apple (Mazzola 1998).	Not assessed	Not assessed	Not assessed	No
Cylindrocarpon didymum (Harting) Wollenw. [Anamorphic Nectriaceae]	Yes. WA (Farr and Rossman 2009).	No. Is a soil-borne fungus causing root rots and seedling blights (Brayford 1987).	Not assessed	Not assessed	Not assessed	No
Fusarium acuminatum Ellis & Everh. Teleomorph: *Gibberella acuminata* Wollenw. Synonym*: Fusarium scirpi* var. *acuminatum* (Ellis & Everh.) Wollenw. [Anamorphic Nectriaceae]	Yes. Northwestern states (Farr and Rossman 2009).	Yes. *Fusarium* spp. cause decay of stored apples (Rosenberger 1990b; Snowdon 1990). *Fusarium acuminatum* has been reported to cause fruit rot on apples in India (Sumbali and Badyal 1990).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Fusarium avenaceum (Fr.:Fr.) Sacc. Teleomorph: *Gibberella avenacea* R.J. Cook [Anamorphic Nectriaceae]	Yes. Eastern and northwestern states, OR, WA (Farr and Rossman 2009).	Yes. Causes rot of apple fruit during storage (Booth and Waterston 1964).	Yes. NSW, NT, Qld, SA, Tas., Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Fusarium heterosporum Nees:Fr. Synonym: *Fusarium graminum* Corda, pro parte [Nectriaceae]	Yes. OR (Farr and Rossman 2009; Glawe 2009).	Yes. *Fusarium* spp. cause decay of stored apples (Rosenberger 1990b; Snowdon 1990).	Yes. NSW, SA, Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Fusarium lateritium Nees:Fr. Teleomorph: *Gibberella baccata* (Wallr.) Sacc. [Anamorphic Nectriaceae]	Yes. Eastern and northwestern states (Farr *et al.* 1989); OR, WA (Farr and Rossman 2009); OR, WA, as *G. baccata* (Farr *et al.* 1989).	Yes. *Fusarium lateritium* causes Bull's eye rot of dropped or stored apple fruit (Farr *et al.* 1989). *Gibberella baccata* causes wilt, die-back and cankering of woody plants (Booth 1971).	Yes. NSW, SA, Qld, Tas., Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Fusarium oxysporum Schltdl.:Fr. Root rot [Nectriaceae]	Yes. ID, OR (Farr and Rossman 2009; Glawe 2009); ID (Utkhede and Smith 1991).	No. Mainly found as soil saprophyte (Booth 1970). Causes root rot of apple (Farr *et al.* 1989; Utkhede and Smith 1991).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Fusarium roseum Link:Fr. Teleomorph: *Gibberella zeae* (Schwein.) Petch [Nectriaceae]	Yes. WA (Shaw 1973).	Yes. *Fusarium* spp. cause decay of stored apples (Rosenberger 1990b; Snowdon 1990).	Yes. NSW, Qld (APPD 2009). NSW, NT, Qld, Vic., WA as *Gibberella zeae* (APPD 2009).	Not assessed	Not assessed	No
Fusarium scirpi Lambotte & Fautrey Teleomorph: *Gibberella acuminata* C. Booth Synonym: *Fusarium equiseti* (Corda) Sacc. [Anamorphic Nectriaceae]	Yes. OR, WA (Shaw 1973). OR, WA, as *F. equiseti* (Farr *et al.* 1989).	Yes. *Fusarium* spp. cause decay of stored apples (Rosenberger 1990b; Snowdon 1990).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Nectria sanguinea Bolton:Fr. [Nectriaceae]	Yes. OR (Shaw 1973). However, no type specimen exists for *N. sanguinea*. Most specimens identified as this species have been reidentified as other *Nectria* species (Farr and Rossman 2009).	No. No type specimen exits. Most specimens identified as this species have been reidentified as other *Nectria* species (Farr and Rossman 2009).	Not assessed	Not assessed	Not assessed	No
Neonectria ditissima (Tul. & C. Tul.) Samuels & Rossman Synonym: *Nectria galligena* Bres Anamorph: *Cylindrocarpon heteronema* (Berk. & Broome) Wollenw. [Anamorphic Nectriaceae] European canker	Yes. ID, OR, WA (APHIS 2007a); eastern, central and western states, CA, MI, MS, NC, OR, WA (Farr and Rossman 2009); OR, WA (Glawe 2009).	Yes. Rain can disperse spores produced in wood cankers to the fruit and cause eye rot (McCartney 1967). Infected fruit may rot on the tree or in storage (Snowdon 1990).	No records found Has been eradicated from Tasmania (Ransom 1997).	Yes. Suitable hosts are present in Australia. Rain and wind disperse the fungus, suggesting potential for spread (Grove 1990b).	Yes. European canker can kill young trees and branches of older trees. It is an economically important disease in many production areas throughout the world (Grove 1990b). Losses can also occur due to storage rot (Swinburne 1970, 1971).	Yes
Stachybotrys albipes (Berk. & Broome) S.C. Jong & Davis Teleomorph: *Melanopsamma pomiformis* (Pers.:Fr.) Sacc. [Anamorphic Niessliaceae]	Yes. OR (Farr and Rossman 2009; Glawe 2009).	No. Limited information available. Has been reported on winter-injured apple bark in Oregon in 1925 (Zeller 1927). Not recorded on apple fruit.	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Trichoderma sp. [Anamorphic Hypocreaceae]	Yes. WA (Shaw 1958, 1973).	Uncertain as species not specified. *Trichoderma* spp. are now also considerd to be opportunistic, avirulent plant symbionts. At least one Trichoderma species, *T. harzianum,* is known to cause postharvest decay of stored apples (Rosenberger 1990b).	Uncertain as species not specified. *T. harzianum* in NSW, SA, Tas., Vic., WA (APPD 2009). *T. koningii* recorded on apple (APPD 2009).	Yes. Presence of *T. harzianum* in Australia (APPD 2009) indicates potential for establishment and/or spread.	No. *Trichoderma* spp. are now considerd to be opportunistic, avirulent plant symbionts. They are not plant parasites (Samuels 2006). Rosenberger (1990b) lists *T. harzianum* as a miscellaneous postharvest decay fungi of stored apples. However, the author cites the listed fungi as being rarely found in apples from commercially tended orchards if the fruit are stored under modern cold-storage conditions (Rosenberger 1990b).	No
Trichothecium roseum (Pers.:Fr.) Link Synonym: *Cephalothecium roseum* Corda [Anamorphic Bionectriaceae] Pink mould rot	Yes. OK, WA, WV (Farr *et al.* 1989).	Yes. Infects apple fruit (Snowdon 1990).	Yes. ACT, NSW, Qld, SA, Vic., WA (APPD 2009). SA (Cook and Dubé 1989) WA (Shivas 1989).	Not assessed	Not assessed	No
Tubercularia vulgaris Tode:Fr. Teleomorph: *Nectria cinnabarina* (Tode: Fr.) Fr. [Anamorphic Nectriaceae] Nectria twig blight	Yes. ID, OR, WA, (APHIS 2007a); AK, MI, NC, OR, WA (Farr and Rossman 2009); OR, WA (Glawe 2009).	No. Infects twigs and branches (APHIS 2007a; Hickey 1990a).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Order Hysteriales						
Hysteropatella sp. [Hysteriaceae]	Yes. WA (Shaw 1973).	No[33]. All of the reports of *Hysteropatella* sp. on apple in the US are based on a report from 1973 (Shaw 1973). Lack of recent records suggests that this pathogen is unlikely to be present on the importation pathway.	Not assessed	Not assessed	Not assessed	No
Order Mucorales						
Mucor mucedo Fresen. [Mucoraceae] Mucor rot	Yes. WA (Shaw 1973).	Yes. Causes decay of apple fruit (Spotts 1990b).	No records found	Yes. Causes post-harvest rot (Spotts 1990b). Suitable hosts are present in Australia.	Yes. Mucor rot of apples can be a serious problem in apples in the Pacific Northwest in fruit stored for a long period (Michailides and Spotts 1990a; Michailides 1991). Serious losses due to this disease have occurred in the US (Spotts 1990b). *Mucor mucedo* is also a post-harvest pathogen of tomato (Moline and Kuti 1984).	Yes
Mucor piriformis E. Fisch. [Mucoraceae] Mucor rot	Yes. Northwestern states, WA (Farr and Rossman 2009); WA (Glawe 2009).	Yes. Fruit infection occurs during harvest or in the dump tank. Infected fruit develop fruit rot in storage (Spotts 1990b). *Mucor* rot of apples in the Pacific Northwest is caused only by *M. piriformis* (Michailides and Spotts 1990a).	Yes. Qld, Vic. (APPD 2009). No records for WA. However, *Mucor* spp. present in WA (Barbetti 1985; Wong *et al.* 1985; Pung *et al.* 1991).	Yes. Its presence in Qld and Vic. indicates potential for establishment and spread in other parts of Australia. The pathogen is dispersed by rain splash, insects and birds (Michailides and Spotts 1990a), suggesting potential for spread. Suitable hosts, including apple, pear and stone fruit, are present in Australia.	Yes. Mucor rot of apples can be a serious problem in apples in the Pacific Northwest (Michailides and Spotts 1990a; Michailides 1991). Serious losses due to this disease have occurred in the US (Spotts 1990b).	Yes[WA]

[33] Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Mucor racemosus Fresen. [Mucoraceae] Mucor rot	Yes. WA (Shaw 1973).	Yes. Causes decay of apple fruit (Spotts 1990b).	Yes. ACT, NSW, Vic. (APPD 2009). No records for WA. However, *Mucor* spp. are present in WA (Barbetti 1985; Wong *et al.* 1985; Pung *et al.* 1991).	Yes. Causes storage rot of fruit and vegetables (Lunn 1977). Its presence in ACT, NSW and Vic. indicates potential for establishment and spread in other parts of Australia.	Yes. Mucor rot of apples can be a serious problem in apples in the Pacific Northwest (Michailides 1991; Michailides and Spotts 1990a). Serious losses due to this disease have occurred in the US (Spotts 1990b).	Yes[WA]
Rhizopus stolonifer (Ehrenb.:Fr.) Vuill. Synonym: *Rhizopus nigricans* Ehrenb. [Mucoraceae] Rhizopus rot	Yes. CA, FL, MT, NY, OR, WA, WV (Farr and Rossman 2009); WA, OR (Glawe 2009).	Yes. This fungus can infect apple fruit and cause storage rot (Snowdon 1990).	Yes. NSW, NT, Qld, Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Order Myriangiales						
Elsinoe piri (Woron.) Jenk. [Elsinoaceae] Elsinoe spot	Yes. OR, WA (Shaw 1973).	Yes. Can occur on fruit (Atkinson 1971).	Yes. NSW, Qld (APPD 2009). No records for WA.	Yes (Biosecurity Australia 2006a).	No. Although *E. piri* occurs in many parts of the world, it is not regarded as a pest of economic importance (Atkinson 1971).	No
Order Phyllachorales						
Colletotrichum acutatum J.H. Simmonds [Anamorphic Glomerellaceae] Anthracnose	Yes. AR, KY, NC, RI, VA (Farr and Rossman 2009).	Yes. Infects fruit of apple causing fruit rot (Sutton 1990c).	Yes. NSW, Qld, SA, Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Colletotrichum gloeosporioides (Penz.) Penz. & Sacc. Teleomorph: *Glomerella cingulata* (Stoneman) Spauld. & H. Schrenk [Anamorphic Glomerellaceae] Anthracnose; bitter rot	Yes. AR, KY, NC, RI (Farr and Rossman 2009).	Yes. Infects fruit of apple causing fruit rot (Sutton 1990c).	Yes. ACT, NSW, NT, Qld, SA, Tas. Vic., WA (APPD 2009). Tas. (Sampson and Walker 1982).	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Phyllachora pomigena (Schwein.) Sacc. Anamorph: *Gloeodes pomigena* (Schwein.) Colby [Phyllachoraceae] Sooty blotch	Yes. Eastern and central states, AL, FL, IN, MS, NC, OK, WA (Farr and Rossman 2009); WA (Glawe 2009).	Yes. Infects fruit of apple (Sutton 1990b). Affects ripening fruit causing blotches (Persley 1993).	Yes. as *Gloeodes pomigena* NSW (APPD 2009), Qld (Simmonds 1966), Tas. (Sampson and Walker 1982), WA (Shivas 1989).	Not assessed	Not assessed	No
Verticillium sp. [Incertae sedis]	Yes. WA (Shaw 1973).	No[34]. Only reported on apple in Washington in 1973 (Shaw 1973) with no later records. Lack of recent records suggests that it is unlikely to be present on the importation pathway. The 1973 report does not specify whether *Verticillium* sp. was found on apple fruit. *Verticillium* spp. are soil-borne plant pathogens causing wilt diseases. These diseases are generally spread via contaminated equipment, soil, irrigation and infected seed or plant materials such as rootstocks, bulbs and tubers (Fradin and Thomma 2006).	Not assessed	Not assessed	Not assessed	No
Order Pleosporales						
Alternaria alternata (Fr.:Fr.) Keissl. Synonym: *Alternaria tenuis* Needs [Pleosporaceae] Alternaria rot; core rot	Yes. ID, OR, WA (APHIS 2007a); CA, MT, NY, WA (Farr and Rossman 2009).	Yes. Found on leaves, shoots, rarely on fruit (Sakuma 1990a; APHIS 2007a).	Yes. ACT, NSW, NT, Qld, SA, Tas., Vic., WA (APPD 2009).	Not assessed	Not assessed	No

[34] Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Alternaria mali Roberts [Pleosporaceae] Alternaria blotch of apple	Yes. NC (Filajdić and Sutton 1991); WA (Glawe 2009).	Yes. Does not typically infect fruit, except on very susceptible cultivars (CABI/EPPO 1997b). Infection occurs on the young fruit, causing fruit-spotting (CABI/EPPO 1997b).	Yes. NSW, Qld, WA (APPD 2009); WA (Shivas 1989). *Alternaria* spp. recorded on apple in Tas. (Sampson and Walker 1982).	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
*Alternaria malorum (*Rühle) U. Braun, Crous & Dugan Synonym: *Cladosporium malorum* Rühle [Anamorphic Davidiellaceae]	Yes. WA (Farr and Rossman 2009; Glawe 2009).	Yes. Causes decay of apple fruit in storage at higher temperatures (Ruehle 1931).	No records found	Yes. *Alternaria malorum* has been isolated from a wide variety of hosts in the Pacific Northwest, including grapewine, wheat, chickpea and conifer (Goetz and Dugan 2006).	No. *Alternaria malorum* is capable of producing decay of ripe apples when inoculated at 20–25°C for 14 days. When stored at 0°C, the fungus developed very feebly and produces small spots, around injured areas, which do not spread to cause decay. After 5 months incubation at 0°C, the spot lesions on inoculated apples did not advance beyond 10 mm (Ruehle 1931). Lack of further reports suggests that it is not an economically significant storage rot of apple. Tests have shown that the fungus is also pathogenic to cherry tomato. It slowly develops lesions on inoculated fruit (Goetz and Dugan 2006). *Alternaria malorum* has also been isolated from cherry fruit (Dugan *et al*. 1995).	No
Alternaria pomicola A.S. Horne [Pleosporaceae]	Yes. WA (Shaw 1973).	No[35]. Limited data available. All of the reports of *A. pomicola* on apple in the US are based on a report from 1973 (Shaw 1973). Lack of recent records suggests that it is unlikely to be present on the importation pathway. *Alternaria pomicola* is reported to cause spots on apple fruit (Horne and Horne 1920; Tweedy and Powell 1963).	Not assessed	Not assessed	Not assessed	No

[35] Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Asteromella mali (Briard) Boerema Synonym: *Phyllosticta mali* Briard Note: Not *Phyllosticta mali* Prillieux and Delacroix 1890 [Anamorphic Didymosphaeriaceae] Apple blotch	Yes. WV (USDA-ARS 1960).	No. Found on leaves (Farr and Rossman 2009; Boerema and Dorenbosch 1965).	Not assessed	Not assessed	Not assessed	No
Coniothyrium convolutum A.S. Horne [Anamorphic Leptosphaeriaceae]	Yes. WA (Shaw 1973).	Yes. This fungus has been reported to be associated with apple fruit (Horne and Horne 1920).	No records found	No. This species is known only from one collection in the US (Farr and Rossman 2009). This indicates that it is unlikely to be imported, to establish or spread.	No. This species is not known to be of economic significance.	No
Coniothyrium olivacea Bonord Synonym: *Coniothyrium cydoniae* Brunaud [Anamorphic Leptosphaeriaceae]	Yes. WA (Farr and Rossman 2009; Glawe 2009).	Yes. This fungus has been reported to be associated with apple fruit (Horne and Horne 1920).	Yes. Australia (Taylor and Hyde 2003) as *Microsphaeropsis olivaceae*; WA (Shivas 1989).	Not assessed	Not assessed	No
Helminthosporium papulosum Anth. Berg [Anamorphic Pleomassariaceae] Black pox	Yes. GA, IN, KY, MA, MS, NC, NJ, OH, OR, PA, WV, (Farr and Rossman 2009); OR (Glawe 2009).	Yes. Causes lesions on apple fruit, leaves and twigs (Yoder 1990d).	No records found	Yes. Spores are dispersed by wind or water splash (Yoder 1990d). Hosts, including apple and pear, are available in Australia. The incubation period on fruit is three to six months (Yoder 1990d).	Yes. Black pox causes lesions on apple fruit, leaves and twigs (Yoder 1990d). Fruit lesions may result in unmarketable fruit. Severly affected leaves may abscise.	Yes
Microdiplodia sp. [Anamorphic Ascomycetes]	Yes. WA (USDA-ARS 1960; Shaw 1973).	No. Has been reported to cause wound rot of apple fruit (USDA-ARS 1960). Damaged fruit would easily be detected and would be culled during harvesting and processing.	Not assessed	Not assessed	Not assessed	No
Microsphaeropsis fuckelii (Sacc.) Boerema Synonym: *Coniothyrium fuckelii* Sacc. Teleomorph: *Kalmusia coniothyrium* (Fuckel) Huhndorf Synonyms: *Diapleella coniothyrium* (Fuckel) M.E. Barr; *Leptosphaeria coniothyrium* (Fuckel) Sacc. [Anamorphic Leptosphaeriaceae] Leptosphaeria canker	Yes. Central and eastern states, NC, NY, OK, WA, WV (Farr *et al.* 1989—as *Diapleella coniothyrium* and *Coniothyrium fuckelii*; Farr and Rossman 2009—as *Leptosphaeria coniothyrium* and *Coniothyrium fuckelii*).	Yes. Causes stem blight and canker of Rosaceous species, including *Malus*. Is also found on apple fruit (Farr *et al.* 1989). However, it attacks its hosts as a wound parasite or saprophyte (Punithalingam 1967).	Yes. NSW. SA, Tas., Vic., WA (APPD 2009).	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Phoma bismarckii Kidd & Beaumont [Anamorphic Leptosphaeriaceae]	Yes. WA (Farr and Rossman 2009; Glawe 2009).	No. Found on dead branches and leaves (Farr and Rossman 2009). Has occasionally been recorded on dead branches of apple trees (Boerema *et al.* 2004).	Not assessed	Not assessed	Not assessed	No
Phoma fuliginea Kidd & Beaumont [Anamorphic Leptosphaeriaceae]	Yes. WA (Shaw 1973).	No[36]. Limited information available. No recent record on apple found. The lack of recent records and the lack of information suggests that this pathogen is not an important pest of apple and is unlikely to be present on the importation pathway.	Not assessed	Not assessed	Not assessed	No
Phoma macrostoma var. *macrostoma* Montagne Synonym: *Phyllosticta mali* Prillieux and Delacroix 1890. Note: Not *Phyllosticta mali* Briard 1888 [Anamorphic Didymosphaeriaceae] Phoma leaf and fruit spot	Yes. AR, FL, IN, OK, WA, WI, WV (Farr *et al.* 1989).	Yes. Found on leaves and fruit (Farr *et al.* 1989; Pennycook 1990).	Yes. NSW, SA, Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Phoma pomorum Thüm. Synonym: *Phoma prunicola* (Opiz) Wollenw. & Hochapf. [Anamorphic Leptosphaeriaceae] Leaf spot	Yes. WA (Farr and Rossman 2009; Glawe 2009); southeastern states, KS, OH, WA (Farr *et al.* 1989).	No. Causes leaf spot of apple (Morgan-Jones 1967). It often is a secondary invader on leaf spots of apple, pear and plum (White and Morgan-Jones 1986).	Not assessed	Not assessed	Not assessed	No

[36] Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Pleospora herbarum (Pers.:Fr.) Rabenh. [Pleosporaceae] Pleospora rot	Yes. Western states, CA, OR, WA (Farr and Rossman 2009); OR, WA (Glawe 2009).	Yes. This fungus causes lesions on apple fruit (Rosenberger 1990f).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Sporormia sp. [Sporormiaceae]	Yes. WA (Shaw 1958, 1973).	No[37]. All of the reports of *Sporormia* sp. on apple in the US are based on reports from 1958 and 1973 (Shaw 1958, 1973). Lack of recent records suggests that this pathogen is unlikely to be present on the importation pathway.	Not assessed	Not assessed	Not assessed	No
Stemphylium congestum Newton [Anamorphic Pleosporaceae] Stemphylium rot	Yes. CA, WA (Farr and Rossman 2009).	No[38]. Causes decay of apples in the Pacific Northwest (Newton 1928; Ruehle 1930). This decay has only rarely been found in apples held in cold storage in Washington (English 1944). There are no recent records of *S. congestum* on apples. Lack of recent records suggests that this pathogen is unlikely to be present on the importation pathway.	Not assessed	Not assessed	Not assessed	No

[37] Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

[38] Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Stemphylium graminis (Corda) Bonord. [Anamorphic Pleosporaceae]	Yes. WA (Shaw 1958, 1973). Note: According to Simmons (pers. comm.) the report from WA on apple is probably a *Ulocladium* (Farr *et al.* 1989).	No[39]. Causes rot of apples (Ruehle 1930). Limited information available. All of the reports of *S. graminis* on apple in the US are based on reports from 1958 and 1973 (Shaw 1958, 1973). Lack of recent records, and the possibility for misidentification, suggests that this pathogen is unlikely to be present on the importation pathway.	Not assessed	Not assessed	Not assessed	No
Ulocladium consortiale (Thüm.) E.G. Simmons [Anamorphic Pleosporaceae]	Yes. WA (Shaw 1973).	No[40]. Found on wood, seeds, stems, leaves of many plants, soil, leaf litter and cattle feed (David 1995). Not known to cause a disease (David 1995). Has been isolated as a saprophytic fungus from apples with lenticel spot disease (Brook 1968). All reports of *U. consortiale* on apple in the US are based a report from 1973 (Shaw 1973). Lack of recent records suggests that it is unlikely to be present on the importation pathway.	Not assessed	Not assessed	Not assessed	No
Venturia inaequalis (Cooke) G. Winter Anamorph: *Fusicladium pomi* (Fr.:Fr.) Lind [Venturiaceae] Apple scab	Yes. ID, OR, WA (APHIS 2007a); AK, AL, CA, CT, FL, GA, ID, MS, MT, NC, OK, OR, SD, TN, WA (Farr and Rossman 2009).	Yes. Found on leaves and fruit (Biggs 1990; APHIS 2007a).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2009), but under official control in WA (Kumar 2002)	Yes. This fungus is under official control in Western Australia indicating its potential for establishment and spread. Dispersal occurs by means of splashing rain and wind (Biggs 1990).	Yes. Losses occur as a result of fruit and pedicel infection. Infection can also cause repeated defoliation and subsequent loss of plant health (Biggs 1990).	Yes[WA]

39 Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

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Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Order Poriales						
Butlerelfia eustacei Weresub & Illman Synonym: *Corticium centrifugum* (Lév.) Bres. [Cystostereaceae] Fisheye rot	Yes. Eastern and northwestern states, ID, IL, NY, OR, VA, WA (Farr and Rossman 2009); WA (Glawe 2009).	Yes. Causes fisheye rot of apples in storage (Weresub and Illman 1980; Bielenin 1986; Rosenberger 1990a). A saprophyte fungus which primarily lives on dead or dying tissue. It has also been found on the surface of apples in the orchard that are not decayed and on stems of healthy apples after harvest. Apples become infested in the field and decay develops when the fungus invades the fruit through wounds or lenticels in overmature fruit (Rosenberger 1990a). A post-harvest rot that affects damaged fruit but is rare in modern storages. It appears primarily in apples that have been held late into the storage season (Rosenberger 1990a).	No. A record of *Corticium centrifugum* on *Delphinium* sp. in Victoria (Chambers 1982) is probably a misidentification.	Yes. *B. eustacei* grows fastest at 18–25ºC (Rosenberger 1990a). It is a saprophyte fungus which primarily lives on dead or dying tissue. Suitable hosts are present in Australia.	No. Fisheye rot caused by *B. eustacei* is rare in modern storage facilities and appears primarily in apples that have been held late into the storage season. It is considered to be a minor post-harvest pathogen (Rosenberger 1990a). No known pre-harvest effects to crops or environment.	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Order Russulales						
Chondrostereum purpureum (Pers.:Fr.) Pouzar Synonym: *Stereum purpureum* Pers.:Fr. [Meruliaceae] Silver leaf	Yes. CA, ID, KS, ME, MN, northwestern states, NY, OR, WA, WI (Farr and Rossman 2009); ID, OR, WA (Glawe 2009); OR, WA (APHIS 2007a).	Yes. Found on leaves, trunk and fruit (APHIS 2007a).	Yes. NSW, Qld, SA, Tas., Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Scytinostroma galactinum (Fr.) Donk [Lachnocladiaceae] Eastern white root rot	Yes. AK, AL, AR, DE, IL, IN, KY, MD, MO, NC, OK, TN, VA, WV (Farr and Rossman 2009).	No. This fungus is known as a root pathogen and is not associated with the mature fresh harvested fruit of its hosts (Jones and Sutton 1996). Causes a root and butt rot of woody plants (Ginns and Lefebvre 1993).	Not assessed	Not assessed	Not assessed	No
Order Saccharomycetales						
Geotrichum candidum Link Synonym: *Oospora mali* Kidd & Beaumont [Anamorphic Dipodascaceae]	Yes. WA (Shaw 1973).	Yes. Is a soil borne pathogen causing post harvest rot. Causes sour rot of citrus (Snowdon 1990). Apple is not a major host (Farr *et al.* 1989).	Yes. NSW, NT, Qld, Tas., Vic., WA, but no records on apple (APPD 2009).	Not assessed	Not assessed	No
Order Taphrinales						
Taphrina bullata (Berk.) Tul. [Taphrinaceae]	Yes. WA (Shaw 1958, 1973; Farr and Rossman 2009; Glawe 2009).	No. Is a pathogen of pear causing leaf blister and is not of economic significance (Cunnington and Mann 2004).	Not assessed	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Order Trichosphaeriales						
Nigrospora oryzae (Berk. & Broome) Petch Teleomorph: *Khuskia oryzae* H.J. Hudson [Incertae sedis] X-spot	Yes. (Jones 2000); X-spot is a disease of apple in the mid-Atlantic region of the US. *Nigrospora oryzae* has been associated with X-spot lesions, but it has not been confirmed as the causal organism (Yoder 1990c).	Yes. X-spot is a disease of apple fruit (Yoder 1990c).	Yes. ACT, NSW, NT, Qld, SA, Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Order Tulasnellales						
Ceratobasidium ochroleucum (F. Noack) Ginns & M.N.L. Lefebvre *Synonyms: Pellicularia koleroga* Cooke *Corticium koleroga* (Cooke) Höhn. [Ceratobasidiaceae] Thread blight	Yes. Southeastern US (Farr and Rossman 2009); WA (Ginns and Lefebvre 1993).	Yes. Sclerotia and rhizomorphs can grow superficially on fruit (Wolf and Bach 1927; Hartman 1990). Fruit can become infected by strands of hyphae growing on twigs, migrating along the fruit spurs to the fruit. Infected fruit are very susceptible to decay by storage moulds (Wolf and Bach 1927).	No records	Yes. Has a wide variety of hosts, including apple, pear, coffee, pecan, fig, *Citrus* and persimmon (Wolf and Bach 1927). The disease is most important on coffee (Rangaswami and Mahadevan 2002; Waller *et al*. 2007). Affected apple fruit are quickly destroyed by common storage moulds (Wolf and Bach 1927). Requires high humidity and high temperature for its spread and development (Wolf and Bach 1927; Mathew 1954). Establishment and spread in tropical areas of Australia is feasible.	Yes. Thread blight affects many hosts, many of which are commercially important crops in Australia. Especially coffee crops can be affected in humid conditions (Rangaswami and Mahadevan 2002; Waller *et al*. 2007). Other crops such as citrus, apples, persimmons, mango, and avocado can also be affected (Farr and Rossman 2009).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Order unassigned						
Chaetomella sp. [Anamorphic Leotiomycetes]	Yes. WA (USDA-ARS 1960; Shaw 1973).	No[41]. Causes fruit rot (USDA-ARS 1960). All reports of *Chaetomella* sp. on apple in the US are based on reports from 1960 and 1973 (USDA-ARS 1960; Shaw 1973). Lack of recent records suggests that it is unlikely to be present on the importation pathway. No other reference for association of *Chaetomella* with apple found—worldwide.	Not assessed	Not assessed	Not assessed	No

[41] Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Geastrumia polystigmatis Bat. & M.L. Farr Sooty blotch [Anamorphic Pezizomycotina]	Yes. NC (Johnson *et al.* 1997; Farr and Rossman 2009); MI, VA (Johnson *et al.* 1997).	Yes. Isolated from apple fruit (Johnson and Sutton 1994; Johnson *et al.* 1997).	No records found	Yes. Sooty blotch and flyspeck (SBFS), caused by a group of fungi, are late-season blemishes on the cuticle of apples and pears in humid regions worldwide (Batzer *et al.* 2005; Batzer *et al.* 2008). Environments with climates similar to these areas exist in various parts of Australia suggesting that fungi associated with SBFS have the potential to establish and spread in Australia. Fungi associated with sooty blotch can grow on a wide range of reservoir hosts including trees, shrubs and vines. The most common hosts in the southeastern US are *Rubus* spp. (Sutton and Williamson 2002). *Geastrumia polystigmatis* overwinters on reservoir hosts and apple twigs. Its conidia are spread by wind and rain (Sutton and Williamson 2002).	Yes. Sooty blotch and flyspeck are two of the most common diseases of pome fruits in many moist, temperate growing regions of the world caused by a group of fungi. In the United States, the diseases are most severe on apples in the southeast, but they occur throughout the apple growing regions in the east and midwest. Although the diseases do not result in a yield loss, they cause considerable economic loss to growers because of reduced fruit quality (Sutton 1990b; Williamson and Sutton 2000). In the southeastern United States, virtually all of the apple crop would be affected each year if fungicides were not applied. Even with the use of fungicides, losses of 25% or more are reported in individual orchards in some years (Sutton 1990b).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Order Uredinales						
Gymnosporangium clavipes (Cooke & Peck) Cooke & Peck [Pucciniaceae] Quince rust	Yes. AR, eastern states, MI, MS (Farr and Rossman 2009).	Yes. Infects fruit of apple (Sinclair and Lyon 2005; Aldwinckle 1990a). Has been reported on *Crataegus douglasii* (black hawthorn) and *Juniperus communis* (common juniper) in Washington (Farr and Rossman 2009) but it is not known to be present on *Malus* in ID, OR and WA.	No. One report on *Crataegus monogyna* (English hawthorn) in Vic. (Chambers 1982), but no herbarium specimen and no record in Australia since 1982.	Yes. Is heteroecious with apple as aecial host (Farr and Rossman 2009). Requires *Juniperus communis* L. (common juniper) or *J. virginiana* L. (eastern red-cedar) as alternate host to complete its life cycle (Aldwinckle 1990a). Juniper hosts, although not wide spread, are grown as ornamentals in Australia (ABC 2008). *Juniperus communis* and *J. virginiana* are grown in Botanic Gardens around Australia (Council of Heads of Australian Botanic Gardens 1992). A change in host preference in a new environment is also possible. It is dispersed by wind (Sinclair and Lyon 2005).	Yes. Quince rust is an important disease of apple in eastern North America (Aldwinckle 1990a). It is the most damaging of the *Gymnosporangium* rusts to rosaceous species (Sinclair and Lyon 2005).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Gymnosporangium globosum (Farl.) Farl. [Pucciniaceae] Hawthorn rust	Yes. AL, eastern states, GA, KS, MS, NC, NE (Farr *et al.* 1989); AL, eastern states, CT, GA, KS, MA, ME, MS, NC, NE, NH, VT (Farr and Rossman 2009).	Yes. Infects leaves, rarely fruit, of apple (Aldwinckle 1990b).	No records found	Yes. Is heteroecious with apple as aecial host (Farr *et al.* 1989). Requires eastern red cedar (*Juniperus virginiana* L.) or related *Juniperus* spp. as alternate host to complete its life cycle (Aldwinckle 1990b). Juniper hosts, although not widely spread, are grown as ornamentals in Australia (ABC 2008). *Juniperus virginiana* is grown in Botanic Gardens around Australia (Council of Heads of Australian Botanic Gardens 1992). It is dispersed by wind (Sinclair and Lyon 2005). Spores from cedar sources can infect alternate hosts at distances as far as 24 km (Sinclair and Lyon 2005).	Yes. Hawthorn rust infects leaves of apple, pear, hawthorn and other rosaceous plants. It is a minor disease compared with cedar apple rust and quince rust (Aldwinckle 1990b).	Yes
Gymnosporangium juniperi-virginianae Schwein. [Pucciniaceae] Cedar apple rust	Yes. AL, CT, eastern states, GA, IA, IN, MA, ME, MS, NH, OK, PA, RI, SD, VA, VT (Farr and Rossman 2009); CA, WA (Sinclair and Lyon 2005).	Yes. Infects leaves, petioles and fruit (Aldwinckle 1990c). Is widespread in the US east of the Rocky Mountains, also in California (Laundon 1977c).	No records found	Yes. Is heteroecious with apple as aecial host (Farr *et al.* 1989). Requires eastern red cedar (*Juniperus virginiana* L.) as alternate host to complete its life cycle (Aldwinckle 1990c). Juniper hosts, although not widely spread, are grown as ornamentals in Australia (ABC 2008). *Juniperus virginiana* is grown in Botanic Gardens around Australia (Council of Heads of Australian Botanic Gardens 1992). It is dispersed by wind (Sinclair and Lyon 2005). Spores from cedar sources mostly infect alternate hosts at distances of a few hundred metres but may remain able to germinate while being carried for several kilometres in air (Sinclair and Lyon 2005).	Yes. Cedar apple rust is the most economically important of the *Gymnosporangium* rusts (Sinclair and Lyon 2005; Aldwinckle 1990c). In areas where eastern red cedar or Rocky Mountain juniper is abundant, this disease can cause severe losses due to fruit infection and premature defoliation (Sinclair and Lyon 2005).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Gymnosporangium libocedri (Henn.) F. Kern [Pucciniaceae] Pacific Coast pear rust	Yes. CA, OR (Farr and Rossman 2009); northern CA, OR, WA (Sinclair and Lyon 2005; Aldwinckle 1990d). On *Pyrus communis* in CA, OR, WA (Farr and Rossman 2009).	Yes. Causes malformation and premature drop of fruit (Aldwinckle 1990d). Is most severe on pear, but also attacks apple (Aldwinckle 1990d).	No records found	Yes. Is heteroecious with apple as aecial host (Farr *et al.* 1989). Requires incense cedar (*Calocedrus decurrens* (Torr.) Florin) as alternate host to complete its life cycle (Aldwinckle 1990d). *Calocedrus decurrens*, although not wide spread, is grown as ornamental in Australia (ABC 2008). It is grown in Botanic Gardens around Australia (Council of Heads of Australian Botanic Gardens 1992). Spores are dispersed by wind (Sinclair and Lyon 2005). Rosaceous hosts can become infected at distances as great as 12–16 km from infected incense cedars (Sinclair and Lyon 2005).	Yes. Has occasionally caused severe infections of pear and quince fruits in orchards in the Northwest of the US where incense cedar was growing nearby (Sinclair and Lyon 2005). Pacific Coast pear rust is a serious disease of pear in the western US. It is most severe on pear, but also attacks apple, quince and ornamental and wild rosaceous species (Aldwinckle 1990d).	Yes
Gymnosporangium yamadae Miyade ex G. Yamada [Pucciniaceae] Japanese apple rust	Yes. DE, PA (Yun *et al*. 2009).	Yes. Fruit are liable to carry this pathogen (Guo 1994). Latent infections on fruit may occur (Laundon 1998), although fruit infection is rare. This pathogen is listed as on the pathway in the IRA for Fuji apples from Japan (AQIS 1998a).	No records found	Yes. Japanese apple rust is widely distributed in all major apple production areas of China (Guo 1994) and was also reported in Japan, North Korea, South Korea (Wang and Guo 1985) and the US (Yun *et al.* 2009). The climate conditions in many parts of Australia are similar to these countries. Japanese apple rust has a restricted host range, including *Malus* species and alternate host *Juniperus* species (Ma 2006; Wang and Guo 1985). These host plants are grown in Australia. Under natural conditions, basidiospores and aeciospores are dispersed by wind (Guo 1994).	Yes. Apple rust is one of the major diseases of apple in China (Guo 1994) and Japan (Tanaka 1922). *Gymnosporangium yamadae* infects leaves and stems of juniper, and leaves, stems and immature fruit of apples (Ma 2006). It causes damage by defoliation. Infection of young fruit causes fruit drop and a reduction in apple fruit yield and quality (Guo 1994).	Yes

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Order Xylariales						
Biscogniauxia marginata (Fr.) Pouzar *Synonym: Nummularia discreta* (Schwein.) Tul. & C. Tul.; *Nummularia discincola* (Schwein.) Cooke [Xylariaceae] Blister canker	Yes. Eastern and central states, GA, IA, MS, NC, OK, WV (Farr and Rossman 2009).	No. This fungus is known as a bark and wood pathogen and is not associated with the mature fresh harvested fruit of its hosts (Ju *et al.* 1998).	Not assessed	Not assessed	Not assessed	No
Dendrophoma sp. [Anamorphic Xylariales]	Yes. WA (Shaw 1973).	No[42]. Known to mainly affect limbs of hardwoods (Farr *et al.* 1989). *Dendrophoma* fruit rots are occasionally reported from strawberry (Howard and Albregts 1973). Only one report where a fungus tentatively identified as *Dendrophoma* sp. was isolated from core rots and lesions of apple (English 1944). No further evidence found for infection of apple fruit. Lack of recent records on apple in the US suggests that it is unlikely to be present on the importation pathway.	Not assessed	Not assessed	Not assessed	No

[42] Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Eutypa lata (Pers.:Fr.) Tul. & C.Tul. Anamorph: *Libertella blepharis* A.L. Sm. Synonym: *Eutypa armeniacae* Hansf. & M.V. Carter [Diatrypaceae] Eutypa dieback	Yes. Reported on apple in WA in 1982, but no further reports from this region (Carter 1991). In California, crabapple serves as a reservoir for this pathogen (Gubler *et al.* 2009).	Yes. In New Zealand, it has been reported to cause fruit rot of apple (Boesewinkel 1986). Causes cankers on apple branches (Carter 1991).	Yes. NSW, Qld, SA, Vic. (APPD 2009). Tas., WA—as *E. armeniacae* (APPD 2009).	Not assessed	Not assessed	No
Eutypella prunastri (Pers.:Fr.) Sacc. [Diatrypaceae]	Yes. OR (Shaw 1973).	No[43]. Has been reported on winter-injured apple bark in Oregon in 1925 (Zeller 1927). All of the reports of *E. prunastri* on apple in the US are based on a report from 1973 (Shaw 1973). Lack of recent records suggests that it is unlikely to be present on the importation pathway.	Not assessed	Not assessed	Not assessed	No
Pestalotia concentrica Berk. & Broome Synonym: *Monochaetia concentrica* (Berk. & Broome) Sacc. [Anamorphic Amphisphaereaceae] Leaf spot	Yes. ID, IN, southeastern states (Farr and Rossman 2009); ID (Glawe 2009).	No. Found on dead leaves of hardwoods (Farr *et al.* 1989).	Not assessed	Not assessed	Not assessed	No
Seiridium unicorne (Cooke & Ellis) B. Sutton Synonym: *Monochaetia mali* (Ellis & Everh.) Sacc. [Amphisphaeriaceae] Monochaetia twig canker	Yes. Eastern states, IL, MO, NJ, WV (Farr and Rossman 2009).	No. Causes twig canker (Farr *et al.* 1989; Jones 2000). Also found on leaves (Farr *et al.* 1989).	Not assessed	Not assessed	Not assessed	No
Sporocadus lichenicola Corda Teleomorph: *Discostroma corticola* (Fuckel) Brockmann Synonym: *Coryneum foliicola* Fuckel [Anamorphic Amphisphaeriaceae]	Yes. AK, WA (Farr and Rossman 2009); WA (Shaw 1958; Glawe 2009).	No. Found on twigs, branches and leaves of host (Farr and Rossman 2009).	Not assessed	Not assessed	Not assessed	No

[43] Should a recent record of this pest be detected on apple in the US, or should it be detected in the future, then this would need to be reported to Australia immediately. The potential for this pest being on the pathway would then need to be reassessed.

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Truncatella hartigii (Tubeuf) Steyaert Synonym: *Pestalotia hartigii* Tubeuf [Anamorphic Amphisphaeriaceae] Leaf spot	Yes. WA (Shaw 1958, 1973; USDA-ARS 1960; Farr and Rossman 2009).	Yes. Was reported to cause rotting of stored apple fruit in Washington (USDA-ARS 1960). Is considered to cause an apple rot of minor or very minor importance (Pierson *et al.* 1971).	No records found	Yes. Suitable hosts, including apple and conifer, are present in Australia. It has been reported to be a seedborne pathogen of apple (Chaudhary *et al.* 1987).	Yes. *Truncatella hartigii* is a significant pathogen of conifers (Vujanovic *et al.* 2000).	Yes
DOMAIN VIRUSES						
POSITIVE SENSE SINGLE-STRANDED RNA						
Order Unassigned						
Apple chlorotic leaf spot virus [Flexiviridae: Trichovirus] ACLSV	Yes. OR, WA (CABI/EPPO 2000; APHIS 2007b, c; Oregon Department of Agriculture 2009).	Yes. The virus has been detected in infected apple fruit (Kinard *et al.* 1996). No fruit symptoms on *Malus* hosts. But can affect fruit of other hosts, including plum and apricot (Oregon Department of Agriculture 2009). According to Hansen and Parish (1990), ACLSV is the causal agent of many russet ring disorders of apple fruit.	Yes. Qld, Tas., Vic. (APPD 2009). Widespread – NSW, Qld, SA, Tas., Vic., WA (Constable *et al.* 2007).	Not assessed	Not assessed	No
Apple mosaic virus [Bromoviridae: Ilavirus] ApMV	Yes. Widespread, including ID, OR, WA (CABI/EPPO 2001a). ID, OR, WA (APHIS 2007b, c, d).	Yes. No symptoms on fruit of most apple cultivars, but fruit of Lord Lambourne trees develop cream-colored blotches (Howell *et al.* 1990). Most cases of spread appear to result from root grafts (Fulton 1985; Howell *et al.* 1990). Very little if any spread is observed in apple orchards with infected trees (Howell *et al.* 1990).	Yes. Qld, SA, Vic., WA (APPD 2009); WA (McLean and Price 1984).	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Apple stem grooving virus [Flexiviridae: Capillovirus] ASGV	Yes. WA (APHIS 2007c). The virus occurs in apple only with other latent viruses, so its significance on commercial apple varieties is unknown (Nemeth 1986).	Yes. The virus has been detected in infected apple fruit (Kinard *et al.* 1996). Fruit symptoms not recorded but seed transmissible (Welsh and van der Meer 1989; Lister 1986). Seed transmission has been reported in *Chenopodium quinoa* and *Malus platycarpa* (Welsh and van der Meer 1989). Natural spread is considered rare, and no vectors have been identified, with transmission attributed to natural root grafting between infected and healthy trees (Welsh and van der Meer 1989; Lister 1986).	Yes. Qld, SA, Tas., Vic., WA (APPD 2009). Widespread – NSW, Qld, SA, Tas., Vic., WA (Constable *et al.* 2007).	Not assessed	Not assessed	No
Apple stem pitting virus [Flexiviridae: Foveavirus] ASPV	Yes. WA (APHIS 2007c). ASPV is one of the most common latent viruses in commercial apple cultivars (Nemeth 1986).	Yes. The virus has been detected in apple fruit (Klerks *et al.* 2001). Transmitted only through grafting. No natural vector of the virus is known (Yanase *et al.* 1990). The virus is more concentrated in the roots, so transmissions carried out with inocula taken from the roots are more successful (Nemeth 1986).	Yes. Qld, SA, Tas., Vic., WA (APPD 2009).	Not assessed	Not assessed	No
Cherry rasp leaf virus [Comoviridae: Cheravirus] CRLV	Yes. Present in a number of states, including ID, OR, WA (CABI/EPPO 1997j; CABI/EPPO 2001b).	Yes. Symptoms of flat apple occur on both foliage and fruit (Hansen and Parish 1990).	Yes. NSW, Vic., WA (Büchen-Osmond *et al.* 1988); Vic. (Washington and Nancarrow 1983).	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Tobacco necrosis viruses [Tombusviridae: Necrovirus]	Yes. Widely prevalent in OR (APHIS 2007b). Known to infect apple (CABI 2007). Occurs in fruit trees in the US (Nemeth 1986).	Yes. Tobacco necrosis viruses (TNVs) have been isolated from apple fruit flesh (Uyemoto and Gilmer 1972). Virus particles released from plant debris and acquired in soil by zoospores of chytrid fungi (*Olpidium* spp.) may be transmitted to suitable hosts (Uyemoto 1981; Spence 2001; CABI 2009). Necroviruses may also be transmitted in soil water without a vector (Lommel *et al*. 2005).	Yes. Viruses likely to be strains of tobacco necrosis viruses A and D have been recorded in Vic. and Qld (Findlay and Teakle 1969; Teakle 1988). Tobacco necrosis virus Nebraska isolate has not been recorded in Australia, nor have other tobacco necrosis viruses that have since been renamed or have not yet been formally recognised (Tomlinson *et al*. 1983; Zhang *et al*. 1993; Cardoso *et al*. 2005; NCBI 2009).	Yes. Tobacco necrosis virus strains are established in Australia (Teakle 1988). TNVs infect common vegetable crop plants, ornamental plants and tree species (Brunt and Teakle 1996; CABI 2009; Zitikaite and Staniulis 2009). TNVs are transmitted by *Olpidium* spp. (Rochon *et al*. 2004; Sasaya and Koganezawa 2006) and these vectors occur in Australia (McDougall 2006; Maccarone *et al.* 2008).	Yes. Tobacco necrosis viruses cause rusty root disease of carrot, Augusta disease of tulip, stipple streak disease of common bean, necrosis diseases of cabbage, cucumber, soybean and zucchini and ABC disease of potato (Uyemoto 1981; Smith *et al*. 1988; Xi *et al*. 2008; Zitikaite and Staniulis 2009).	Yes
Tobacco ringspot virus [Comoviridae: Nepovirus] TRSV	Yes. Primarily eastern and central US states. Recently in OR but only on *Vaccinium* (CABI/EPPO 1997m). Apple is known as a host (CABI/EPPO 1997m; CABI 2007).	Yes. The virus spreads systemically in host plants (CABI/EPPO 1997m).	Yes. Qld, SA, WA (CABI/EPPO 1997m); SA, WA (CMI 1984).	Not assessed	Not assessed	No
Tomato ringspot virus [Comoviridae: Nepovirus] TmRSV, Apple union necrosis and decline	Yes. Eastcoast, OR, MI (Pscheidt 2008e). The disease occurs primarily in the northeastern and middle Atlantic regions of the US and to a much lesser extent in the northwestern region and other areas of eastern states (Gonsalves 1990). Widely prevalent in OR (APHIS 2007b). Pacific Northwest (Stouffer and Powell 1989).	Yes. Little, if any spread of the virus by infected scions. Possibly because most commercial scions are resistant to infection or because the virus does not move systemically in the scion much above the the graft union. However, it is easily spread by infected MM.106 rootstock (Gonsalves 1990). Transmission primarily through propagation of trees from infected rootstock and through vectoring nematodes (Gonsalves 1990).	Yes. SA (CABI/EPPO 1997k, 1998).	Not assessed	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Tulare apple mosaic virus [Bromoviridae: Ilarvirus] TAMV	Yes. A single record for Tulare County, California (Howell *et al.* 1990).	Yes. No symptoms on fruit of most apple cultivars, but fruit of Lord Lambourne trees develop cream-colored blotches (Howell *et al.* 1990).	No records found	No. No natural vectors are known and there is no evidence suggesting seed transmission. Most cases of spread appear to result from root grafts. Very little if any spread is observed in apple orchards with infected trees (Howell *et al.* 1990).	Not assessed	No
UNKNOWN VIRUSES OR VIRUS-LIKE AGENTS						
Apple freckle scurf	Yes. US Northwest (Nemeth 1986).	Uncertain. Symptoms occur on bark (Parish and Hansen 1990). Caused by an unknown virus (Nemeth 1986).	No records found	No. The disorder is transmitted by grafting. Spread occurs through infected budwood (Parish and Hansen 1990).	Not assessed	No
Apple green crinkle	Yes. WA (Hansen and Parish 1990).	Yes. Causes fruit symptoms (Nemeth 1986; Eastwell 2008). Caused by an unknown virus (Nemeth 1986).	Yes. NSW (Letham 1995); Qld (Simmonds 1966); Tas. (Sampson and Walker 1982); WA (McLean and Price 1984).	Not assessed	Not assessed	No
Apple green mottle virus	Yes. Eastern US (Nemeth 1986).	Yes. Symptoms on fruit (Nemeth 1986). Caused by an unknown virus (Nemeth 1986).	No records found	No. It is transmitted by grafting, budding and chip budding (Nemeth 1986).	Not assessed	No
Apple leaf pucker virus	Yes. US—no particular region specified (Nemeth 1986).	Yes. Symptoms on fruit (Nemeth 1986). Caused by an unknown virus (Nemeth 1986).	No records found	No. Transmitted by grafting and budding (Nemeth 1986).	Not assessed	No
Apple McIntosh depression virus	Yes. Eastern US (Nemeth 1986; Zawadzka and Millikan 1989).	Yes. Severely affects fruit (Nemeth 1986; Palmiter 1969). Caused by an unknown virus (Nemeth 1986).	No records found	No. Spread by grafting and budding (Nemeth 1986).	Not assessed	No
Apple platycarpa scaly bark Platycarpa dwarf virus	Yes. US—no particular region specified (Nemeth 1986).	Yes. Causes latent infections (Nemeth 1986). Caused by an unknown virus (Nemeth 1986). Transmission by budding, grafting and vegetatively propagated rootstocks (Nemeth 1986).	Yes. No particular region specified (Nemeth 1986).	Not assessed	Not assessed	No
Apple pustule canker	Yes. Western US (Nemeth 1986).	Uncertain. Symptoms occur on woody parts of the plant (Nemeth 1986). Caused by an unknown virus (Nemeth 1986).	No records found	No. The disorder is spread by infected budwood (Parish and Hansen 1990). Transmission by budding and grafting (Nemeth 1986).	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Apple rough skin	Yes. US—no particular region specified. Apple is the only known host (Nemeth 1986).	Yes. Symptoms on fruit (Hansen and Parish 1990). Caused by an unknown virus (Nemeth 1986).	No records found	No. The virus is transmitted mostly by grafting, budding and chip budding, and although a very slow natural spread within the orchards was observed, its vector is still unknown (Hansen and Parish 1990; Nemeth 1986). Most spread of the apple rough skin appears to be due to the use of infected stock and scion material for propagation in nurseries and orchards (Hamdorf 1989).	Not assessed	No
Apple russet ring and associated disorders Apple russet ring; leaf pucker and fruit russet; leaf fleck; bark blister and fruit distortion	Yes. Graft-transmissible fruit disorders have been found in most apple growing areas of the world (Hansen and Parish 1990).	Yes. Symptoms on fruit. Caused by an unknown virus (Hansen and Parish 1990). Russet ring is considered to be a graft-transmissible fruit disorder (Hansen and Parish 1990).	Yes. WA (McLean and Price 1984); Tas. (Sampson and Walker 1982); NSW (Letham 1995).	Not assessed	Not assessed	No
Apple star crack agent Apple star crack virus	Yes. WA (Blodgett and Aichele 1961); Pacific Northwest (Pscheidt 2008e).	Yes. Symptoms on fruit (Hansen and Parish 1990). An unknown virus has been suggested as the causal agent (Blodgett and Aichele 1961). Is considered to be a graft-transmissible fruit disorder (Hansen and Parish 1990).	Yes. NSW (Letham 1995).	Not assessed	Not assessed	No
Dead spur of apple	Yes. First observed in WA, but has since been reported in other states, including ID and OR (Parish 1990).	Uncertain. Kills the fruiting spurs in the centers of the trees (Parish 1990). The causal agent has not been identified (Parish 1990), but virus-like particles have been associated with the disease (Parish *et al.* 1982).	No records found	No. No vectors are known. Spread by grafting (Parish 1990).	Not assessed	No

Pest	Present in US[18]	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
VIROIDS						
Apple scar skin viroid [Pospiviroidae: Apscaviroid] ASSVd; Apple scar skin; dapple apple	Yes. WA (Hadidi *et al.* 1991; CABI 2007); US—no specific regions identified (Nemeth1986).	Yes. This viroid can be found in the fruit pulp (Hurtt and Podleckis 1995; Koganezawa *et al.* 2003) and seeds (Hadidi *et al.* 1991; Han *et al.* 2003).	No records found	Yes. Apple scar skin viroid is present in a number of asian countries, Europe and North America. The climate conditions in many parts of Australia are similar to these countries. It is generally agreed that the means of transmission of Apple scar skin viroid is by grafting and contaminated pruning equipments (Grove *et al.* 2003; Han *et al.* 2003). A recent paper suggested ASSVd can transmit from infected seeds to the seedlings germinated from these seeds with a 7.7% transmision rate (Kim *et al.* 2006).	Yes. Apple scar skin caused by Apple scar skin viroid is one of the most destructive diseases in Korea (Kim *et al.* 2006). According to surveys conducted in 1950s in China, in some counties of Shanxi, Hebei and Shaanxi provinces, more than 50% of apple trees were affected with this disease (Han *et al.* 2003). In the US, this disease was first described in 1956 (Millikan and Martin 1956; Smith *et al.* 1956). The disease decreases the market value of the fruit (Nemeth 1986). The entire crop from affected trees becomes unmarketable (Koganezawa 2001).	Yes
UNKNOWN ETIOLOGY						
Blister Bark	Yes. Blister bark was first observed in 1969 in a Red Delicious tree near Cashmere, WA (Parish 1989). Blister bark 3 occurs in WA (Parish 1989). Host range restricted to Red Delicious apple (Parish 1989).	Uncertain. Symptoms occur on woody parts of the plant (Parish and Hansen 1990).	No records found. Symptoms of blister bark occur worldwide on the cultivar Delicious (Parish and Hansen 1990).	No. The disorder is spread by infected budwood (Parish and Hansen 1990). Transmitted by grafting or the use of infected budwood (Parish 1989).	Not assessed	No

Appendix B Additional quarantine pest data

DOMAIN BACTERIA	
Quarantine pest	***Pseudomonas syringae* pv. *papulans* (Rose 1917) Dhanvantari 1977**
Synonyms	*Pseudomonas papulans* Rose 1917
Common name(s)	blister spot, blister canker
Main hosts	*Malus pumila* (common apple), *Pyrus communis* (pear) (Bradbury 1986)
Distribution	Presence in Australia: No record found Presence in the US: AK, IL, IN, MI, MO, NY, PA, VA (Smith 1944; Bradbury 1986) Presence elsewhere: Canada, France, Germany, Italy, United Kingdom (Dhanvantari 1969; Bradbury 1986; Burr 1990; Sholberg and Bedford 1997; Kerkoud *et al.* 2000; Moltmann 2002)
Quarantine pest	***Erwinia amylovora* (Burrill 1882) Winslow *et al*. 1920, emend. Hauben *et al*. 1998**
Synonyms	*Micrococcus amylovorus* Burrill 1882 *Bacillus amylovorus* (Burrill 1882) Trevisan 1889 *Bacterium amylovorum* (Burrill 1882) Chester 1901
Common name(s)	fire blight
Main hosts	Besides the species in the genera *Malus* and *Pyrus*, there are 129 species of plants belonging to 37 genera of the family Rosaceae that have been reported to be susceptible to *E. amylovora* (van der Zwet and Keil, 1979). These authors showed that most of the hosts are susceptible only when inoculated artificially. The natural host range of *E. amylovora* is now generally considered to be restricted to genera of the subfamily Maloideae (formerly: Pomoideae) of the family Rosaceae (CABI 2007). Plants belonging to the subfamilies Rosoideae and Amygdaloideae can also be affected (Momol and Aldwinckle 2000). Primary hosts of economic and epidemiological significance: *Cotoneaster* spp. (cotoneaster), *Crataegus* spp. (hawthorns), *Cydonia oblonga* (quince), *Eriobotrya* spp. (bolanchin, loquat, etc.), *Malus* spp. (apple), *Prunus salicina* (Japanese plum), *Pyracantha* spp. (firethorn) and *Pyrus* spp. (pears) (Douglas 2006; CABI 2007) Secondary hosts: *Amelanchier* spp. (serviceberry), *Chaenomeles* spp. (flowering quince), *Mespilus* spp. (medlar), *Rubus* spp. (blackberry, raspberry) and *Sorbus* spp. (mountain ash, rowan) (Douglas 2006; CABI 2007) Within each genus given as hosts of fire blight, there are species or cultivars that may show high level of resistance under natural conditions or artificial inoculations (van der Zwet and Keil 1979; CABI 2007).
Distribution	Presence in Australia: *Erwinia amylovora* was detected on Cotoneaster in the Melbourne Royal Botanic Garden in 1997, and its eradication was confirmed by national survey (Rodoni *et al.* 1999; Jock *et al.* 2000). Presence in the US: Every region of the US (Bonn and van der Zwet 2000), AL, CA, CO, CT, GA, IL, LA, MD, ME, MI, NC, NY, OH, OR, PA, TX, UT, VA, WA, WV, WI (CABI 2007) Presence elsewhere: Albania, Armenia, Austria, Belgium, Bermuda, Bosnia and Herzegovina, Bulgaria, Canada, Croatia, Cyprus, Czech Republic, Denmark, Egypt, France, Germany, Greece, Guatemala, Hungary, Iran, Ireland, Israel, Italy, Jordan, Lebanon, Luxembourg, Macedonia, Mexico, Moldova, Montenegro, Netherlands, New Zealand, Norway, Poland, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom (CABI 2007)
DOMAIN EUKARYA	
Quarantine pest	***Cenopalpus pulcher* (Canestrini & Fanzago, 1876)**
Synonyms	*Brevipalpus ciferrii* Lombardini, 1951 *Brevipalpus pulcher* (Canestrini & Fanzago, 1876) *Brevipalpus pyri* Sayed, 1946 *Caligonus pulcher* Canestrini & Fanzago, 1876 *Tenuipalpus bodenheimeri* Bodenheimer, 1930 *Tenuipalpus oudemansi* Geijskes, 1939
Common name(s)	flat scarlet mite
Main hosts	*Cydonia oblonga* (quince), *Eriobotrya* sp. (loquat), *Juglans* sp. (walnut), *Malus* sp. (apple), *Plantanus orientalis* (plane), *Prunus armeniaca* (apricot), *Prunus domestica* (plum), *Punica granatum* (pomegranate), *Pyrus communis* (European pear), *Salix* sp. (willow) (Jeppson *et al*. 1975 ; USDA-APHIS 2000a)

Distribution	Presence in Australia: No record found Presence in the US: OR (USDA-APHIS 2000a; Bajwa and Kogan 2003) Presence elsewhere: Afghanistan, Algeria, Armenia, Austria, Azerbaijan, Bulgaria, Central Asian Republics, China, Cyprus, Denmark, Libya, Egypt, England, Georgia, Germany, India, Iraq, Iran, Israel, Italy, Lebanon, Libya, Netherlands, Portugal, Russia, Syria, Turkey (Jeppson *et al.* 1975; USDA-APHIS 2000a)
Quarantine pest	***Tetranychus mcdanieli*** **McGregor, 1931**
Synonyms	
Common name(s)	McDaniel spider mite
Main hosts	*Acer saccharum* (sugar maple), *Fragaria* spp. (strawberry), *Lonicera japonica* (Japanese honeysuckle), *Malus pumila* (apple), *Morus* sp. (mulberries), *Phleum pratense* (timothy), *Prunus* spp. (plum, cherry, apricot, peach), *Pyrus communis* (pear), *Ribes* sp. (currants); *Rubus idaeus* (raspberry), *Thalictrum fendleri* (Fendler's meadow-rue); *Thermopsis pinetorum* (golden pea), *Ulmus americana* (American elm); *Vitis vinifera* (grapevine) (Bolland *et al*. 1998)
Distribution	Presence in Australia: No record found Presence in the US: AZ, CA, CO, ID, MI, ND, NM, NY, OH, OR, UT, WA (Hoyt and Beers 1993; Baker and Tuttle 1994) Presence elsewhere: Canada, France (Bolland *et al.* 1998)
Quarantine pest	***Tetranychus pacificus*** **McGregor, 1919**
Synonyms	
Common name(s)	Pacific spider mite
Main hosts	*Amaranthus* sp. (pigweed), *Asarum* sp. (wild ginger), *Asclepias* spp. (milkweed), *Bocconia frutescens* (parrotweed, tree poppy), *Brassica* spp., *Ceanothus fendleri* (buckbrush), *Citrullus lanatus* (watermelon), *Citrus* spp., *Cotoneaster* spp., *Cucumis melo* (melon), *Cucurbita pepo* (zucchini), *Eschscholtzia californica* (Californian poppy), *Ficus carica* (fig), *Fragaria* spp. (strawberry), *Glycine max* (soyabean), *Gossypium* spp. (cotton), *Helianthus annuus* (sunflower), *Ipomoea* spp., *Juglans* spp. (walnut), *Magnolia fraseri* (earleaf cucumber tree), *Malus pumila* (apple), *Malva* spp. (mallow), *Marrubium vulgare* (white horehound), *Medicago sativa* (lucerne), *Melia azedarach* (white cedar), *Morus* sp. (mulberry), *Oemleria cerasiformis* (Indian plum), *Phaseolus* spp. (bean), *Philadelphus* spp., *Prunus* spp. (peach, nectarine, apricot, plum, cherry), *Pyrus communis* (pear), *Rhamnus betulaefolia* (birchleaf buckthorn), *Robinia pseudoacacia* (black locust), *Rosa* spp. (roses), *Rubus* spp. (blackberry, raspberry), *Salvia* spp. (sage), *Solanum melongena* (eggplant), *Stachys* spp. (woundwort), *Syringa* spp. (lilac), *Thermopsis pinetorum* (golden pea), *Trifolium* spp. (clover), *Ulmus* spp. (elm), *Vicia* spp. (vetch), *Vitis vinifera* (grape vine), *Zea mays* (maize) (Bolland *et al.* 1998; Migeon and Dorkeld 2006)
Distribution	Presence in Australia: No record found Presence in the US: AZ, CA, ID, OR, UT, WA (Jeppson *et al.* 1975; Baker and Tuttle 1994) Presence elsewhere: Canada, Mexico (Bolland *et al.* 1998)
Quarantine pest	***Tetranychus turkestani*** **(Ugarov & Nikolskii, 1937)**
Synonyms	*Eotetranychus turkestani* Ugarov & Nikolskii, 1937 *Tetranychus atlanticus* McGregor, 1941
Common name(s)	strawberry spider mite
Main hosts	More than 200 hosts in more than 60 families, including *Citrus*, *Malus*, *Prunus*, *Pyrus*, *Vitis* spp. For a comprehensive list see Bolland *et al*. (1998) and Migeon and Dorkeld (2006)
Distribution	Presence in Australia: No record found Presence in the US: widespread in the US (Baker and Tuttle 1994) Presence elsewhere: Algeria, Azerbaijan, Bulgaria, China, Costa Rica, France, Germany, Greece, Hungary, India, Iran, Iraq, Israel, Japan, Kazakhstan, Kuwait, Mexico, Morocco, Netherlands, New Zealand, Pakistan, Poland, Portugal, Russia, Serbia, South Africa, Spain, Switzerland, Tajikistan, Tunisia, Turkey, Ukraine, United Kingdom, Uzbekistan (Bolland *et al.* 1998; Migeon and Dorkeld 2006; CABI 2007)
Quarantine pest	***Anthonomus quadrigibbus*** **Say, 1831**
Synonyms	*Tachypterellus consors cerasi* List, 1932 *Tachypterellus quadrigibbus* (Say, 1831) *Tachypterellus quadrigibbus magna* List 1932 *Tachypterus quadrigibbus* (Say, 1831)
Common name(s)	apple curculio

Main hosts	*Amelanchier* spp., *Cornus* spp., *Crataegus* spp. (hawthorn), *Cydonia oblonga* (quince), *Malus* spp. (crabapple), *Malus pumila* (apple), *Prunus* spp., *Pyrus* spp. (pear), *Sorbus* spp. (Burke and Anderson 1989; CABI 2007)
Distribution	Presence in Australia: No record found Presence in the US: widespread in the US (CABI 2007) Presence elsewhere: Canada, Mexico (CABI 2007)
Quarantine pest	***Dasineura mali* (Kieffer, 1904)**
Synonyms	*Perrisia mali* Kieffer, 1904
Common name(s)	apple leafcurling midge, apple leaf midge
Main hosts	*Malus* spp. are the only hosts of *D. mali* (Tomkins 1998)
Distribution	Presence in Australia: No record found Presence in the US: MA, NY, WA (CABI 2007; CABI/EPPO 2008) Presence elsewhere: Argentina, Austria, Belgium, Bosnia-Herzegovina, Bulgaria, Canada, Finland, France, Germany, Hungary, Italy, Macedonia, Netherlands, New Zealand, Norway, Poland, Romania, Russia, Serbia, Slovenia, Sweden, Switzerland, United Kingdom (CABI 2007; CABI/EPPO 2008)
Quarantine pest	***Rhagoletis pomonella* (Walsh, 1867)**
Synonyms	*Trypeta albiscutellata* Harris, 1835 *Trypeta pomonella* Walsh, 1867
Common name(s)	apple maggot, apple maggot fly
Main hosts	More than 30 hosts in the family Rosaceae, including *Amelanchier* spp., *Aronia* spp., *Cotoneaster* spp., *Crataegus* spp. (hawthorn) , *Malus* spp. (apples and crabapples), *Prunus* spp., *Pyracantha* spp., *Pyrus* spp. (pears), *Rosa* spp. (Bush 1966; Yee and Goughnour 2006; CABI 2007)
Distribution	Presence in Australia: No record found Presence in the US: widespread in the US (CABI 2007) Presence elsewhere: Canada, Mexico (CABI 2007)
Quarantine pest	***Lygus elisus* Van Duzee, 1914**
Synonyms	*Lygus pratensis* var. *elisus* Van Duzee, 1914 *Lygus nigrosignatus* Knight, 1941 *Lygus desertus* Knight, 1944 *Liocoris nigrosignatus* (Kelton, 1955) *Liocoris desertus* (Kelton, 1955) *Liocoris elisus* (Kelton, 1955)
Common name(s)	Lucerne plant bug; green lygus
Main hosts	More than 60 hosts in 16 families, including *Brassica juncea* (mustard), *B. oleracea* (cabbage), *B. campestris*, *B. napus* (oilseed rape), *Lotus corniculatus* (birdsfoot- trefoil), *Lupinus albus* (white lupine), *Lupinus argenteus*, *Medicago sativa* (alfalfa), *Melilotus alba* (sweet clover), *Menthea* spp. (mints), *Onobrychis viciifolia* (sainfoin), *Phaseolus* spp. (beans), *Sinapis alba*, *S. arvensis* (mustard), *Trifolium pratense* (red clover) (Schwarz & Foottit 1992) ; *Ambrosia psilostachya* (western ragweed), *Artemisia* spp. (sagebrush), *Bassia* spp. (smotherweed), *Brassica* spp. (wild mustards), *Chrysothamnus* spp. (rabbitbrush), *Conyza* spp. (horseweed), *Malus* sp. (apple) *Prunus* spp. (peach, apricot), *Pyrus communis* (pear), *Salsola tragus* (Russian thistle), *Verbascum* spp. (mullein) (Anthon 1993b). For a comprehensive list, see Schwartz & Foottit (1992)
Distribution	Presence in Australia: No record found Presence in the US: WA (Anthon 1993b; CABI 2007) Presence elsewhere: southern Canada (Schwartz & Foottit 1992)
Quarantine pest	***Lygus hesperus* Knight, 1917**
Synonyms	*Lygus elisus* var. *hesperus* Knight, 1917 *Lygus hesperus* Shull, 1933 *Liocoris hesperus* (Kelton, 1955)
Common name(s)	western tarnished plant bug; brown lygus
Main hosts	On same hosts as *Lygus elisus* but prefers *Kochia scoparia* (Mexican fireweed), *Malus* sp. (apple), *Prunus* spp. (peach, apricot), *Pyrus communis* (pear) (Anthon 1993b); *Daucus carota* (carrot), *Gossypium hirsutum* (Bourbon cotton), *Lycopersicon esculentum* (tomato) (CABI 2007)

Distribution	Presence in Australia: No record found Presence in the US: ID, OR, WA (Anthon 1993b); AZ, CA, GA, MT, NV, UT (CABI 2007) Presence elsewhere: No record found
Quarantine pest	***Lygus lineolaris* (Palisot de Beauvois, 1818)**
Synonyms	*Capsus lineolaris* Palisot de Beauvois, 1818 *Capsus oblineatus* Say, 1832 *Lygus lineolaris* (Uhler, 1872) *Capsus flavonotatus* Provancher, 1872 *Capsus strigulatus* Walker, 1873
Common name(s)	Tarnished plant bug
Main hosts	More than 300 recorded hosts with 130 of these regarded as economically important plants (Young 1986) including *Achillea millefolium* (western yarrow), *Ambrosia* sp., *Antennaria aprica*, *Artemisia frigida* (fringed sagebrush), *Artemisia tridentate* (big sagebrush), *Aster* spp., *Beta vulgaris* (beetroot), *Betula nana* var. *sibirica* (bog birch), *Brassica campestris*, *B. juncea* (Chinese mustard), *B. napus* (rape), *Capsella bursa-pastoris* (shepherd's purse), *Caragana* spp. (peashrub), *Chenopodium album* (lambsquarters), *Fagopyrum esculentum* (buckwheat), *Fragaria ananassa* (strawberry), *Lupinus argenteus* (silvery lupine), *Medicago sativa* (alfalfa), *Melilotus alba* (white sweetclover), *Mentha arvensis* (wild mint), *Avena sativa* (oats), *Picea glauca* (western white spruce), *Pinus banksiana* (black pine), *Polygonum* sp., *Populus tremuloides* (quaking aspen), *Prunus virginiana* var. *melanocarpa* (chokecherry), *Axyris amaranthoides* (Russian pigweed), *Quercus macrocarpa* (bur oak), *Salix* sp. (willow), *Sinapis alba* (white mustard), *Solidago* sp. (goldenrod), *Symphoricarpos occidentalis* (western snowberry), *Thlaspi arvense* (fanweed), *Trifolium* hybrids (clovers) (Schwartz & Foottit 1992); *Malus* sp. (apple) *Prunus* spp. (peach, apricot), *Pyrus communis* (pear) (Anthon 1993b)
Distribution	Presence in Australia: No record found Presence in the US: ID, OR, WA (Anthon 1993b; CABI 2007), throughout the US (Anthon 1993b), east central Alaska (Schwartz & Foottit 1992) Presence elsewhere: Canada from Alberta to Newfoundland; Mexico (Schwartz & Foottit 1992)
Quarantine pest	***Lopholeucaspis japonica* (Cockerell, 1897)**
Synonyms	*Leucaspis hydrangeae* (Takahashi, 1939) *Leucaspis japonica* (Cockerell, 1897) *Leucaspis japonica darwiniensis* Green, 1916 *Leucaspis japonicus* Cockerell, 1897 *Leucaspis menoni* (Borchsenius, 1964) *Leucodiaspis hydrangeae* Takahashi, 1934 *Leucodiaspis japonica* (Cockerell, 1897) *Leucodiaspis japonica darwiniensis* (Green, 1916) *Lopholeucaspis darwiniensis* Borchsenius, 1966 *Lopholeucaspis menoni* Borchsenius, 1964
Common name(s)	Japanese maple scale
Main hosts	More than 50 hosts in more than 30 families, including *Citrus*, *Malus*, *Prunus*, *Pyrus*, *Vitis* spp. For a comprehensive list see Watson (2005) and Miller and Gimpel (2009a)
Distribution	Presence in Australia: reported from the Northern Territory in the early 20th century (Donaldson and Tsang 2002), but is now considered absent from Australia (CABI/EPPO 1997c) Presence in the US: CT, DC, DE, GA, MD, NJ, NY, PA, RI, VA (Watson 2005; Miller and Gimpel 2009a) Presence elsewhere: Afghanistan, Azerbaijan, Brazil, Burma, China, Congo, Georgia, Germany, Greece, India, Iran, Japan, Korea, Nepal, Pakistan, Russia, Slovakia, Taiwan, Turkey, Ukraine, United Kindom (Watson 2005; Miller and Gimpel 2009a)
Quarantine pest	***Parlatoria oleae* (Colvée, 1880)**
Synonyms	*Diaspis oleae* Colvée, 1880 *Diaspis squamosus* Newstead & Theobald, 1904 *Parlatoria affinis* Newstead, 1897 *Parlatoria calianthina* Berlese &Leonardi, 1896 *Parlatoria judaica* Bodenheimer, 1924 *Parlatoria morrisoni* Bodenheimer, 1944 *Syngenaspis oleae* (Colvée, 1880)

Common name(s)	olive parlatoria scale
Main hosts	More than 150 hosts in more than 50 families, including *Citrus*, *Malus*, *Prunus*, *Pyrus*, *Vitis* spp. For a comprehensive list see Watson (2005) and Miller and Gimpel (2009b)
Distribution	Presence in Australia: NSW, Qld (Donaldson and Tsang 2002; CSIRO 2005) Presence in the US: AZ, CA, DE, MD, TX (Watson 2005; Miller and Gimpel 2009b) Presence elsewhere: Afghanistan, Algeria, Argentina, Armenia, Azerbaijan, Bangladesh, Belgium, Bolivia, Brazil, Bulgaria, China, Cyprus, Czech Republic, Egypt, Ethiopia, France, Georgia, Germany, Greece, Hungary, India, Iran, Iraq, Israel, Italy, Jordan, Kazakhstan, Kenya, Lebanon, Libya, Macedonia, Malta, Mexico, Morocco, Pakistan, Poland, Portugal, Romania, Russia, Saudi Arabia, Serbia, Slovakia Spain, Sri Lanka, Sudan, Syria, Taiwan, Tajikistan, Tunisia, Turkey, Turkmenistan, Ukraine, United Kingdom, Uzbekistan (Watson 2005; Miller and Gimpel 2009b)
Quarantine pest	***Parlatoria pergandii* Comstock, 1881**
Synonyms	*Parlatoria sinensis* Maskell, 1897 *Parlatoria proteus pergandei* Cockerell, 1899 *Syngenaspis pergandei* (Comstock, 1881)
Common name(s)	chaff scale
Main hosts	More than 100 hosts in more than 30 families, including *Citrus*, *Malus*, and *Prunus* spp. For a comprehensive list see Watson (2005) and Miller and Gimpel (2009c)
Distribution	Presence in Australia: NSW, Qld (Donaldson and Tsang 2002; CSIRO 2005) Presence in the US: widespread in the US, including WA. Not recorded in ID and OR (Watson 2005; Miller and Gimpel 2009c) Presence elsewhere: Algeria, Argentina, Armenia, Azerbaijan, Belize, Bermuda, Brazil, Bulgaria, Burma, Cameroon, Canada, Cayman Islands, China, Colombia, Cook Islands, Cuba, Cyprus, Czech Republic, Denmark, Dominica, Dominican Republic, Ecuador, Egypt, El Slavador, Eritrea, France, Georgia, Germany, Greece, Guatemala, Guyana, Honduras, India, Indonesia, Iran, Iraq, Israel, Italy, Jamaica, Japan, Korea, Lebanon, Libya, Malta, Mexico, Micronesia, Montserrat, Morocco, Mozambique, New Zealand, Nicaragua, Nigeria, Niue, Pakistan, Panama, Peru, Philippines, Portugal, Puerto Rico, Russia, Saudi Arabia, Senegal, Serbia, Seychelles, Sierra Leone, Singapore, Slovakia, Somalia, South Africa, Spain, St Kitts and Nevis, St Lucia, St Vincent and the Grenadines, Syria, Switzerland, Taiwan, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, United Kingdom, Western Samoa (Watson 2005; Miller and Gimpel 2009c)
Quarantine pest	***Phenacoccus aceris* (Signoret, 1875)**
Synonyms	*Dactylopius vagabundus* Reh, 1903 *Phenacoccus aesculi* (Signoret, 1875) *Phenacoccus gorgasalicus* Hadzibejli, 1960 *Phenacoccus hederae* (Signoret, 1875) *Phenacoccus mespili* (Signoret, 1875) *Phenacoccus platani* (Signoret, 1875) *Phenacoccus polyphagus* Borchsenius, 1949 *Phenacoccus prunicola* Borchsenius, 1962 *Phenacoccus quercus* (Douglas, 1890) *Phenacoccus socius* (Newstead, 1892) *Phenacoccus ulicis* (Douglas, 1888) *Phenacoccus ulmi* (Douglas, 1888) *Pseudococcus mespili* Signoret, 1875 *Pseudococcus aceris* Signoret, 1875 *Pseudococcus aesculi* Signoret, 1875 *Pseudococcus hederae* Signoret, 1875 *Pseudococcus platani* Signoret, 1875 *Pseudococcus ulicis* Douglas, 1888 *Pseudococcus ulmi* Douglas, 1888 *Pseudococcus quercus* Douglas, 1890 *Pseudococcus socius* Newstead, 1892 *Spinococcus gorgasalicus* (Hadzibejli, 1960)
Common name(s)	apple mealybug, polyphagous tree mealybug
Main hosts	More than 100 hosts in more than 25 families, including *Malus*, *Prunus*, *Pyrus*, *Vitis* spp. For a comprehensive list see Ben-Dov (2009a)

Distribution	Presence in Australia: No record found Presence in the US: CA, ME, OR, VT, WA (CABI 2007; Ben-Dov 2009a; Beers 2007b) Presence elsewhere: Afghanistan, Armenia, Austria, Bulgaria, Canada, China, Czech Republic, Denmark, France, Georgia, Germany, Hungary, Iran, Iraq, Italy, Kazakhstan, Latvia, Moldova, Netherlands, North Korea, Poland, Romania, Russia, South Korea, Sweden, Switzerland, Turkey, Ukraine, United Kingdom (Ben-Dov 2009a)
Quarantine pest	***Pseudococcus calceolariae* (Maskell, 1879)**
Synonyms	*Dactylopius calceolariae* Maskell, 1879 *Dactylopius similans* Lidgett, 1898 *Erium calceolariae* (Maskell, 1879) *Pseudococcus citrophilus* Clausen, 1915 *Pseudococcus fragilis* Brain, 1912 *Pseudococcus gahani* Green, 1915 *Pseudococcus similans* (Lidgett, 1898)
Common name(s)	citrophilus mealybug, currant mealybug, scarlet mealybug
Main hosts	More than 100 hosts in more than 40 families, including *Citrus*, *Malus*, *Prunus*, *Pyrus*, *Vitis* spp. For a comprehensive list see Ben-Dov (2009b)
Distribution	Presence in Australia: Australian Capital Territory, New South Wales, Queensland, South Australia, Tasmania and Victoria (Ben-Dov 2009b), absent from Western Australia (DAWA 2006) Presence in the US: CA, LA (CABI 2007; Ben-Dov 2009b) Presence elsewhere: Brazil, Bulgaria, Chile, China, Colombia, Czech Republic, France, Georgia, Ghana, Indonesia, Italy, Madagascar, Mexico, Morocco, Namibia, Netherlands, New Zealand, Portugal, South Africa, Spain, Ukraine, United Kingdom (CABI 2007; Ben-Dov 2009b)
Quarantine pest	***Pseudococcus comstocki* (Kuwana, 1902)**
Synonyms	*Dactylopius comstocki* Kuwana, 1902
Common name(s)	Comstock's mealybug
Main hosts	More than 60 hosts in more than 40 families, including *Citrus*, *Malus*, *Prunus*, *Pyrus* spp. For a comprehensive list see Ben-Dov (2009c)
Distribution	Presence in Australia: No record found Presence in the US: AL, CA, CT, DC, DE, GA, IL, IN, LA, MA, MD, MI, MO, NH, NJ, NY, OH, PA, SC, TX, VA, WV (CABI 2007; Ben-Dov 2009c) Presence elsewhere: Afghanistan, Argentina, Armenia, Azerbaijan, Brazil, Cambodia, Canada, China, Colombia, France, Georgia, Indonesia, Iran, Italy, Japan, Kazakhstan, Kyrgyzstan, Malaysia, Mexico, Micronesia, Moldova, Portugal, Russia, South Korea, Sri Lanka, Tajikistan, Turkmenistan, Uzbekistan, Vietnam (Ben-Dov 2009c)
Quarantine pest	***Pseudococcus maritimus* (Ehrhorn, 1900)**
Synonyms	*Dactylopius maritimus* Ehrhorn, 1900 *Pseudococcus bakeri* Essig, 1910 *Pseudococcus omniverae* Hollinger, 1917
Common name(s)	grape mealybug, Baker's mealybug, ocean mealybug
Main hosts	More than 80 hosts in more than 40 families, including *Citrus*, *Malus*, *Prunus*, *Pyrus*, *Vitis* spp. For a comprehensive list see Ben-Dov (2009d)
Distribution	Presence in Australia: No record found Presence in the US: AK, CA, CT, DC, DE, FL, GA, IA, IL, IN, MA, MD, MI, MO, NH, NJ, NY, OH, OR, PA, RI, TN, TX, VA, VT, WA, WV (Ben-Dov 2009d) Presence elsewhere: Argentina, Armenia, Bermuda, Brazil, Canada, Chile, Colombia, French Guiana, Guatemala, Hungary, Indonesia, Mexico, Netherlands, Poland, Puerto Rico, Russia (CABI 2007; Ben-Dov 2009d)
Quarantine pest	***Ametastegia glabrata* (Fallén, 1808)**
Synonyms	*Ametastegia fulvipes* Costa, 1882 *Strongylogaster abnormis* Provancher, 1885 *Strongylogastroidea potulenta* MacGillivray, 1923 *Taxonus glabrata* Fallén, 1808 *Taxonus nigrisoma* Norton, 1862 *Tenthredo agilis* Klug, 1817

	Tenthredo rufipes Audinet-Serville, 1823
Common name(s)	dock sawfly
Main hosts	*Chenopodium* spp. (goosefoots), *Polygonum* (knotweed, smartweed), *Rheum* spp. (rhubarb), *Rumex* spp. (dock) *Epilobium* spp. (willowherb), *Fagopyrum* spp. (buckwheat), *Lythrum salicaria* (purple loosestrife), *Plantago* spp. (plantains), *Solanum* spp., *Malus pumila* (apple), *Philadelphus* spp. (mock-orange), *Prunus* spp. (peach, nectarine, apricot, plum, cherry), *Ribes* spp. (currants), *Rubus* spp. (raspberries, blackberries, dewberries), *Salix* spp. (willow), *Vitis* spp. (grape), *Zea mays* (maize) (Carillo *et al.* 1990; Naumann *et al.* 2002; Çalmaşur and Özbek 2004)
Distribution	Presence in Australia: Vic (Malipatil *et al*. 1995) Presence in the US: OR, WA (APHIS 2007a) Presence elsewhere: Canada, Chile, Kazakhstan, Mongolia, Russia, Turkey, Caucasus, Central Asia, Europe, Mediterranean Region, North Africa (Çalmaşur and Özbek 2004; Carter 2004; CABI 2007)
Quarantine pest	***Archips argyrospila* (Walker, 1863)**
Synonyms	*Cacoecia argyrospila* (Walker, 1863) *Cacoecia columbiana* McDunnough, 1923 *Cacoecia vividana* Dyar, 1902 *Retinia argyrospila* Walker, 1863 *Tortrix furvana* Robinson, 1869 *Tortrix v-signatana* Packard, 1875
Common name(s)	fruit-tree leafroller, apple leafroller
Main hosts	*Citrus* spp., *Malus pumila* (apple), *Taxodium distichum* (bald cypress), *Fraxinus* spp. (Kruse and Sperling 2001; CABI 2007)
Distribution	Presence in Australia: No record found Presence in the US: CA, CO, IN, LA, MN, MO, MS, NC, TX, WA, WI, WY (Kruse and Sperling 2001; CABI 2007) Presence elsewhere: Canada (Kruse and Sperling 2001; CABI 2007)
Quarantine pest	***Archips podana* (Scopoli, 1763)**
Synonyms	*Archips meridana* Kozlov & Esartia, 1991 *Cacoecia ameriana* Treitschke, 1830 *Phalaena podana* Scopoli, 1763 *Tortrix congenerana* Hübner, [1823-1824] *Tortrix fulvana* [Denis & Schiffermüller], 1775 *Tortrix pyrastrana* Hübner, [1796-1799] *Tortrix vulpeculana* Fuchs, 1903
Common name(s)	great brown twist moth, large fruit tree tortrix
Main hosts	*Cydonia oblonga* (quince), *Humulus lupulus* (hop), *Malus pumila* (apple), *Prunus avium* (sweet cherry), *Prunus domestica* (plum), *Prunus salicina* (Japanese plum), *Pyrus communis* (European pear), *Ribes nigrum* (blackcurrant), *Rubus fruticosus* (blackberry), *Rubus idaeus* (raspberry) (CABI 2007)
Distribution	Presence in Australia: No record found Presence in the US: WA (LaGasa *et al*. 2003) Presence elsewhere: Albania, Austria, Belgium, Bulgaria, Canada, Czech Republic, Denmark, Finland, France, Georgia, Germany, Hungary, Italy, Kazakhstan, Lithuania, Netherlands, Poland, Romania, Russia, Slovakia, South Korea, Sweden, Switzerland, Ukraine, United Kingdom (CABI 2007)
Quarantine pest	***Archips rosana* (Linnaeus, 1758)**
Synonyms	*Cacoecia hewittana* Busck, 1920 *Cacoecia rosana* var. *orientana* Krulikowsky, 1909 *Cacoecia rosana* var. *splendana* Kennel, 1910 *Lozotaenia nebulana* Stephens, 1834 *Phalaena americana* Gmelin, 1788 *Phalaena (Tortrix) ameriana* Linnaeus, 1758 *Phalaena (Tortrix) avellana* Linnaeus, 1758 *Phalaena (Tortrix) rosana* Linnaeus, 1758 *Pyralis variana* Fabricius, 1787

	Tortrix acerana Hübner, [1796-1799] *Tortrix laevigana* [Denis & Schiffermüller], 1775 *Tortrix oxyacanthana* Hübner, [1796-1799]
Common name(s)	*European leafroller*
Main hosts	*Malus pumila* (apple), *Pyrus communis* (pear), also on *Pinopsida* spp., *Prunus* spp. (peach, nectarine, apricot, plum, cherry), *Ribes* spp. (currants), *Rubus* spp. (CABI 2007)
Distribution	Presence in Australia: No record found Presence in the US: OR, WA (Brunner 1993) Presence elsewhere: Albania, Armenia, Azerbaijan, Belgium, Bulgaria, Canada, Czech Republic, Finland, France, Georgia, Germany, Greece, Hungary, Iran, Iraq, Italy, Kazakhstan, Lithuania, Netherlands, Poland, Russia, Serbia, Slovakia, Spain, Switzerland, Turkey, Ukraine, United Kingdom, Middle East, North Africa (CABI 2007; Ovsyannikova and Grichanov 2008f)
Quarantine pest	***Argyrotaenia franciscana* (Walsingham, 1879)**
Synonyms	*Argyrotaenia citrana* (Fernald, 1889) *Argyrotaenia kearfotti* Obraztsov, 1961 *Argyrotaenia purata* Freeman, 1958 *Cacoecia franciscana* (Walsingham, 1879) *Eulia citrana* (Fernald, 1889) *Eulia franciscana* (Walsingham, 1879) *Tortrix citrana* Fernald, 1889 *Tortrix franciscana* Walsingham, 1879
Common name(s)	orange tortrix, tortrix citrana
Main hosts	*Malus pumila* (apple), *Rubus* spp. (blackberry, raspberry), *Vitis* spp. (grape), also *Citrus* spp., *Persea americana* (avocado), *Pinus radiata*, *Prunus armeniaca* (apricot), *Vaccinium* spp. (blueberries) (CABI 2007; Gilligan and Epstein 2009)
Distribution	Presence in Australia: No record found Presence in the US: AZ, CA, OR, WA (Heppner 2004; CABI 2007) Presence elsewhere: No record found
Quarantine pest	***Argyrotaenia velutinana* (Walker, 1863)**
Synonyms	*Cacoecia triferana* Walker, 1863 *Cacoecia velutinana* Walker, 1863 *Tortrix incertana* Clemens, 1865 *Tortrix lutosana* Clemens, 1865
Common name(s)	red-banded leafroller
Main hosts	*Malus pumila* (apple), *Leucanthemum vulgare* (CABI 2007)
Distribution	Presence in Australia: No record found Presence in the US: MA, MI, MN, NC, NY, PA, VA, WV (CABI 2007) Presence elsewhere: Canada (CABI 2007)
Quarantine pest	***Choristoneura rosaceana* (Harris, 1841)**
Synonyms	*Loxotaenia rosaceana* Harris, 1841 *Lozotaenia gossypiana* Packard, 1869 *Teras vicariana* Walker, 1863
Common name(s)	oblique banded leafroller
Main hosts	*Acer rubrum* (red maple), *Aesculus* spp. (buckeye), *Betula* spp. (birches), *Corylus* spp. (hazelnuts), *Crataegus* spp. (hawthorn), *Fraxinus nigra* (black ash), *Ilex* spp. (holly), *Malus pumila* (apple), *Physocarpus* spp. (ninebark), *Pistacia vera* (pistachio), *Platanus occidentalis* (plane), *Populus* spp. (poplars), *Prunus* spp. (peach, nectarine, apricot, plum, cherry), *Pyrus communis* (European pear), *Quercus* spp. (oaks), *Rosa* spp. (roses), *Rubus* spp. (blackberry, raspberry), *Salix* spp. (willows), *Shepherdia canadensis* (Russet buffaloberry), *Tilia* spp., *Ulmus* spp. (elms) (CABI 2007; Gilligan and Epstein 2009)
Distribution	Presence in Australia: No record found Presence in the US: AK, AZ, CA, CO, FL, GA, IA, LA, MA, ME, MI, MN, MS, ND, NY, OR, PA, TX, UT, VA, WA, WI, WY(CABI 2007) Presence elsewhere: Canada (CABI 2007)

Quarantine pest	***Hedya nubiferana* (Haworth, 1811)**
Synonyms	*Phalaena dimidioalba* Retzius, 1783 *Tortrix nubiferana* Haworth, [1811] *Tortrix variegana* Hübner, [1796-1799]
Common name(s)	green budmoth
Main hosts	*Malus* spp., *Prunus* spp., *Pyrus* spp. (CABI 2007)
Distribution	Presence in Australia: No record found Presence in the US: OH, WA (LaGasa 1996; CABI 2007) Presence elsewhere: Albania, Armenia, Azerbaijan, Belarus, Bulgaria, Canada, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Hungary, Iraq, Iran, Italy, Kazakhstan, Latvia, Lithuania, Moldova, Netherland, Poland, Romania, Russia, Serbia, Slovakia, Turkey, Turkmenistan, Ukraine, United Kingdom (CABI 2007; Ovsyannikova and Grichanov 2008c)
Quarantine pest	***Pandemis heparana* (Denis & Schiffermüller, 1775)**
Synonyms	*Phalaena (Tortrix) cappana* Villers, 1789 *Pyralis fasciana* Fabricius, 1787 *Tortrix carpiniana* Hübner, [1796-1799] *Tortrix heparana* [Denis & Schiffermüller], 1775 *Tortrix padana* Schrank, 1802 *Tortrix pasquayana* [Denis & Schiffermüller], 1775 *Tortrix rubrana* Sodoffsky, 1830 *Tortrix (Lozotaenia) vulpisana* Herrich-Schäffer, 1851
Common name(s)	dark fruit tree tortrix
Main hosts	*Malus* spp., *Prunus* spp., *Pyrus* spp. (CABI 2007)
Distribution	Presence in Australia: No record found Presence in US: WA (LaGasa 2008) Presence elsewhere: Belgium, Bulgaria, Canada, China, France, Germany, Hungary, Italy, Netherlands, Japan, Mongolia, Poland, Romania, Russia, Serbia, Sweden, Switzerland, Ukraine, United Kingdom (CABI 2007; Ovsyannikova and Grichanov 2008b)
Quarantine pest	***Pandemis pyrusana* Kearfott, 1907**
Synonyms	*Pandemis pyrana* Meyrick, 1912
Common name(s)	Pandemis leafroller
Main hosts	*Alnus* sp.*, Betula* sp.*, Ceanothus* sp.*, Cornus* sp.*, Lonicera* sp.*, Malus* spp., *Populus tremuloides*, *Prunus* spp., *Pyrus* spp., *Ribes* sp., *Rosa* sp., *Salix* sp. (CABI 2007; Gilligan and Epstein 2009)
Distribution	Presence in Australia: No record found Presence in the US: CA, CO, ID, OR, UT, WA (CABI 2007; Gilligan and Epstein 2009) Presence elsewhere: Canada (Gilligan and Epstein 2009)
Quarantine pest	***Platynota flavedana* Clemens, 1860**
Synonyms	*Platynota iridana* Barnes & Busck, 1920 *Teras concursana* Walker, 1863 *Teras laterana* Robinson, 1869 *Teras tinctana* Walker, 1863
Common name(s)	variegated leafroller, rusty brown tortricid
Main hosts	*Acer* spp. (maple), *Begonia* spp., *Euphorbia pulcherrima* (poinsettia), *Fragaria* spp. (strawberry), *Gossypium* spp. (cotton), *Helianthus* spp., *Juglans nigra* (black walnut), *Malus pumila* (apple), *Prunus persica* (peach), *Trifolium* spp. (clovers), *Rhododendron* spp., *Rosa* spp. (roses), *Sassafras albidum* (sassafras) (Howitt 1998; Baker *et al*. 2009)
Distribution	Presence in Australia: No record found Presence in the US: widespread in the eastern US, not present in ID, OR, WA (CABI 2007) Presence elsewhere: Jamaica (CABI 2007)
Quarantine pest	***Platynota idaeusalis* (Walker, 1859)**
Synonyms	*Hypena idaeusalis* Walker, 1859 *Phylacteritis dioptrica* Meyrick, 1922

	Platynota sentana Clemens, 1860
Common name(s)	tufted apple budworm
Main hosts	*Malus* spp., *Prunus* spp., *Pyrus* spp. (CABI 2007)
Distribution	Presence in Australia: No record found Presence in the US: DE, GA, MI, NC, NJ, PA, VA, WV (CABI 2007) Presence elsewhere: Canada (CABI 2007)
Quarantine pest	***Platynota stultana*** **Walshingham, 1884**
Synonyms	*Platynota chiquitana* Barnes & Busck, 1920
Common name(s)	carnation moth, cotton leaf roller, leaf tier, omnivorous leaf roller, orange calyx worm, orange platynota, orange web worm, rose leaf roller
Main hosts	*Capsicum annuum*, *Citrus* spp., *Gossypium* spp. (cotton), *Medicago sativa* (lucerne), *Prunus persica* (peach), *Punica granatum* (pomegranate), *Pyrus* spp. (pears), *Vitis vinifera* (grapevine), *Zea mays* (maize). Also on more then 30 other species, including *Malus* spp. (CABI 2007)
Distribution	Presence in Australia: No record found Presence in the US: AR, AZ, CA, FL, HI, IL, MA, MD, MI, PA, TX, VA (CABI 2007) Presence elsewhere: Mexico (CABI 2007)
Quarantine pest	***Pseudexentera mali*** **Freeman, 1942**
Synonyms	
Common name(s)	pale apple leafroller
Main hosts	*Malus* spp. (Miller 1986)
Distribution	Presence in Australia: No record found Presence in the US: MI, MO, NY, WI (Miller 1986) Presence elsewhere: Canada (Miller 1986)
Quarantine pest	***Spilonota ocellana*** **(Denis & Schiffermüller, 1775)**
Synonyms	*Hedya pyrifoliana* Clemens, 1860 *Penthina occulana* Harris, 1862 *Pyralis luscana* Fabricius, 1794 *Tmetocera zellerana* Borgmann, 1895 *Tortrix comitana* Hübner, [1796-1799] *Tortrix ocellana* [Denis & Schiffermüller], 1775
Common name(s)	eyespotted bud moth
Main hosts	*Malus* spp., *Pyrus* spp., also on many other species including *Alnus*, *Cydonia*, *Crataegus*, *Prunus*, *Quercus*, *Rosa*, *Rubus*, *Salix*, and *Vaccinium* spp. (Meijerman and Ulenberg 2000; CABI 2007)
Distribution	Presence in Australia: No record found Presence in the US: CT, ID, MA, MD, MI, MT, NH, NJ, NY, OH, OR, PA, WA, WI (CABI 2007) Presence elsewhere: Albania, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bulgaria, Canada, China, Denmark, Estonia, Finland, France, Georgia, Germany, Hungary, Iran, Ireland, Italy, Japan, Kazakhstan, Korea, Latvia, Lithuania, Moldova, Netherlands, Norway, Pakistan, Poland, Portugal, Romania, Russia, Serbia, Spain, Sweden, Switzerland, Tajikistan, Turkey, Turkmenistan, Ukraine, United Kingdom, Uzbekistan (CABI 2007; Ovsyannikova and Grichanov 2008g)
Quarantine pest	***Argyresthia conjugella*** **Zeller, 1839**
Synonyms	
Common name(s)	apple fruit moth
Main hosts	*Malus pumila* (apple), *Sorbus aucuparia* (rowan) (CABI 2007)
Distribution	Presence in Australia: No record found Presence in the US: WA (LaGasa 2008) Presence elsewhere: Canada, Finland, former USSR, Germany, Hungary, India, Japan, Lithuania, Netherlands, Norway, Sweden, Turkey (Krämer 1960; CABI 2007; Ovsyannikova and Grichanov 2008e)
Quarantine pest	***Cydia pomonella*** **(Linnaeus, 1758)**
Synonyms	*Carpocapsa pomonana* ([Denis & Schiffermüller], 1775)

	Carpocapsa pomonella (Linnaeus, 1758) *Enarmonia pomonella* (Linnaeus, 1758) *Laspeyresia pomonella* (Linnaeus, 1758) *Phalaena (Tortrix) pomonella* Linnaeus, 1758 *Pyralis pomana* Fabricius, 1775 *Tortrix pomonana* [Denis & Schiffermüller], 1775
Common name(s)	codling moth
Main hosts	*Cydonia oblonga*, *Juglans* spp., Malus spp., *Prunus* spp., *Pyrus* spp., *Zea mays* (CABI 2007)
Distribution	Presence in Australia: NSW, Qld, SA, Tas, Vic (CABI 2007), but not in WA (DAWA 2006) Presence in the US: widespread in the US (CABI 2007) Presence elsewhere: Afghanistan, Albania, Algeria, Argentina, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bolivia, Brazil, Bulgaria, Canada, Chile, China, Colombia, Cyprus, Czech Republic, Denmark, Egypt, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, India, Iran, Iraq, Ireland, Israel, Italy, Jordan, Kazakhstan, Kyrgyzstan, Latvia, Lebanon, Libya, Lithuania, Malta, Mauritius, Mexico, Moldova, Montenegro, Morocco, Netherlands, New Zealand, Norway, Pakistan, Peru, Poland, Portugal, Romania, Russia, Serbia, Slovakia, South Africa, Spain, Sweden, Switzerland, Syria, Tajikistan, Tunisia, Turkey, Turkmenistan, Ukraine, United Kingdom, Uruguay, Uzbekistan (CABI 2007)
Quarantine pest	***Grapholita molesta* (Busck, 1916)**
Synonyms	*Cydia molesta* (Busck, 1916) *Laspeyresia molesta* Busck, 1916 *Carpocapsa molesta* (Busck, 1916)
Common name(s)	Oriental fruit moth
Main hosts	*Cotoneaster* spp. (cotoneaster), *Crataegus* spp. (hawthorne), *Cydonia vulgaris* (quince), *Eriobotrya japonica* (loquat), *Malus* spp., *Mespilus germanica* (common medlar), *Photinia* spp., *Prunus* spp., *Pyrus* spp., *Rosa* spp. (roses) (Rothschild and Vickers 1991)
Distribution	Presence in Australia: ACT, NSW, Qld, SA, Tas, Vic (CSIRO 2005; APPD 2009), no report from NT and WA (CSIRO 2005) Presence in the US: AR, CA, GA, MI, MO, NC, NY, OH, PA, VA, WA (CABI 2007) Presence elsewhere: Argentina, Armenia, Austria, Azerbaijan, Brazil, Bulgaria, Canada, Chile, China, Croatia, Czech Republic, France, Georgia, Germany, Greece, Hungary, Italy, Japan, Kazakhstan, Korea, Latvia, Lithuania, Malta, Mauritius, Mexico, Moldova, Montenegro, Morocco, New Zealand, Portugal, Romania, Russian Federation, Serbia, Slovakia, South Africa, Spain, Switzerland, Taiwan, Turkey, Ukraine, United Kingdom, Uruguay, Uzbekistan (CABI 2007)
Quarantine pest	***Grapholita packardi* Zeller, 1875**
Synonyms	*Cydia packardi* (Zeller, 1875) *Enarmonia packardi* (Zeller, 1875) *Enarmonia pyricolana* (Murtfeldt, 1891) *Laspeyresia packardi* (Zeller, 1875) *Laspeyresia pyricolana* (Murtfeldt, 1891) *Steganoptycha pyricolana* Murtfeldt, 1891
Common name(s)	cherry fruitworm
Main hosts	*Crataegus* spp. (hawthorn), *Cydonia oblonga* (quince), *Malus pumila* (apple), *Prunus* spp., *Pyracantha* spp. (firethorn), *Pyrus communis* (European pear), *Rosa* spp. (roses), *Vaccinium* spp. (blueberry) (CABI 2007)
Distribution	Presence in Australia: No record found Presence in the US: AR, CA, CO, DE, FL, IA, IL, MA, MD, MI, MO, MS, NC, NH, NJ, NY, OR, TX, VA, WA, WV, WI (Chapman and Lienk 1971; Barcenas *et al*. 2005) Presence elsewhere: Canada, Mexico (Chapman and Lienk 1971)
Quarantine pest	***Grapholita prunivora* (Walsh, 1868)**
Synonyms	*Cydia prunivora* (Walsh, 1868) *Enarmonia prunivora* (Walsh, 1868) *Laspeyresia prunivora* (Walsh, 1868) *Semasia prunivora* Walsh, 1868
Common name(s)	Lesser apple fruitworm
Main hosts	*Amelanchier* (serviceberries), *Malus pumila* (apple), *Photinia* spp., *Prunus* spp., *Pyrus domestica*

	(pears), *Rosa* spp. (roses), *Crataegus* spp. (hawthorn), *Quercus* spp. (oaks), *Ulmus* spp. (elms) (Weires and Riedl 1991; Mantey *et al.* 2000)
Distribution	Presence in Australia: No record found Presence in the US: AR, CA, CO, GA, IA, ID, IL, IN, MA, MD, ME, MI, MO, NY, OH, OR, PA, VA, WA, WV, WI (APHIS 2007a; CABI 2007) Presence elsewhere: Canada (CABI 2007)
Quarantine pest	***Lacanobia subjuncta* (Grote & Robinson, 1868)**
Synonyms	*Hadena subjuncta* Grote & Robinson, 1868
Common name(s)	Lacanobia fruitworm
Main hosts	*Malus pumila*, *Prunus* spp., *Pyrus* spp., also *Amaranthus retroflexus* (redroot pigweed), *Cardaria draba* (hoary cress), *Chenopodium berlandieri* (lambsquarter), *Cirsium arvense* (Canada thistle), *Convolvulus arvensis* (field bindweed), *Kochia scoparia* (kochia), *Malva neglecta* (common mallow), *Medicago* spp., *Sonchus* spp., *Taraxacum officinale* (dandelion), *Pisum sativum* (peas), *Solanum tuberosum* (potato) (Landolt 1998; Landolt 2002)
Distribution	Presence in Australia: No record found Presence in the US: AZ, CA, CO, ID, IN, MA, ME, MN, MT, ND, NH, NJ, NM, NY, OH, OR, PA, UT, VA, VT, WA, WY (McCabe 1980; Landolt 1998) Presence elsewhere: Canada (McCabe 1980)
Quarantine pest	***Ostrinia nubilalis* (Hübner, 1796)**
Synonyms	*Botys nubilalis* (Hübner, 1796) *Botys silacealis* Hübner, 1796 *Micractis nubilalis* (Hübner, 1796) *Pyralis nubilalis* Hübner, 1796 *Pyrausta nubilalis* (Hübner, 1796)
Common name(s)	European corn borer
Main hosts	Primary hosts: *Avena sativa* (oats), *Echinochloa crus-galli* (barngrass), *Hordeum vulgare* (barley), *Pennisetum glaucum* (pearl millet), *Setaria italica* (foxtail millet), *Sorghum* sp., *Sorghum halepense* (aleppo grass), *Zea mays* (maize) (Graham 2007) Secondary hosts: *Amaranthus* spp.(amaranth), *Arctium minus* (common burdock), *Artemisia vulgaris* (carline thistle), *Capsicum* spp. (peppers), *Chrysanthemum* spp. (daisy), *Cynara scolymus* (artichoke), *Datura stramonium* (thorn apple), *Glycine max* (soybean), *Gossypium* sp. (cotton), *Helianthus annuus* (sunflower), *Humulus lupulus* (hop), *Lycopersicon esculentum* (tomato), *Malus pumila* (apple), *Phaseolus vulgaris* (common bean), *Prunus persica* (peach), *Solanum tuberosum* (potato), *Triticum aestivum* (wheat) (Straub *et al.* 1986; Graham 2007)
Distribution	Presence in Australia: No record found Presence in the US: widespread in the US, no records from ID, OR, WA (CABI 2007) Presence elsewhere: Algeria, Austria, Belgium, Bulgaria, Canada, Cyprus, Czech Republic, Denmark, Egypt, France, Georgia, Germany, Greece, Hungary (restricted), Iran, Ireland, Israel, Italy, Lebanon, Libya, Moldova, Montenegro, Morocco, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Spain, Sweden, Switzerland, Syria, Tunisia, Turkey, Ukraine, United Kingdom (CABI 2007)
Quarantine pest	***Frankliniella occidentalis* (Pergande, 1895)**
Synonyms	*Euthrips helianthi* Moulton, 1911 *Euthrips occidentalis* Pergande, 1895 *Euthrips tritici* var. *californicus* Moulton, 1911 *Frankliniella canadensis* Morgan, 1925 *Frankliniella chrysanthemi* Kurosawa, 1941 *Frankliniella claripennis* Morgan, 1925 *Frankliniella conspicua* Moulton, 1936 *Frankliniella dahliae* Moulton, 1948 *Frankliniella dianthi* Moulton, 1948 *Frankliniella nubila* Treherne, 1924 *Frankliniella syringae* Moulton, 1948 *Frankliniella trehernei* Morgan, 1925 *Frankliniella tritici maculata* Priesner, 1925 *Frankliniella tritici moultoni* Hood, 1914 *Frankliniella umbrosa* Moulton, 1948

	Frankliniella venusta Moulton, 1936
Common name(s)	Western flower thrips
Main hosts	*Frankliniella occidentalis* is highly polyphagous and has been reported from 250 plant species form more than 65 families, including*: Allium cepa* (onion), *Capsicum annuum* (bell pepper), *Chrysanthemum* spp., *Daucus carota* (carrot), *Gossypium* spp. (cotton), *Malus pumila* (apple), Prunus *persica* (peach), *Salvia* spp. (sage), *Trifolium* (clovers) (CABI 2007). For a comprehensive list see CABI (2007)
Distribution	Presence in Australia: NSW, Qld, SA, Vic, WA, absent from NT (Williams and Pullman 2000; CSIRO 2005) and Tas (CSIRO 2005) Presence in the US: widespread in the US (CABI 2007) Presence elsewhere: Albania, Algeria, Argentina, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Estonia, Finland, France, French Guiana, Germany, Greece, Guatemala, Guyana, Hungary, India, Ireland, Israel, Italy, Japan, Kenya, Korea, Kuwait, Latvia, Lithuania, Macedonia, Malaysia, Malta, Mexico, Montenegro, Morocco, Netherlands, New Zealand, Nigeria, Norway, Poland, Portugal, Puerto Rico, Réunion, Martinique, Romania, Russian Federation, Serbia, Singapore Peru, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Swaziland, Sweden, Switzerland, Thailand, Tunisia, Turkey, United Kingdom, Uruguay, Venezuela, Zimbabwe (CABI 2007)
Quarantine pest	***Frankliniella tritici* (Fitch, 1855)**
Synonyms	*Frankliniella clara* Moulton, 1948 *Frankliniella fulvus* Moulton, 1936 *Frankliniella salicis* Moulton, 1948 *Frankliniella varicorne* Bagnall, 1919 *Thrips tritici* Fitch, 1855
Common name(s)	Eastern flower thrips
Main hosts	*Fragaria* spp. (strawberry), *Rosa* spp. (roses), *Malus* pum*i*la (apple) (CABI 2007; Frantz and Fasulo 2008)
Distribution	Presence in Australia: No record found Presence in the US: widespread in the US (CABI 2007) Presence elsewhere: Canada, Czech Republic, Georgia, Hungary, Kazakhstan, Poland, Puerto Rico, Romania, Russia, Slovakia, Spain, Ukraine (CABI 2007)
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Quarantine pest	***Coprinopsis psychromorbida* (Redhead & Traquair) Redhead, Vilgalys & Moncalvo**
Synonyms	*Coprinus psychromorbidus* Redhead & Traquair
Common name(s)	Coprinus rot
Main hosts	Multiple genera in multiple families including: *Calamagrostis canadensis* (bluejoint grass), *Malus pumila* (apple), *Medicago sativa* (alfalfa), *Poa pratensis* (Kentucky bluegrass), *Pyrus communis* (pear), *Secale cereale* (rye), *Trifolium* spp. (clover), *Triticum aestivum* (winter wheat) and various other grasses (Broadfoot and Cormack 1941; Cormack 1948; Smith 1981; Gaudet and Sholberg 1990; Farr and Rossman 2009)
Distribution	Presence in Australia: No record found Presence in the US: AK, ID, OR, WA (Willett *et al.* 1989; Farr and Rossman 2009) Presence elsewhere: Canada (Traquair 1980, 1987; Farr and Rossman 2009)
Quarantine pest	**Fungi associated with sooty blotch and flyspeck complex (SBFS):** ***Colletogloeum* spp. (FG2.1, FG2.2, FG2.3)** ***Geastrumia polystigmatis* Bat. & M.L. Farr** ***Mycelia sterilia* spp. (RS1, RS2)** ***Passalora* sp. FG3** ***Peltaster fructicola* Eric M. Johnson, T.B. Sutton & Hodges** ***Peltaster* spp. (P2.1, P2.2, CS1)** ***Pseudocercospora* spp. (FS4, FG1.1, FG1.2)** ***Pseudocercosporella* spp. (RH1, RH2.1, RH2.2)** ***Ramularia* sp. P5** ***Dissoconium* spp. (DS1.1, DS1.2, DS2, FG4, FG5)** ***Xenostigmina* spp. (P3, P4)** ***Zygophiala cryptogama* Batzer & Crous**

	***Zygophiala tardicrescens* Batzer & Crous** ***Zygophiala wisconsinensis* Batzer & Crous**
Synonyms	
Common name(s)	Sooty blotch and flyspeck complex
Main hosts	Fungi associated with sooty blotch and flyspeck complex grow on a wide range of plants, including *Malus* spp. (apple) (Farr and Rossman 2009). In particular, the following hosts are associated with: *Geastrumia polystigmatis*: *Andira jamaicensis* (cabbage bark tree), *Costus afer* (spiral ginger), *Hymenocardia acida*, *Malus pumila* (apple), *Qualea grandiflora*, *Rubus argutus* (sawtooth blackberry) (Farr and Rossman 2009) *Peltaster fructicola*: *Asimina triloba* (North American pawpaw), *Malus pumila* (apple) (Farr and Rossman 2009) *Zygophiala cryptogama*: *Malus pumila* (apple) , *Prunus americana* (American plum) (Batzer *et al.* 2008; Farr and Rossman 2009) *Zygophiala tardicrescens*: *Malus pumila* (apple) (Batzer *et al*. 2008) *Zygophiala wisconsinensis*: *Malus pumila* (apple), *Prunus americana* (American plum) (Batzer *et al*. 2008; Farr and Rossman 2009)
Distribution	Presence in Australia: no record found Presence in the US: widespread in the eastern US (Sutton 1990b; Rosenberger *et al.* 1996). No records from ID, OR, WA Presence elsewhere: The sooty blotch and flyspeck complex is present with a varying species ensemble in various countries, such as China (Zhang 2006; Zhang 2007). *Geastrumia polystigmatis* is also reported from Brazil, Dominican Republic, Tanzania (Farr and Rossman 2009)
Quarantine pest	***Phyllosticta arbutifolia* Ellis & G. Martin**
Synonyms	*Phyllosticta solitaria* Ellis & Everh. *Phyllostictina solitaria* (Ellis & Everh.) Shear
Common name(s)	apple blotch, leaf spot, twig canker
Main hosts	*Aronia* spp. (chokeberry), *Crataegus* spp. (hawthorn), *Malus* spp. (apple), *Pyrus* spp. (pear) (Zherikhin and Gratshev 1995; Farr and Rossman 2009)
Distribution	Presence in Australia: No record found Presence in the US: AL, FL, IA, IL, IN, KS, LA, MD, MS, NC, NE, NJ, OH, OK, TX, WA, WI, WV (CABI 2007; Farr and Rossman 2009) Presence elsewhere: Brazil, Canada, China, Denmark, Greece, India, Japan, South Africa, Zimbabwe (Farr and Rossman 2009)
Quarantine pest	***Sphaeropsis pyriputrescens* C.L. Xiao & J.D. Rogers**
Synonyms	
Common name(s)	Sphaeropsis rot
Main hosts	*Malus* spp. (apple, crabapple), *Pyrus* spp. (pear) (Xiao and Rogers 2004; Xiao and Boal 2005a; Kim and Xiao 2006; Kim and Xiao 2008)
Distribution	Presence in Australia: No record found Presence in the US: WA (Xiao *et al.* 2004; Xiao and Boal 2005a; Kim and Xiao 2006; Kim and Xiao 2008) Presence elsewhere: Canada (Stokes *et al.* 2007)
Quarantine pest	***Podosphaera clandestina* (Wallr.) Lév.**
Synonyms	*Alphitomorpha clandestina* Wallr. *Erysiphe clandestina* (Wallr.) Fr. *Erysiphe oxyacanthae* DC. *Podosphaera oxyacanthae* (DC.) de Bary *Podosphaera minor* Howe
Common name(s)	Hawthorn powdery mildew
Main hosts	Wide range of hosts including: *Alnus* sp. (alders), *Amelanchier* spp.(serviceberries), *Aronia melanocarpa* (chokeberry), *Chaenomeles speciosa* (flowering quince), *Crategomespilus* spp., *Crataegus* spp. (hawthorns), *Cydonia* spp. (quince), *Diospyros* spp. (persimmon), *Holodiscus* sp., *Malus* sp. (apple), *Malus sylvestris* (crabapple), *Mespilus germanica* (common medlar), *Padus asiatica*, *Prunus* spp., *Pyracantha* sp. (firethorn), *Pyrus* spp. (pears), *Sorbus* spp. (mountain ash), *Spiraea* spp. (meadowsweet), *Symphoricarpos albus* (snowberry), *Vaccinium uliginosum* (blueberry) (Farr and Rossman 2009)

Distribution	Presence in Australia: NSW, Tas, Vic (on *Crataegus* only, APPD 2009) Presence in the US: AK, CA, FL, GA, IA, ID, IL, MD, MS, MT, NC, ND, NE, NJ, NM, NY, OK, OR, PA, SD, TX, VT, WA, WI, WY(Farr and Rossman 2009) Presence elsewhere: Armenia, Austria, Belarus, Bolivia, Bulgaria, Canada, China, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, India, Ireland, Italy, Japan, Korea, Libya, Mauritius, Mexico, Montenegro, New Zealand, Norway, Poland, Romania, Russia, Scotland, Slovakia, Sweden, Switzerland, Ukraine, United Kingdom, Uzbekistan (Farr and Rossman 2009)
Quarantine pest	***Cryptosporiopsis curvispora* (Peck) Gremmen**
Synonyms	*Neofabraea malicorticis* H.S. Jacks. (teleomorph) *Cryptosporiopsis malicorticis* (Cordley) Nannf. *Gloeosporium malicorticis* Cordley *Macrophoma curvispora* Peck *Pezicula malicorticis* (H.S. Jacks.) Nannf. (teleomorph)
Common name(s)	bull'e eye rot, anthracnose
Main hosts	*Amelanchier pallida*, *Chaenomeles* sp., *Crataegus* spp., *Cydonia oblonga*, *Malus* spp., *Prunus* spp., *Pyrus* spp., *Rosa* spp. and *Sorbus* spp. (Kienholz 1939; de Jong *et al.* 2001)
Distribution	Presence in Australia: no record found. Some specimens formerly labelled *Pezicula malicorticis* have been found to be *Neofabraea alba*, an undescribed *Neofabraea* species found by de Jong *et al*. (2001), or a *Pyricularia aquatica*-like fungus (Cunnington 2004). Some specimens formerly labelled *Cryptosporiopsis malicorticis* have been found to be *Cryptosporiopsis perennans* (Cunnington 2004). Presence in the US: CA, ID, IL, MA, ME, MI, MT, NE, OK, OR, WA (Grove 1990a; Farr and Rossman 2009) Presence elsewhere: Canada, China, Denmark, Estonia, Finland, France, Germany, Ireland, Japan, Lithuania, Netherlands, New Zealand, Norway, Poland, Portugal, Russia, Sweden, United Kingdom, Zimbabwe (Grove 1990a, de Jong *et al.* 2001; Farr and Rossman 2009)
Quarantine pest	***Cryptosporiopsis perennans* (Zeller & Childs) Wollenw.**
Synonyms	*Neofabraea perennans* Kienholz (teleomorph) *Gloeosporium perennans* Zeller & Childs *Pezicula perennans* (Kienholz) Dugan, R.G. Roberts & G.G. Grove (teleomorph)
Common name(s)	bull's eye rot, perennial canker
Main hosts	*Amelanchier pallida*, *Chaenomeles* sp., *Crataegus* spp., *Cydonia oblonga*, *Malus* spp., *Prunus* spp., *Pyrus* spp. and *Sorbus* spp. (Kienholz 1939)
Distribution	Presence in Australia: Vic (Cunnington 2004) Presence in the US: CA, ID, ME, MS, MT, OR, WA (Grove 1990a; Farr and Rossman 2009) Presence elsewhere: Canada, Germany, Netherlands, United Kingdom (Grove 1990a; de Jong *et al.* 2001)
Quarantine pest	***Phacidiopycnis piri* (Fuckel) Weindlm.**
Synonyms	*Potebniamyces pyri* (Berk. & Broome) Dennis (teleomorph) *Phacidiella discolor* (Mout. & Sacc.) Potebnia
Common name(s)	Phacidiopycnis rot
Main hosts	*Malus* spp. (apple), *Pyrus* spp. (pear), *Cydonia vulgaris* (quince) (DiCosmo *et al.* 1984; Farr and Rossman 2009)
Distribution	Presence in Australia: No record found Presence in the US: OR, WA (Xiao and Boal 2005b; Farr and Rossman 2009) Presence elsewhere: Austria, Canada (British Columbia), Germany, India, United Kingdom (DiCosmo *et al.* 1984; Xiao and Boal 2005b; Farr and Rossman 2009)
Quarantine pest	***Phacidiopycnis washingtonensis* C.L. Xiao & J.D. Rogers**
Synonyms	
Common name(s)	Speck rot
Main hosts	*Malus* spp. (apple, crabapple), *Pyrus communis* (pear) (Xiao and Rogers 2004; Xiao and Boal 2005a; Kim and Xiao 2006; Kim and Xiao 2008)
Distribution	Presence in Australia: No record found Presence in the US: WA (Xiao *et al.* 2004; Xiao and Boal 2005a; Kim and Xiao 2006; Kim and Xiao 2008)

	Presence elsewhere: No record found
Quarantine pest	***Neonectria ditissima* (Tul. & C. Tul.) Samuels & Rossman**
Synonyms	*Cylindrocarpon heteronema* (Berk. & Broome) Wollenw. (Anamorph) *Cylindrocarpon mali* (Allesch.) Wollenw. *Cylindrocarpon willkommii* (Lindau) Wollenw. *Fusarium heteronemum* Berk. & Broome *Fusarium mali* Allesch. *Fusarium willkommii* J. Lindau *Nectria galligena* Bres. *Nectria magnoliae* M.L. Lohman & Hepting *Neonectria galligena* (Bres.) Rossman & Samuels
Common name(s)	European canker
Main hosts	*Acer* spp. (maples), *Aesculus* sp. (horse-chestnut), *Alnus incana* (grey alder), *Betula* spp. (birches), *Carpinus betulus* (common hornbeam), *Carya* spp. (hickories), *Cornus nuttallii* (Pacific dogwood), *Corylus avellana* (hazel), *Fagus* spp. (beeches), *Frangula alnus* (alder buckthorn), *Fraxinus* spp. (ashes), *Juglans* spp. (walnuts), *Liriodendron tulipifera* (yellow poplar), *Malus pumila* (apple), *Nyssa sylvatica* (blackgum), *Populus* spp. (poplars), *Prunus serotina* (black cherry tree), *Pyrus* spp. (pears), *Quercus* spp. (oaks), *Rosa* spp. (rose), *Rhus typhina* (staghorn sumac), *Salix* spp. (willows), *Sorbus aucuparia* (rowan), *Tilia americana* (American basswood), *Ulmus* spp. (elms) (CABI 2007)
Distribution	Presence in Australia: The disease has been eradicated from Tasmania (Ransom 1997). No record found from any other states. Presence in the US: CA, CT, FL, IL, IN, MA, MD, ME, MI, MN, MS, NC, ND, NH, NJ, NY, OR, PA, RI, SD, TN, VA, VT, WA, WV (CABI 2007, Farr and Rossman 2009) Presence elsewhere: Afghanistan, Argentina, Austria, Belgium, Bulgaria, Canada, Chile, China, Czech Republic, Denmark, Estonia, Faeroe Islands, France, Germany, Greece, Hungary, Iceland, India, Indonesia, Iran, Iraq, Ireland, Italy, Japan, South Korea, Lithuania, Lebanon, Macedonia, Madagascar, Malaysia, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, Saudi Arabia, Slovakia, South Africa, Spain, Sweden, Switzerland, Syria, Taiwan, Ukraine, United Kingdom, Uruguay (CABI 2007, Farr and Rossman 2009)
Quarantine pest	***Mucor mucedo* Fresen.**
Synonyms	
Common name(s)	Mucor rot
Main hosts	Multiple genera in multiple families including: *Fragaria* spp., (strawberries), *Malus pumila* (apple), *Pyrus communis* (pear), *Rubus* spp. (blackberry, raspberry), *Lycopersicon esculentum* (tomato) (Dennis and Mountford 1975; Moline and Kuti 1984; Spotts 1990b; Farr and Rossman 2009)
Distribution	Presence in Australia: No records found Presence in the US: IA, WA (Farr and Rossman 2009) Presence elsewhere: Chile, China, Cuba, Dominican Republic, Germany, India, Libya (Farr and Rossman 2009)
Quarantine pest	***Mucor piriformis* A. Fisch.**
Synonyms	*Mucor wosnessenskii* Schostak. *Mucor alboater* Naumov *Hydrophora fischeri* Sumst.
Common name(s)	Mucor rot
Main hosts	*Fragaria* spp. (strawberry), *Malus pumila* (apple), *Prunus* spp. (peach, nectarine, apricot, plum, cherry), *Pyrus communis* (pear), *Ribes uva-crispa* (gooseberry) (Kirk 1997)
Distribution	Presence in Australia: Qld, Vic (APPD 2009) Presence in the US: AL, CA, MD, OR, PA, WA (Michailides and Spotts 1990a; Kirk 1997) Presence elsewhere: Austria, Canada, Chile, France, Germany, Italy, Mexico, Romania, Russia, United Kingdom (Kirk 1997)
Quarantine pest	***Mucor racemosus* Fresen.**
Synonyms	*Mucor dimorphosporus* Lendn. *Mucor oudemansii* Váňová *Mucor paronychius* Suth.-Campb. & Plunkett
Common name(s)	Mucor rot

Main hosts	Stored fruit and vegetables (Lunn 1977)
Distribution	Presence in Australia: ACT, NSW, Vic (APPD 2009) Presence in the US: CA, FL, GA, IA, WA (Farr and Rossman 2009) Presence elsewhere: world-wide (Lunn 1977)
Quarantine pest	***Helminthosporium papulosum*** **Anth. Berg**
Synonyms	
Common name(s)	Black pox
Main hosts	*Malus* spp. (apple), *Pyrus* spp. (pear) (Farr and Rossman 2009)
Distribution	Presence in Australia: No record found Presence in the US: GA, IN, KY, MA, MS, NC, NJ, OH, OR, PA, WV (Farr and Rossman 2009) Presence elsewhere: No record found
Quarantine pest	***Venturia inaequalis*** **(Cooke) G. Winter**
Synonyms	*Didymosphaeria inaequalis* (Cooke) Niessl *Endostigme cinerascens* (Aderh.) Jorst. *Endostigme inaequalis* (Cooke) Syd. *Fusicladium dendriticum* (Wallr.) Fuckel (anamorph) *Fusicladium pomi* (Fr. : Fr.) Lind (anamorph) *Passalora dendritica* (Wallr.) Sacc. (anamorph) *Phaeosphaerella berolinensis* Kirschst. *Sphaerella inaequalis* Cooke *Spilocaea pomi* Fr. : Fr. (anamorph) *Spilosticta cinerascens* (Aderh.) Petr. *Spilosticta inaequalis* (Cooke) Petr. *Venturia chlorospora* f. *mali* Aderh.
Common name(s)	apple scab
Main hosts	Various *Rosaceae* including *Amelanchier* spp. (serviceberry), *Aronia* spp. (Chokeberry), *Cotoneaster* spp. (cotoneaster), *Crataegus oxyacantha* (Midland hawthorn), *Docynia* spp. (docynia), *Eriobotrya* spp. (loquat), *Heteromeles* spp., *Kageneckia* spp. (olivillos, iloque), *Malus* spp. (apple), *Prunus* spp. (peach, nectarine, apricot, plum, cherry), *Pyracantha* spp. (firethorn), *Pyrus* spp. (pear), *Sorbus* spp. (mountain ash), *Viburnum* spp. (viburnum) (CABI 2007; Farr and Rossman 2009)
Distribution	Presence in Australia: Reported in all states. Since the first outbreak of apple scab in Western Australia in 1930 (Pittman 1930), there have been five more outbreaks of scab between 1930 and 1996 (MacHardy 1996). Apple scab was eradicated in Western Australia in 1997 and Western Australia was declared free of scab (McKirdy *et al*. 2001). In Western Australia, this pathogen is under official control. Presence in the US: AK, AL, CA, CT, DE, FL, GA, IA, ID, IL, KS, MA, MI, MN, MO, MS, MT, NC, ND, NE, NH, NY, OH, OK, OR, RI, SD, TN, TX, VA, WA, WI (Farr and Rossman 2009) Presence elsewhere: Afghanistan, Argentina, Armenia, Austria, Azerbaijan, Belgium, Bhutan, Bolivia, Brazil, Bulgaria, Canada, Chile, China, Colombia, Cyprus, Czech Republic, Denmark, Egypt, Estonia, Ethiopia, Faeroe, Finland, France, Georgia, Germany, Ghana, Greece, Guatemala, Hungary, India, Iran, Iraq, Ireland, Israel, Italy, Japan, Jordan, Kazakhstan, Kenya, North Korea, South Korea, Latvia, Lebanon, Libya, Madagascar, Malta, Mexico, Morocco, Mozambique, Nepal, Netherlands, New Zealand, Norway, Pakistan, Panama, Peru, Poland, Portugal, Romania, Russia, Saudi Arabia, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Syria, Taiwan, Turkey, Turkmenistan, Ukraine, United Kingdom, Uruguay, Uzbekistan, Yugoslavia, Zimbabwe (CABI 2007; Farr and Rossman 2009)
Quarantine pest	***Ceratobasidium ochroleucum*** **(F. Noack) Ginns & M.N.L. Lefebvre**
Synonyms	*Botryobasidium koleroga* (Cooke) Venkatar *Ceratobasidium noxium* (Donk) P. Roberts *Ceratobasidium stevensii* (Burt) Venkatar *Corticium koleroga* (Cooke) Höhn. *Corticium ochroleucum* (F. Noack) Burt *Corticium stevensii* Burt *Hypochnopsis ochroleucus* (F. Noack) F. Noack *Hypochnus ochroleucus* F. Noack *Koleroga noxia* Donk *Pellicularia koleroga* Cooke

Common name(s)	Thread blight
Main hosts	Wide range of hosts including: *Annona* spp., *Citrus* spp., *Coffea* spp. (coffee), *Eucalyptus saligna*, *Malus pumila* (apple), *Mangifera indica* (mango), *Persea americana* (avocado), *Prunus* spp., *Pyrus* spp. (pears) (Segura 1970; Farr and Rossman 2009)
Distribution	Presence in Australia: no record found. Presence in the US: AL, FL, GA, IN, KY, LA, MS, NC, OK, SC, TX, WA, WV (Hartman 1990; Ginns and Lefebvre 1993; Farr and Rossman 2009) Presence elsewhere: American Samoa, Argentina, Bolivia, Brazil, Colombia, DR Congo, Cote d'Ivoire, Cuba, Dominican Republic, El Salvador, Fiji, Greece, Guatemala, Haiti, Honduras, India, Jamaica, Japan, Madagascar, Mexico, New Caledonia, Nicaragua, Panama, Papua New Guinea, Peru, Puerto Rico, Samoa, Suriname, Trinidad and Tobago, Venezuela, Vietnam, Virgin Islands, West Indies (CABI/EPPO 2007; Farr and Rossman 2009)
Quarantine pest	***Gymnosporangium clavipes* (Cooke & Peck) Cooke & Peck**
Synonyms	*Gymnosporangium germinale* F. Kern *Podisoma gymnosporangium-clavipes* Cooke & Peck
Common name(s)	quince rust
Main hosts	Aecia on: *Cydonia oblonga* (quince), *Malus* spp. (apple) Telia on: *Juniperus virginianae* (eastern red cedar), *Juniperus communis* (common juniper), (CABI/EPPO 1997e; Laundon 1977a)
Distribution	Presence in Australia: No record found Presence in the US: widespread in the US (Farr and Rossman 2009). In WA, it has been reported on *Crataegus douglasii* (black hawthorn) and *Juniperus communis* (common juniper) (Farr and Rossman 2009), but it is not known to be present on *Malus* (apple) in the PNW. Presence elsewhere: Canada, Guatemala, Mexico (CABI/EPPO 1997e)
Quarantine pest	***Gymnosporangium globosum* (Farl.) Farl.**
Synonyms	*Gymnosporangium fuscum* var. *globosum* Farl.
Common name(s)	hawthorn rust
Main hosts	Aecia on: *Amelanchier* spp. (serviceberry), *Crataegus* spp. (hawthorn), *Malus* spp. (apple), *Pyrus* spp. (pear) and *Sorbus* spp. (mountain ash) (CABI/EPPO 1997i; Laundon 1977b) Telia on: *Juniperus virginiana* (eastern red cedar) and related *Juniperus* spp. (Laundon 1977b; Aldwinckle 1990b)
Distribution	Presence in Australia: No record found Presence in the US: AK, AL, CO, CT, FL, GA, IA, IL, IN, KS, KY, MA, ME, MI, MS, NC, ND, NE, NH, NJ, NY, OK, PA, RI, SC, SD, TX, VA, VT, WI (CABI/EPPO 1997i; Farr and Rossman 2009) Presence elsewhere: Canada, Korea, Mexico (CABI/EPPO 1997i; Farr and Rossman 2009)
Quarantine pest	***Gymnosporangium juniperi-virginianae* Schwein.**
Synonyms	*Gymnosporangium macropus* Link *Gymnosporangium virginianum* Spreng.
Common name(s)	cedar apple rust
Main hosts	Aecia on: *Malus* spp. (apple) Telia on: *Juniperus virginiana* (eastern red cedar) and related *Juniperus* spp. (junipers) (Laundon 1977c)
Distribution	Presence in Australia: No record found Presence in the US: AL, AR, CA, CO, CT, FL, GA, IA, IL, IN, KS, MA, MD, MI, MO, MS, NC, ND, NE, NY, OH, OK, PA, RI, SD, TN, VA, WA, WI, WY (CABI/EPPO 1997l) Presence elsewhere: Canada (CABI/EPPO 1997l)
Quarantine pest	***Gymnosporangium libocedri* (Henn.) F. Kern**
Synonyms	*Gymnosporangium blasdaleanum* (Dietel & Holw.) F. Kern *Phragmidium libocedri* Henn.
Common name(s)	pacific coast pear rust
Main hosts	Aecia on: *Amelanchier* spp. (serviceberry), *Chaenomeles* spp. (flowering quince), *Crataegus* spp. (hawthorn), *Cydonia vulgaris* (quince), *Malus* spp. (apple), *Pyrus communis* (pear) and *Sorbus* spp. (mountain ash) Telia on: *Calocedrus decurrens* (incense cedar) (Laundon 1977d)

Distribution	Presence in Australia: No record found Presence in the US: AK, CA, NV, OR, WA (Farr and Rossman 2009) Presence elsewhere: No record found
Quarantine pest	***Gymnosporangium yamadae*** **Miyabe ex G. Yamada**
Synonyms	
Common name(s)	Japanese apple rust
Main hosts	Aecia on: *Malus* spp. (apple) (Farr and Rossman 2009) Telia on: *Juniperus* spp. (Farr and Rossman 2009)
Distribution	Presence in Australia: No record found Presence in the US: DE, PA (Yun *et al.* 2009) Presence elsewhere: China (all major apple production areas), Japan (Hokkaido, Honshu), North Korea, South Korea (CABI/EPPO 1997n; Farr and Rossman 2009).
Quarantine pest	***Truncatella hartigii*** **(Tubeuf) Steyaert**
Synonyms	*Pestalotia hartigii* Tubeuf
Common name(s)	Truncatella leaf spot
Main hosts	*Abies* spp. (firs), *Cannomois virgata*, *Fagus sylvatica* (beech), *Fraxinus excelsior* (common ash), *Lactuca sativa* (lettuce), *Larix occidentalis* (western larch), *Malus* spp. (apple), *Olea laurifolia* (olive), *Picea* spp. (spruces), *Pinus* spp. (pines), *Pseudotsuga* spp. (douglas firs), *Pyrus* spp. (pears), and *Rhodocoma capensis* (Cooke 1906; Spaulding 1956; Vujanovic *et al*. 2000; ; Lee *et al*. 2006; Farr and Rossman 2009)
Distribution	Presence in Australia: No record found Presence in the US: Oregon, Washington (Farr and Rossman 2009) Presence elsewhere: Austria, Belgium, China, Czech Republic, Denmark, Finland, France, Germany, India, Japan, Korea, Norway, Pakistan, Poland, South Africa, Sweden, Turkey, United Kingdom (Farr and Rossman 2009)
DOMAIN VIRUSES	
Quarantine pest	**Tobacco necrosis viruses** The names below are used for distinct necrovirus species that have been called 'tobacco necrosis virus' ***Chenopodium necrosis virus*** ***Olive mild mosaic virus*** ***Tobacco necrosis virus A*** ***Tobacco necrosis virus D*** **Tobacco necrosis virus Nebraska isolate**
Synonyms	See CABI (2009)
Common name(s)	Tobacco necrosis virus
Main hosts	*Brassica oleracea* (cabbage), *Chenopodium quinoa* (quinoa), *Cucumis sativus* (cucumber), *Cucurbita pepo* (zucchini), *Daucus carota* (carrot), *Fragaria* × *ananassa* (strawberry), *Glycine max* (soybean), *Malus pumila* (apple), *Nicotiana tabacum (tobacco)*, *Lactuca sativa* (lettuce), *Olea europaea* (olive), *Phaseolus vulgaris* (common bean), *Solanum tuberosum* (potato), *Tulipa* sp. (tulip), other hosts are infected but remain symptomless (Kassanis 1970; Brunt and Teakle 1996; CABI 2009; Zitikaite and Staniulis 2009).
Distribution	Presence in Australia: Qld, Vic (Findlay and Teakle 1969; Teakle 1988) Presence in the US: Probably in every state but species and strain distributions are largely unknown. Records in CA, IL, NE, NY, OR, UT, WI (Babos and Kassanis 1963; Grogan and Uyemoto 1967; Uyemoto and Gilmer 1972; APHIS 2007b; CABI 2009). Presence elsewhere: Probably worldwide but species and strain distributions are largely unknown. Records in Belgium, Brazil, Canada, China, Czechoslovakia (former), denmark, Finland, France, Germany, Hungary, India, Italy, Japan, Lativa, Netherlands, New Zealand, Norway, Romania, Russia, South Africa, Spain, Sweden, Switzerland, Turkey, United Kingdom (CABI 2009).
Quarantine pest	**Apple scar skin viroid**
Synonyms	ASSVd
Common name(s)	apple scar skin disease, apple dimple, pear rusty skin, pear fruit crinkle, Japanese pear fruit dimple
Main hosts	*Malus pumila* (apple), *Pyrus* spp. (pears) (CABI 2007)
Distribution	Presence in Australia: No record found

	Presence in the US: MA, ME, MO, NH, WA (CABI 2007) Presence elsewhere: China, Canada, Denmark, France, Greece, India, Iran, Italy, Japan, Poland, South Korea, Turkey, United Kingdom (CABI 2007)

Appendix C Biosecurity 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. Australia's 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[44], 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.

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.

[44] The Australian Government Department of Health and Ageing is responsible for human health aspects of quarantine.

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).

The Biosecurity Services Group (BSG) within the Department takes the lead in biosecurity and quarantine policy development and the establishment and implementation of risk management measures across the biosecurity continuum, and:

• though Biosecurity Australia, conducts risk analyses, including IRAs, and develops recommendations for biosecurity policy as well as providing quarantine policy advice to the Director of Animal and Plant Quarantine

• through the Australian Quarantine and Inspection Service, 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

• 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. The BSG work in partnership with state and territory governments to address regional differences in pest and disease status and risk within Australia, and develops 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 (update 2009)* 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
- 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 (update 2009).*

Appendix D Responses to stakeholder submissions

Biosecurity Australia received written comments from nine stakeholders on the *Issues paper for the import risk analysis for fresh apple fruit from the United States of America* by the due date of the comment period, 5 September 2008. The submissions from stakeholders were placed on the public file and on the Biosecurity Australia website on 23 September 2008.

Submissions were received from the following stakeholders: United States Department of Agriculture – Animal and Plant Health Inspection Service (USDA-APHIS); five Australian state departments of primary industry/agriculture; Apple and Pear Australia Limited (APAL); Western Australian Fruit Growers' Association (WAFGA); and one individual.

Many of the comments provided by these stakeholders have been addressed by Biosecurity Australia in the technical detail of this draft IRA report. However, comments which were considered to be out of the scope of an IRA, for example, the WTO challenge between New Zealand and Australia, will not be addressed within this document.

Key issues raised by stakeholders for consideration in this IRA are discussed here in detail.

Method

Biosecurity Australia notes that the method was not discussed in detail in the issues paper and the stakeholder's comments on method were based on previously published IRA reports. The method used to determine the unrestricted risk of potential quarantine pests in the IRA process has been developed in accordance with international standards and addresses Australia's ALOP. The expression of Australia's ALOP has been discussed at different levels of government. For example the Primary Industries Ministerial Council (PIMC) discussed this issue in 2002 and agreed that: the work done to date on the policy framework surrounding ALOP including practical guidelines for risk analysis which illustrate the concept of a risk estimation matrix adequately meets Australia's present needs and further work on this definition is not a PIMC priority. This information can be viewed at http://www.mincos.gov.au/pdf/pimc_res_01.pdf

Biosecurity issues have been a standing agenda item at PIMC meetings held biannually. Since this agreement, there have been no proposals from state and territory governments to change the approach used by Biosecurity Australia to express ALOP.

The method used for IRAs has been explained in detail in all the IRA reports released by Biosecurity Australia. The qualitative method is outlined in Section 2 of this draft IRA report.

One stakeholder has commented in detail on alternative approaches to the method for the risk assessments in this and other concurrent IRAs. The suggested changes to the method used by Biosecurity Australia will be considered in the context of future reviews of the method consistent with international standards, the Australian Centre of Excellence for Risk Analysis (ACERA) and Australian expertise in biosecurity.

The states and territories agreed to conform with the provisions of the SPS Agreement in a Memorandum of Understanding (MOU) on Animal and Plant Quarantine Measures signed in 1995. In 2002, the MOU was amended to include recognition of regional differences in risk through PIMC. Biosecurity Australia proposes to consult informally with the relevant state department and industry stakeholders in regards to their submissions.

Pest Information

A number of stakeholders commented on the status, in the US, of specific pests included in the preliminary pest list contained within the issues paper. Some also suggested additional pests that had not been included in the list. Biosecurity Australia values the scientific advice provided and has considered and incorporated the information, where relevant, in the pest categorisation included in this draft IRA report. Biosecurity Australia welcomes any further additions and/or corrections on: the pests associated with apples from the US, the outcome of the pest categorisation and the resulting pest risk assessments during the stakeholder comment period for this draft IRA report.

Regional differences in pest status both in the proponent country, the US, and in the pest risk analysis area, Australia or specific states and territories, are considered according to international guidelines. Two stakeholders indicated an expectation that apples would not be permitted into Western Australia based on existing policy for apple scab (*Venturia inequalis*) from the New Zealand apple IRA. However, the US may propose areas free of apple scab for the export of apples. Therefore, there would be a possibility that apples would be recommended to be imported to Western Australia if other pest issues can be addressed.

As stated earlier in the scope, this IRA pertains to the importation of mature fresh apple fruit from the three states of the PNW: Washington, Oregon and Idaho. The US has listed a number of pests that they do not consider to be present in the PNW and movement restrictions are imposed on both apple fruit and propagative material into these states. Through the course of the IRA, APHIS will be asked to provide comprehensive information on how the PNW states maintain freedom from these pests present in other areas of the US.

Status of fire blight in the US

A number of stakeholders provided submissions expressing their views about fire blight and its status in the US.

A brief overview of the status of fire blight within the US was provided on page 12 of the issues paper. Within this draft IRA report for US apples, BA has conducted a pest categorisation and a risk assessment for fire blight. Please see pages 35–37 for more detail of this assessment.

A number of submissions have referred to the current WTO challenge between New Zealand and Australia. One submission has suggested that BA should wait for the outcome of this process before finalising the policy for US apples.

The WTO case is ongoing and at this stage is not expected to be resolved before mid 2010. This IRA for US apples is an expanded IRA. It is therefore required to be completed within 30 months from commencement as stipulated within the Regulations.

Australia has developed a policy for apple fruit imported from New Zealand where fire blight is known to occur. This policy has been taken into account, where relevant, as part of this IRA for US apples.

Other submissions have commented on content relating to fire blight and other pests that are currently being debated within the WTO forum including information that was not specifically discussed within the issues paper. Given the ongoing nature of this forum, Biosecurity Australia will not respond to comments relating to the WTO challenge between Australia and New Zealand here.

US apple movement controls/area freedom

In its submission, USDA-APHIS raised concerns over BA's inclusion for assessment of pests of quarantine concern for apple production occurring in the continental US, but not explicitly recorded from the PNW. The APHIS asserts that few, if any, producers in the Eastern US apple producing States ship fresh apples to the PNW due to high transportation costs, abundant PNW apple production, and that restrictions for specific pests are imposed on the movement of apple commodities.

The scope of this IRA is to consider any potential quarantine risks associated with the importation of apple fruit into Australia from the PNW. Should quarantine pests be recorded for other continental states that are not explicitly defined within the scope of the IRA report, BA would seek sufficient confidence that adequate measures are imposed to prevent their spread into the PNW, so as to merit their exclusion from consideration. While the economics of transporting apples may preclude many producers from the east shipping to the west, or vice versa, this does not constitute a definitive assurance that trade between these regions does not take place, especially where production shortfalls may occur and product is potentially sourced from elsewhere to meet orders. Additionally, it does not take into account any incidental transit of apples across state borders through human movement.

Although the scope of this draft IRA report is defined to the PNW, the purpose of the IRA report is to take into consideration any quarantine risks posed by the importation of commodities, and estimate whether additional measures are required to meet Australia's ALOP. In our view, the minimal restrictions regulating the domestic movement of commodities within the continental US necessitates the consideration of quarantine pests from conterminous regions.

Furthermore, the consultation period provides stakeholders with the opportunity to provide comments on specific issues and make recommendations for inclusion in the final assessment. USDA-APHIS has provided additional information regarding seven pests that are subject to restrictions on the movement of apple fruit and propagative materials under Federal and/or State quarantines. This information will be considered within the pest categorisation/risk analysis process to assess whether claims for area freedom (pest free areas, pest free places of production or areas of low pest prevalence - ISPM No.4 and ISPM No.10) for these pests can be met.

Should additional data be presented to BA supporting the imposition of regulatory measures for the domestic movement of commodities in the US against the assessed pests, we would be happy to review this information. Where specific pest issues are raised, BA would make any appropriate amendments should they be deemed necessary.

Apple Industry in the United States

The issues paper gave a brief overview of the US apple industry. Some information is from first hand accounts of BA scientists who have visited apple orchards in the US. However, most information was sourced from various state universities and other sources who make publicly available information on this subject.

A number of submissions referred to the US apple industry's production, cultivation and processing practices listed in the issues paper, including USDA-APHIS.

USDA-APHIS has provided the 2006 fruit surveys for Washington, Oregon and Idaho and where appropriate this information has been reflected in this draft IRA report starting at page

15. The fruit surveys have been listed on the BA public file and are available to view at http://www.daff.gov.au/ba/ira/current-plant/apples_usa/submissions.

A number of submissions have referred to the calculation error on page 9 of the issues paper, relating to the conversion of trees per acre to trees per hectare. This has been revised to reflect the true conversion rate in this draft IRA report.

Appendix E List of States of the United States of America

States of the United States of America			
Abbreviation	**State**	**Abbreviation**	**State**
AK	Alaska	MT	Montana
AL	Alabama	NC	North Carolina
AR	Arkansas	ND	North Dakota
AZ	Arizona	NE	Nebraska
CA	California	NH	New Hampshire
CO	Colorado	NJ	New Jersey
CT	Connecticut	NM	New Mexico
DC	District of Columbia	NV	Nevada
DE	Delaware	NY	New York
FL	Florida	OH	Ohio
GA	Georgia	OK	Oklahoma
HI	Hawaii	OR	Oregon
IA	Iowa	PA	Pennsylvania
ID	Idaho	RI	Rhode Island
IL	Illinois	SC	South Carolina
IN	Indiana	SD	South Dakota
KS	Kansas	TN	Tennessee
KY	Kentucky	TX	Texas
LA	Louisiana	UT	Utah
MA	Massachusetts	VA	Virginia
MD	Maryland	VT	Vermont
ME	Maine	WA	Washington
MI	Michigan	WI	Wisconsin
MN	Minnesota	WV	West Virginia
MO	Missouri	WY	Wyoming
MS	Mississippi		

Glossary

Term or abbreviation	Definition
Additional declaration	A statement that is required by an importing country to be entered on a phytosanitary certificate and which provides specific additional information on a consignment in relation to regulated pests (FAO 2009).
Appropriate level of protection (ALOP)	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 2009).
Area of low pest prevalence	An area, whether all of a country, part of a country, or all parts of several countries, as identified by the competent authorities, in which a specific pest occurs at low levels and which is subject to effective surveillance, control or eradication measures (FAO 2009).
Biosecurity Australia	The unit, within the Biosecurity Service Group, responsible for recommendations for the development of Australia’s biosecurity policy.
Biosecurity Service Group (BSG)	The group responsible for the delivery of biosecurity policy and quarantine services within the Department of Agriculture, Fisheries and Forestry.
Certificate	An official document which attests to the phytosanitary status of any consignment affected by phytosanitary regulations (FAO 2009).
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 2009).
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO 2009).
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 2009).
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 2009).
Establishment	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO 2009).
Fresh	Living; not dried, deep-frozen or otherwise conserved (FAO 2009).
Host range	Species capable, under natural conditions, of sustaining a specific pest or other organism (FAO 2009).
Import permit	Official document authorising importation of a commodity in accordance with specified phytosanitary import requirements (FAO 2009).
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)	Official document authorising importation of a commodity in accordance with specified phytosanitary import requirements (FAO 2009).
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 2009).
Intended use	Declared purpose for which plants, plant products, or other regulated articles are imported, produced, or used (FAO 2009).
Interception (of a pest)	The detection of a pest during inspection or testing of an imported consignment (FAO 2009).
International Standard for Phytosanitary Measures (ISPM)	An international standard adopted by the Conference of the Food and Agriculture Organization, the Interim Commission on phytosanitary measures or the Commission on phytosanitary measures, established under the IPCC (FAO 2009).
Introduction	The entry of a pest resulting in its establishment (FAO 2009).
Lot	A number of units of a single commodity, identifiable by its homogeneity of composition, origin etc., forming part of a consignment (FAO 2009).
National Plant Protection Organization (NPPO)	Official service established by a government to discharge the functions specified by the IPPC (FAO 2009).
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 2009).

Term or abbreviation	Definition
Pathway	Any means that allows the entry or spread of a pest (FAO 2009).
Pest	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2009).
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 2009).
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 2009).
Pest free place of production	Place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period (FAO 2009).
Pest free production site	A defined portion of a place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this conditions is being officially maintained for a defined period and that is managed as a separate unit in the same way as a pest free place of production (FAO 2009).
Pest risk analysis (PRA)	The process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated, and the strength of any phytosanitary measures to be taken against it (FAO 2009).
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 2009).
Pest risk management (for quarantine pests)	Evaluation and selection of options to reduce the risk of introduction and spread of a pest (FAO 2009).
Phytosanitary certificate	Certificate patterned after the model certificates of the IPPC (FAO 2009).
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 2009).
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 2006.
Polyphagous	Feeding on a relatively large number of hosts from different genera.
PRA area	Area in relation to which a pest risk analysis is conducted (FAO 2009).
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 2009).
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 2009).
Restricted risk	Risk estimate with phytosanitary measure(s) applied.
Spread	Expansion of the geographical distribution of a pest within an area (FAO 2009).
SPS Agreement	WTO Agreement on the Application of Sanitary and Phytosanitary Measures (WTO 1995).
Stakeholders	Government agencies, individuals, community or industry groups or organizations, whether in Australia or overseas, including the proponent/applicant for a specific proposal, who have an interest in the policy issues.
Systems approach(es)	The integration of different risk management measures, at least two of which act independently, and which cumulatively achieve the appropriate level of protection against regulated pests (FAO 2009).
Unrestricted risk	Unrestricted risk estimates apply in the absence of risk mitigation measures.

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