



Australian Government  
Department of Agriculture,  
Fisheries and Forestry

# Final report for the review of biosecurity import requirements for fresh apple fruit from the Pacific Northwest states of the United States of America

October 2022



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### **Acknowledgement of Country**

We acknowledge the Traditional Custodians of Australia and their continuing connection to land and sea, waters, environment and community. We pay our respects to the Traditional Custodians of the lands we live and work on, their culture, and their Elders past and present.

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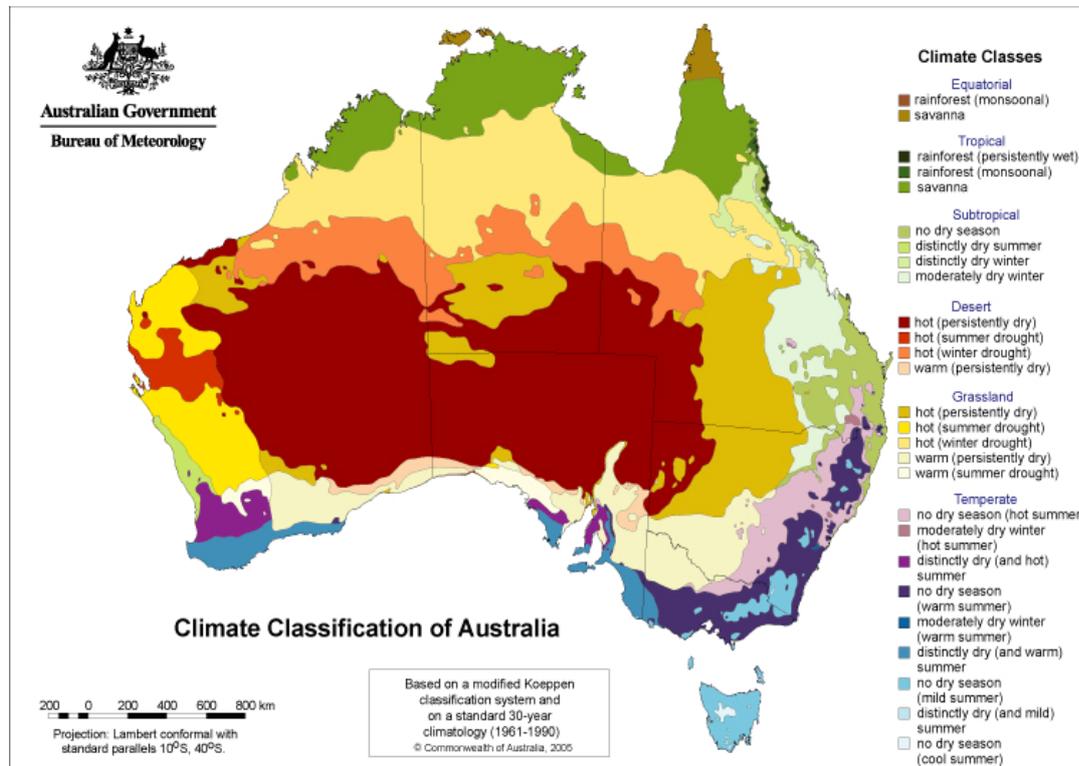
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Map 1 Map of Australia



Map 2 A guide to Australia's bio-climatic zones

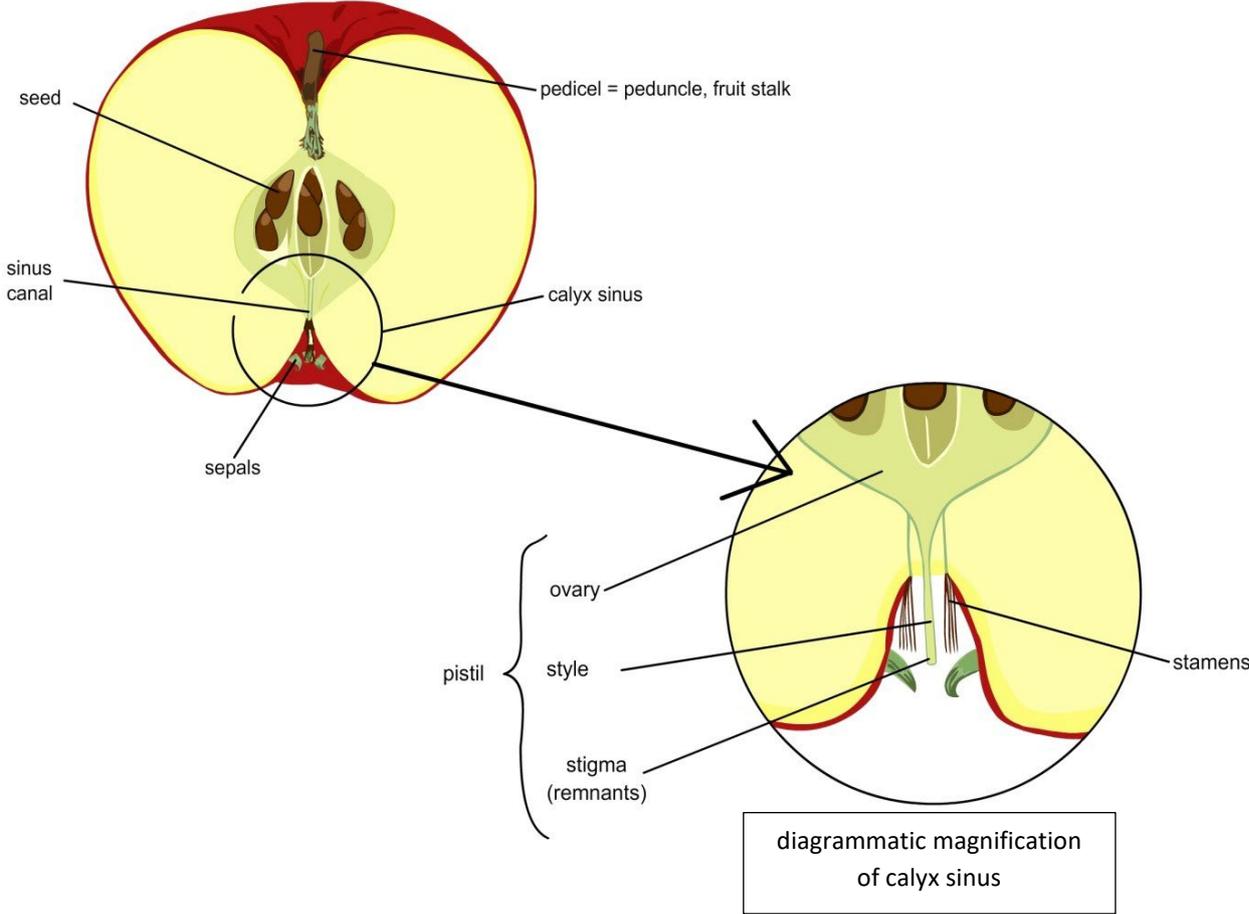


Map 3 Apple production areas in Australia



Source: (APAL 2020)

Figure 1 Diagram of apple fruit



## Acronyms and abbreviations

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<b>Term or abbreviation</b>	<b>Definition</b>
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)
BICON	Australia's Biosecurity Import Conditions System
BIRA	Biosecurity Import Risk Analysis
EP	Existing policy
FAO	Food and Agriculture Organization of the United Nations
IPC	International Phytosanitary Certificate
IPPC	International Plant Protection Convention
ISPM	International Standard for Phytosanitary Measures
NSW	New South Wales
NPPO	National Plant Protection Organisation
NT	Northern Territory
PNW	Pacific Northwest
PRA	Pest risk analysis
Qld	Queensland
SA	South Australia
SPS Agreement	WTO agreement on the Application of Sanitary and Phytosanitary Measures
Tas.	Tasmania
The department	The Department of Agriculture, Fisheries and Forestry
URE	Unrestricted risk estimate
USA	United States of America
USDA	United States Department of Agriculture
Vic.	Victoria
WA	Western Australia
WTO	World Trade Organization

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## Summary

The Australian Government Department of Agriculture, Fisheries and Forestry (the department) has prepared this final report to assess the proposal by the United States of America (USA) for market access to Australia for fresh apple fruit from the Pacific Northwest states of Idaho, Oregon and Washington, USA (PNW-USA) for human consumption.

Australia permits the importation of fresh apples from New Zealand and the People's Republic of China, for human consumption, provided they meet Australian biosecurity requirements.

This final report recommends that the importation of commercially produced mature fresh apple fruit to Australia from all production areas of the PNW-USA be permitted, subject to a range of biosecurity requirements.

This final report contains details of pests that are of biosecurity concern to Australia and are potentially associated with the importation of fresh apple fruit from the PNW-USA, and the risk assessments for the identified quarantine pests. The final report also contains the recommended risk management measures to reduce the level of biosecurity risk to an acceptable level, that is, to achieve the appropriate level of protection (ALOP) for Australia.

Twenty pests have been identified in this risk analysis as requiring specific risk management measures to reduce the biosecurity risk to an acceptable level. Fourteen of these pests are arthropod pests and 6 are fungal pathogens.

The 20 quarantine pests requiring risk management measures are:

- fruit fly: apple maggot (*Rhagoletis pomonella*)
- mites: flat scarlet mite (*Cenopalpus pulcher*) and McDaniel spider mite (*Tetranychus mcdanieli*)
- thrips: eastern flower thrips (*Frankliniella tritici*) and western flower thrips (*Frankliniella occidentalis*)
- mealybugs: apple mealybug (*Phenacoccus aceris*) and grape mealybug (*Pseudococcus maritimus*)
- leafroller and fruit moths: codling moth (*Cydia pomonella*), European leafroller (*Archips rosana*), fruit tree leafroller (*Archips argyrospila*), large fruit tree tortrix (*Archips podana*), oblique-banded leafroller (*Choristoneura rosaceana*), orange tortrix (*Argyrotaenia franciscana*) and Pandemis leafroller (*Pandemis pyrusana*)
- fungi: apple blotch (*Phyllosticta arbutifolia*), Gymnosporangium rusts (*Gymnosporangium clavipes*, *G. juniperi-virginianae* and *G. libocedri*), speck rot (*Phacidiopycnis washingtonensis*), and Sphaeropsis rot (*Sphaeropsis pyriputrescens*).

The recommended risk management measures take into account regional differences in pest distribution within Australia. One of the arthropod pests requiring risk management measures, *Frankliniella occidentalis*, has been identified as a regional quarantine pest for the Northern Territory and one arthropod pest, *Cydia pomonella*, has been identified as a regional quarantine pest for Western Australia.

*Frankliniella occidentalis* was also assessed as a regulated article for all of Australia as it is capable of harbouring and spreading (vectoring) emerging orthotospoviruses that are quarantine pests for Australia.

This final report recommends a range of risk management measures, combined with an operational system, to reduce the risks posed by the 20 quarantine pests to achieve the ALOP for Australia. These measures include:

- for mites, mealybugs and thrips:
  - pre-export visual inspection and, if found, remedial action
- for apple maggot:
  - pest free areas, pest free places of production or pest free production sites, or
  - an appropriate pre-export phytosanitary treatment approved by the department
- for leafrollers:
  - in-field controls, and pre-export inspection, and if found, remedial action, or
  - an appropriate pre-export phytosanitary treatment (such as methyl bromide fumigation) approved by the department
- for codling moth:
  - pest free areas, pest free places of production or pest free production sites, or
  - systems approach approved by the department, or
  - an appropriate pre-export phytosanitary treatment (such as methyl bromide fumigation) approved by the department
- for Gymnosporangium rusts:
  - pre-export visual inspection and, if found, remedial action
- for Sphaeropsis rot, speck rot and apple blotch:
  - systems approach approved by the department.

The unrestricted risk estimate (URE) for three pests, apple leafcurling midge (*Dasineura mali*), fire blight (*Erwinia amylovora*) and European canker (*Neonectria ditissima*), achieved the ALOP for Australia, taking into consideration commercial production practices already in place in PNW-USA. Specific commercial production practices are therefore recommended to be mandatory for *D. mali*, *E. amylovora* and *N. ditissima*. These commercial production practices include:

- for apple leafcurling midge
  - in-field monitoring and controls, packing house procedures including sorting, grading and packing house sanitation, and pre-export visual inspection and, if found, remedial action
- for fire blight
  - in-field monitoring and controls, fruit maturity testing, packing house sanitation, and pre-export visual inspection and, if found, remedial action
- for European canker
  - in-field monitoring and controls, packing house sanitation, and pre-export visual inspection and, if found, remedial action.

Upon finalisation of this policy, the USA must be able to demonstrate to the department that processes and procedures are in place to implement the recommended risk management measures. This will ensure safe trade in fresh apples from the USA. Import conditions can then be published in the Australian Government's Biosecurity Import Conditions (BICON) system on the department's website, which can be accessed at [bicon.agriculture.gov.au/BiconWeb4.0](http://bicon.agriculture.gov.au/BiconWeb4.0).

The department received written submissions on the draft report from 62 stakeholders, but 6 submissions contained no written response to the draft report. The department has made a number of changes to the report following consideration of stakeholder comments and subsequent review of the literature. These changes include:

- minor amendments to Chapter 3 to enhance clarity on commercial production and pest management practices
- amendments to Chapter 4 'Pest risk assessments for quarantine pests'
  - The likelihood of importation for *Cenopalpus pulcher* in Section 4.1, *Tetranychus mcdanieli* in Section 4.2, and *Grapholita molesta*, *Grapholita prunivora* and *Grapholita packardi* in Section 4.12 have been assessed specifically for PNW-USA apples, instead of adopting from the existing policies. For *C. pulcher*, the URE of Low, which does not achieve the ALOP for Australia, has not changed. For *T. mcdanieli*, the URE has changed from Very Low, which achieves the ALOP for Australia, to Low, which does not achieve the ALOP for Australia. For *G. prunivora* and *G. packardi*, the URE has changed from Low, which does not achieve the ALOP for Australia, to Very Low, which achieves the ALOP for Australia. For *G. molesta*, the URE of Very Low, which achieves the ALOP for Australia, has not changed.
  - The typing error for the likelihood of importation for *Argyresthia conjugella* (apple fruit moth) in Section 4.13 has been amended from Very low to Low. Subsequently, the likelihood of entry has been amended from Very Low to Low, and the likelihood of entry, establishment and spread has also been amended from Very low to Low. However, these changes have not resulted in a change in URE of Very Low for this pest.
  - For *Coprinopsis psychromorbida* the likelihood of spread in Section 4.16 was re-assessed and the rating changed from Low to Moderate. The URE of Negligible for *Coprinopsis psychromorbida* has not changed, which achieves the ALOP for Australia.
  - *Neofabraea perennans* has been removed from the risk assessment at Section 4.19 as it is considered to be present in Australia and is not under official control.
  - The risk assessment for *Parlatoria pergandii* in Section 4.6 has been updated to incorporate components of the *Final group pest risk analysis for soft and hard scale insects on fresh fruit, vegetable, cut-flower and foliage imports* (scales Group PRA) (DAWE 2021).
  - Where relevant, references have been updated, new references have been added and changes have been made to the likelihood assessments of importation, distribution, establishment and/or spread, and the potential consequence assessments.
- amendments to Appendix A 'Initiation and categorisation for pests of apple fruit from the Pacific Northwest states of the USA' to include additional information and references
  - *Lambertella corni-maridis*, *Apple hammerhead viroid*, *Apple rubbery wood virus 1*, *Apple rubbery wood virus 2* and *Citrus concave gum-associated virus* have been added.

- Status of *Neofabraea perennans* in Australia has been updated to reflect that it is present in Australia (and is not under official control).
- Status of *Conotrachelus nenuphar* (plum curculio) has been updated to clarify its absence from the PNW-USA.
- Status of *Aculus malivagrans* (synonym *Vasates malivagrans*) has been updated as present in the PNW-USA and Australia.
- addition of Appendix B 'Issues raised in stakeholder comments', which summarises the key technical issues raised by stakeholders, and how the issues were considered by the department in this final report
- minor corrections, rewording and editorial changes for consistency, accuracy, clarity and web-accessibility
- updates to weblinks to cited references where appropriate.

# 1 Introduction

## 1.1 Australia's biosecurity policy framework

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

The risk analysis process is an important part of Australia's biosecurity policy development. It enables the Australian Government to formally consider the level of biosecurity risk that may be associated with proposals to import goods into Australia. If the biosecurity risks do not achieve the appropriate level of protection (ALOP) for Australia, risk management measures are proposed to reduce the risks to an acceptable level. If the risks cannot be reduced to an acceptable level, the goods will not be imported into Australia until suitable measures are identified or developed.

Successive Australian Governments have maintained a stringent, but not a zero risk, approach to the management of biosecurity risks. This approach is expressed in terms of the ALOP for Australia, which is defined in the *Biosecurity Act 2015* as providing a high level of protection aimed at reducing risk to a very low level, but not to zero.

Australia's risk analyses are undertaken by the Department of Agriculture, Fisheries and Forestry using technical and scientific experts in relevant fields and involve consultation with stakeholders at various stages during the process.

Risk analyses may take the form of a biosecurity import risk analysis (BIRA) or a review of biosecurity import requirements (such as scientific review of existing policy and import conditions, pest-specific assessments, weed risk assessments, biological control agent assessments or scientific advice).

Further information about Australia's biosecurity framework is provided in the *Biosecurity Import Risk Analysis Guidelines 2016* located on the Department of Agriculture, Fisheries and Forestry website at [agriculture.gov.au/biosecurity-trade/policy/risk-analysis/guidelines](http://agriculture.gov.au/biosecurity-trade/policy/risk-analysis/guidelines).

## 1.2 This risk analysis

### 1.2.1 Background

The United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS) formally requested market access to Australia for fresh apple fruit from the Pacific Northwest states of Idaho, Oregon and Washington, United States of America (PNW-USA) in a submission received in June 1999. This submission included information on the pests associated with fresh apple fruit from the PNW-USA, including the plant part affected and the standard commercial production practices for fresh apple fruit in the PNW-USA.

A previous risk analysis for fresh apple fruit from the PNW-USA commenced in March 2008 and was progressed as an expanded regulated Import Risk Analysis (IRA) under the *Quarantine Regulations 2000*. The expanded, regulated IRA was to be completed within 30 months from commencement. A draft report was released in October 2009, proposing that the importation of fresh apple fruit be permitted, subject to a range of quarantine measures, including the

development of effective management measures for 3 post-harvest rot fungi, *Sphaeropsis pyriputrescens*, *Discula pyri* and *Phaciidiopycnis washingtonensis*. However, in March 2010, the department invoked the 'stop the clock' provisions for the USA apple IRA due to lack of risk management information from the USA on *S. pyriputrescens*, *D. pyri* and *P. washingtonensis*. This information was needed before the IRA process could be completed. Post-harvest rot management information was later received from the USA. However, the IRA had ceased when the *Quarantine Regulations 2000* instrument was repealed in June 2016 when the *Biosecurity Act 2015* replaced the *Quarantine Act 1908*.

The current risk analysis is being completed as an assessment, under the *Biosecurity Act 2015*, independent of the previous IRA process.

Australia has established conditions for the importation of fresh apples from New Zealand and China, and for Fuji apples from Japan. A pest categorisation for apple fruit from the PNW-USA indicated that the potential pests of quarantine concern are of the same pest species or pest groups as those associated with the apples from New Zealand and China pathways, and/or the stone fruit from the USA pathway, and/or other horticultural commodities that have been assessed previously by the department, and for which risk management measures are established. On 1 November 2018, the department publicly announced the commencement of this risk analysis advising that it would be progressed as a review of biosecurity import requirements for the purposes of the *Biosecurity Act 2015*.

In August 2010 and March 2016, Australian Government officials visited apple production areas in the PNW-USA. The objective of those visits was to observe commercial production, pest management and other export practices.

### **1.2.2 Scope**

The scope of this risk analysis is to consider the biosecurity risk that may be associated with the pathway of imported mature fresh apple fruit (*Malus domestica* Bork), grown in the PNW-USA using standard commercial production practices as described in Chapter 3, for human consumption.

In this risk analysis, apple fruit are defined as fruit with the pedicel or stalk (Figure 1). This risk analysis covers all commercially produced mature fresh apple fruit of all cultivars from the PNW-USA, grown for export.

### **1.2.3 Existing policy**

#### **International policy**

Import policies exist for fresh apple fruit from New Zealand (Biosecurity Australia 2006a, 2011b), China (Biosecurity Australia 2010a) and Japan (AQIS 1998a). Apples have been imported into Australia from China and New Zealand under the respective policies.

The New Zealand apple import policy (Biosecurity Australia 2006a) was considered in a World Trade Organization (WTO) dispute. On 29 November 2010, the Appellate Body of the World Trade Organization's Dispute Settlement Body (DSB) released a report on Australia and New Zealand's dispute over the importation of New Zealand apples. The report concluded that Australia's phytosanitary measures for New Zealand apples were inconsistent with Australia's WTO obligations. Australia agreed to implement the findings of the DSB and review the import

policy for New Zealand apples for the three pests under dispute. Australia announced the commencement of the review on 7 December 2010, released the draft report for 60 days consultation on 4 May 2011 and released the final report of the review on 17 August 2011 with the revised policy for the importation of New Zealand apples (Biosecurity Australia 2011b).

Import policy also exists for stone fruit from California and the PNW-USA states. The potential pests of biosecurity concern for apples from PNW-USA are the same as or similar to those identified for the pathways of apples from New Zealand, apples from China, stone fruit from the PNW-USA, and/or other for horticultural commodities for which policies exist.

The import requirements for these commodity pathways can be found at the department's Biosecurity Import Conditions (BICON) system on the department's website at [bicon.agriculture.gov.au/BiconWeb4.0](http://bicon.agriculture.gov.au/BiconWeb4.0).

The department has reviewed all the pests and pest groups previously identified in existing policies and, where relevant, the information in those assessments has been considered in this risk analysis. The department has also reviewed the latest scientific literature and other information to ensure that the previous assessments are still valid.

The biosecurity risk posed by thrips, and the orthospoviruses they transmit, was previously assessed for all countries in the *Final group pest risk analysis for thrips and orthospoviruses on fresh fruit, vegetable, cut-flower and foliage imports* (thrips Group PRA) (DAWR 2017). Similarly, the biosecurity risk posed by mealybugs and the viruses they transmit was previously assessed for all countries in the *Final group pest risk analysis for mealybugs and the viruses they transmit on fresh fruit, vegetable, cut-flower and foliage imports* (mealybug Group PRA) (DAWR 2019). Likewise, the biosecurity risk posed by soft and hard scale insects was previously assessed for all countries in the *Final group pest risk analysis for soft and hard scale insects on fresh fruit, vegetable, cut-flower and foliage imports* (scales Group PRA) (DAWE 2021).

These Group policies are applicable for the fresh apple fruit from the PNW-USA. The department has determined that the information in those policies can be adopted for the species under consideration in this risk analysis, unless specified otherwise in a specific pest risk assessment.

### **Domestic arrangements**

The Australian Government is responsible for regulating the movement of goods such as plants and plant products into and out of Australia. The state and territory governments are responsible for plant health controls within their individual jurisdiction. Legislation relating to resource management or plant health may be used by state and territory government agencies to control interstate movement of plants and their products. After imported plant and plant products have been cleared by Australian Government biosecurity officers, they may be subject to interstate movement regulations/arrangements. It is the importer's responsibility to identify and ensure compliance with all requirements.

#### **1.2.4 Contaminating pests**

In addition to the pests of apples from the PNW-USA that are assessed in this risk analysis, other organisms may arrive with the imported commodity. These organisms may include pests of other crops or predators and parasitoids of arthropods. The department considers these organisms to be contaminating pests ('contaminants') that could pose sanitary (to human or

animal life or health) or phytosanitary (to plant life or health) risks. These risks are identified and addressed using existing operational procedures that require an inspection of all consignments during processing and preparation for export. Consignments will also undergo another inspection on arrival in Australia. The department will investigate whether any pest identified through import verification processes may be of biosecurity concern to Australia, and may thus require remedial action.

### **1.2.5 Consultation**

On 1 November 2018, the department notified stakeholders, in Biosecurity Advice 2018/29, of the commencement of a review of biosecurity import requirements for fresh apple fruit from the PNW-USA.

Prior to and after the commencement of this risk analysis, the department engaged with the Australian apple industry regarding the process and technical aspects of this risk analysis.

The department has also consulted with the US Government and Australian state and territory governments during the preparation of this report.

The draft report was released on 23 October 2020 (Biosecurity Advice 2020-P10) for a 90-day stakeholder consultation period that concluded on 21 January 2021.

The department received 62 written submissions on the draft report. All submissions received, and technical issues raised by stakeholders throughout the risk analysis process, were carefully considered, and, where relevant, changes were made in this final report. A summary of key technical stakeholder comments and how they were considered is provided in Appendix B.

### **1.2.6 Next Steps**

The final report will be published on the department's website, along with a notice advising stakeholders of its release. The department will also notify the proposer, the registered stakeholders and the World Trade Organization (WTO) Secretariat about the release of the final report. Publication of the final report represents the end of the risk analysis process.

Before any trade in apple from PNW-USA commences, the department will verify that USA can implement the required pest risk management measures, and the systems of operational procedures for the assurance, maintenance and verification of the phytosanitary status of apples for export to Australia (as specified in Chapter 5: 'Pest risk management' of this report). On verification of these requirements, the import conditions for apples from the PNW-USA will be published in the department's Biosecurity Import Conditions (BICON) system.

## 2 Method for pest risk analysis

This chapter sets out the method used for the pest risk analysis (PRA) in this report. The Department of Agriculture, Fisheries and Forestry has conducted this PRA in accordance with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for pest risk analysis* (FAO 2021a) and ISPM 11: *Pest risk analysis for quarantine pests* (FAO 2021e) that have been developed under the SPS Agreement (WTO 1995).

A PRA is ‘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 2021c). A pest is ‘any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products’ (FAO 2021c). This definition is also applied in the *Biosecurity Act 2015*.

Biosecurity risk consists of two major components: the likelihood 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 recognition that, on arrival in Australia, the department 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/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests’ (FAO 2021c).

A glossary of the terms used in the risk analysis is provided at the end of this report.

The PRAs are 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.

Appendix A: Initiation and categorisation for pests of fresh apple fruit from the Pacific Northwest States of the USA of this risk analysis report lists the pests with the potential to be associated with the exported commodity produced using commercial production and packing procedures. Appendix A: Initiation and categorisation for pests of fresh apple fruit from the Pacific Northwest States of the USA 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. 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: Initiation and categorisation for pests of fresh apple fruit from the Pacific Northwest States of the USA. The species name is used in most instances but a lower taxonomic level is used where appropriate. Synonyms are provided where

the current scientific name differs from that provided by the exporting country's National Plant Protection Organisation (NPPO) or where the cited literature used a different scientific name.

For this risk analysis, 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 the department in other risk assessments and for which import conditions already exist, this risk analysis considers the likelihood of entry of pests on the commodity and whether existing policy is adequate to manage the risks associated with its import. Where appropriate, the previous risk assessment was taken into consideration in this risk analysis. The outcomes of group pest risk analyses for thrips, mealybugs and scales have been adopted for this report, as explained in Section 2.2.7.

## **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 magnitude of the associated potential economic consequences' (FAO 2021c).

The following three consecutive steps were used in pest risk assessment:

### **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 (FAO 2021c).

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 Appendix A: Initiation and categorisation for pests of fresh apple fruit from the Pacific Northwest States of the USA. The quarantine pests identified during 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 2021e). The SPS Agreement (WTO 1995) uses the term 'likelihood' rather than 'probability' for these estimates. In qualitative PRAs, the department uses the term 'likelihood' for the descriptors it uses for its estimates of likelihood of

entry, establishment and spread. The use of the term 'probability' is limited to the direct quotation of ISPM definitions.

A summary of this process is given here, followed by a description of the qualitative methodology used in this risk analysis.

### **Likelihood of entry**

The likelihood of entry describes the likelihood 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 likelihood 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 Chapter 3. These practices are taken into consideration by the department when estimating the likelihood of entry.

For the purpose of considering the likelihood of entry, the department divides this step into two components:

- **Likelihood of importation**—the likelihood that a pest will arrive in Australia when a given commodity is imported.
- **Likelihood of distribution**—the likelihood 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 to be considered in the likelihood of importation may include:

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

Factors to be considered in the likelihood of distribution may include:

- commercial procedures (for example, 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 (for example, for planting, processing or consumption)
- risks from by-products and waste.

#### **Likelihood of establishment**

Establishment is defined as the 'perpetuation for the foreseeable future, of a pest within an area after entry' (FAO 2021c). In order to estimate the likelihood of establishment of a pest, reliable biological information (for example, lifecycle, host range, epidemiology, and survival) 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 likelihood of establishment.

Factors to be considered in the likelihood of establishment in the PRA area may 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.

#### **Likelihood of spread**

Spread is defined as 'the expansion of the geographical distribution of a pest within an area' (FAO 2021c). The likelihood 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 likelihood 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 likelihood of spread.

Factors to be considered in the likelihood of spread may 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 likelihoods for entry, establishment and spread

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). Definitions for these descriptors and their indicative ranges are given in Table 2.1. The indicative ranges are only provided to illustrate the boundaries of the descriptors and are not used beyond this purpose in qualitative PRAs. These indicative ranges provide guidance to the risk analyst and promote consistency between different pest risk assessments.

**Table 2.1 Nomenclature of likelihoods**

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

### Combining likelihoods

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 likelihood of importation is assigned a descriptor of 'low' and the likelihood of distribution is assigned a descriptor of 'moderate', then they are combined to give a likelihood of 'low' for entry. The likelihood for entry is then combined with the likelihood assigned for establishment of 'high' to give a likelihood for entry and establishment of 'low'. The likelihood for entry and establishment is then combined with the likelihood assigned for spread of 'very low' to give the overall likelihood for entry, establishment and spread of 'very low'. This can be summarised as:

importation x distribution = entry [E]

**low x moderate = low**

entry x establishment = [EE]

**low x high = low**

[EE] x spread = [EES]

**low x very low = very low**

**Table 2.2 Matrix of rules for combining 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.

The department 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 the department'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. If there are substantial changes in the volume and nature of the trade in specific commodities then the department will review the risk analysis and, if necessary, provide updated policy advice.

In assessing the volume of trade in this risk analysis, the department assumed that a substantial volume of trade will occur.

### 2.2.3 Assessment of potential consequences

The objective of the consequence assessment is to provide a structured and transparent analysis of the potential 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 2021c) and ISPM 11 (FAO 2021e).

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

- the life or health of plants and plant products  
This may include pest impacts on the life or health of the plants or production effects (yield or quality) either at harvest or during storage.
  - Where applicable, pest impacts on the life or health of humans or of animals and animal products may also be considered.
- other aspects of the environment.

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

- eradication and control  
This may include pest impacts on new or modified eradication, control, surveillance or monitoring and compensation strategies or programs.
- domestic trade  
This may include pest impacts on domestic trade or industry, including changes in domestic consumer demand for a product resulting from quality changes and effects on other industries supplying inputs to, or using outputs from, directly affected industries.
- international trade  
This may include pest impacts on international trade, including loss of markets, meeting new technical requirements to enter or maintain markets and changes in international consumer demand for a product resulting from quality changes.
- non-commercial and environment  
This may include pest impacts on the community and environment, including reduced tourism, reduced rural and regional economic viability, loss of social amenity, and any 'side effects' of control measures.

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

**Local**—an aggregate of households or enterprises (a rural community, a town or a local government area).

**District**—a geographically or geopolitically associated collection of aggregates (generally a recognised section of a state or territory, such as 'Far North Queensland').

**Regional**—a geographically or geopolitically associated collection of districts in a geographic area (generally a state or territory, although there may be exceptions with larger states such as Western Australia).

**National**—Australia wide (Australian mainland states and territories and Tasmania).

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

**Indiscernible**—pest impact unlikely to be noticeable.

**Minor significance**—expected to lead to a minor increase in mortality/morbidity of hosts or a minor decrease in production but not expected to threaten the economic viability of production. Expected to decrease the value of non-commercial criteria but not threaten the criterion's intrinsic value. Effects would generally be reversible.

**Significant**—expected to threaten the economic viability of production through a moderate increase in mortality/morbidity of hosts, or a moderate decrease in production. Expected to

significantly diminish or threaten the intrinsic value of non-commercial criteria. Effects may not be reversible.

**Major significance**—expected to threaten the economic viability through a large increase in mortality/morbidity of hosts, or a large decrease in production. Expected to severely or irreversibly damage the intrinsic ‘value’ of non-commercial criteria.

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

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

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

Note: In earlier qualitative PRAs, 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 to F has been 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.

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.

**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 assessment of the overall likelihood of entry, establishment and spread and for potential consequences 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

estimate of the overall likelihood of entry, establishment and spread and the consequences of pest entry, establishment and spread. Therefore, risk is the combination of likelihood and consequence.

When interpreting the risk estimation matrix, note the descriptors for each axis are similar (for example, 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**

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

### 2.2.5 The appropriate level of protection (ALOP) for Australia

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. The ALOP for Australia, 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 the ALOP for Australia.

### 2.2.6 Adoption of outcomes from previous assessments

Outcomes of previous risk assessments have been adopted in this assessment for pests for which the risk profile is assessed as comparable to previously assessed situations.

The prospective adoption of previous risk assessment ratings is considered on a case-by-case basis by comparing factors relevant to the current commodity/country pathway with those assessed previously. For assessment of the likelihood of importation, factors considered/compared include the commodity type, the prevalence of the pest and commercial

production practices, whereas for assessment of the likelihood of distribution of a pest the factors include the commodity type, the time of year when importation occurs, and the availability and susceptibility of hosts at that time. After comparing these factors and reviewing the latest literature, previously determined ratings may be adopted if the department considers the likelihoods to be comparable to those assigned in the previous assessment(s).

The likelihood of establishment and of spread of a pest species in the PRA area (in this instance, Australia) will be comparable between risk assessments, regardless of the commodity/country pathway through which the pest is imported, as these likelihoods relate specifically to conditions and events that occur in the PRA area, and are independent of the importation pathway. Similarly, the estimate of potential consequences associated with a pest species is also independent of the importation pathway. Therefore, the likelihoods of establishment and of spread of a pest, and the estimate of potential consequences, are directly comparable between assessments, and may be adopted with confidence.

### 2.2.7 Application of Group PRAs

The Group PRAs that were applied to this risk analysis are:

- the *Final group pest risk analysis for thrips and orthospoviruses on fresh fruit, vegetable, cut-flower and foliage imports* (the thrips Group PRA) (DAWR 2017)
- the *Final group pest risk analysis for mealybugs and the viruses they transmit on fresh fruit, vegetable, cut-flower and foliage imports* (the mealybugs Group PRA) (DAWR 2019)
- the *Final group pest risk analysis for soft and hard scale insects on fresh fruit, vegetable, cut-flower and foliage imports* (the scales Group PRA) (DAWE 2021).

The Group PRA approach is consistent with relevant international standards and requirements—including ISPM 2: *Framework for Pest Risk Analysis* (FAO 2021a), ISPM 11: *Pest Risk Analysis for Quarantine Pests* (FAO 2021e) and the SPS Agreement (WTO 1995). ISPM 2 states that ‘Specific organisms may be analysed individually, or in groups where individual species share common biological characteristics.’

Risk estimates derived from a Group PRA are ‘indicative’ in character. This is because the likelihood of entry (the combined likelihoods of importation and distribution) can be influenced by a range of pathway-specific factors, as explained in Section 2.2.6. Therefore, the indicative likelihood of entry from a Group PRA needs to be verified on a case-by-case basis.

In contrast, and as noted in Section 2.2.6, the risk factors considered in the likelihoods of establishment and spread, and the potential consequences associated with a pest species are not pathway-specific, and are therefore comparable across all import pathways within the scope of the Group PRA. This is because at these latter stages of the risk analysis the pest is assumed to have already found a host within Australia at or beyond its point of entry. Therefore, unless there is specific evidence to suggest otherwise a Group PRA assessment can be applied as the default outcome for any pest species on a plant import pathway once the previously assigned likelihood of entry has been verified.

In a scenario where the likelihood of entry for a pest species on a commodity is assessed as different to the indicative estimate, the Group PRA-derived likelihoods of establishment and

spread and the estimate of consequences can still be used, but the overall risk rating may change.

Application of Group policy involves identification of up to three species of each relevant group associated with the commodity pathway. However, if any other quarantine pests or regulated articles not included in this risk analysis and/or in the relevant group policies are detected at pre-export or on arrival in Australia, the relevant Group policy will also apply.

### **2.3 Stage 3 Pest risk management**

Pest risk management describes the process of identifying and implementing phytosanitary measures to manage risks to achieve the ALOP for Australia, 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 does not achieve the ALOP for Australia, 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 the ALOP for Australia. The effectiveness of any proposed phytosanitary measures (or combination of measures) is evaluated, using the same approach as used to evaluate the unrestricted risk, to ensure the restricted risk for the relevant pest or pests achieves the ALOP for Australia.

ISPM 11 (FAO 2021e) 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 likelihood of entry of the pest.

Examples given of measures commonly applied to traded commodities include:

- options for consignments—for example, 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—for example, 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—for example, pest-free area, pest-free place of production or pest-free production site
- options for other types of pathways—for example, consider natural spread, measures for human travellers and their baggage, cleaning or disinfestations of contaminated machinery
- options within the importing country—for example, 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 level of biosecurity risk does not achieve the ALOP for Australia. These are presented in Chapter 5: Pest risk management, of this report.

### 3 The Pacific Northwest - United States of America commercial apple production practices

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

#### 3.1 Assumptions used in estimating unrestricted risk

The USA provided Australia with information on the standard practices for commercial production of apple cultivars in the PNW-USA. This information has been complemented with data from other sources, such as published literature, and was taken into consideration when estimating the unrestricted risks of pests that may be associated with the import of this commodity.

In August 2010 and March 2016, officers from the Department of Agriculture, Fisheries and Forestry visited apple production areas in the PNW-USA. The objective of these visits was to observe the apple production system, harvesting, processing, packing and pest management procedures. The observations by the department, and additional information provided by the USA, confirmed the production and processing procedures described in this chapter as standard commercial production practices for apple fruit for export.

In estimating the likelihood of pest introduction, it was considered that the pre-harvest, harvest and post-harvest production practices for PNW-USA apples, as described in this chapter, are implemented for all regions within the PNW-USA, and for all apple cultivars produced for export.

For example, commercial production practices already in place for three pests, apple leafcurling midge (*Dasineura mali*), fire blight (*Erwinia amylovora*) and European canker (*Neonectria ditissima*), as outlined in this chapter, were taken into consideration when assessing the risk of those pests associated with PNW-USA apples. These commercial control practices include the following:

- in-field monitoring and controls, fruit maturity testing, packing house sanitation and phytosanitary inspection prior to export for fire blight
- in-field monitoring and controls, packing house sanitation and phytosanitary inspection prior to export for European canker
- in-field monitoring and controls, packing house procedures (sorting, grading and packing house sanitation) and phytosanitary inspection prior to export for apple leafcurling midge.

This approach is consistent with the risk assessment methodology for these three pests in apples from New Zealand (Biosecurity Australia 2011b).

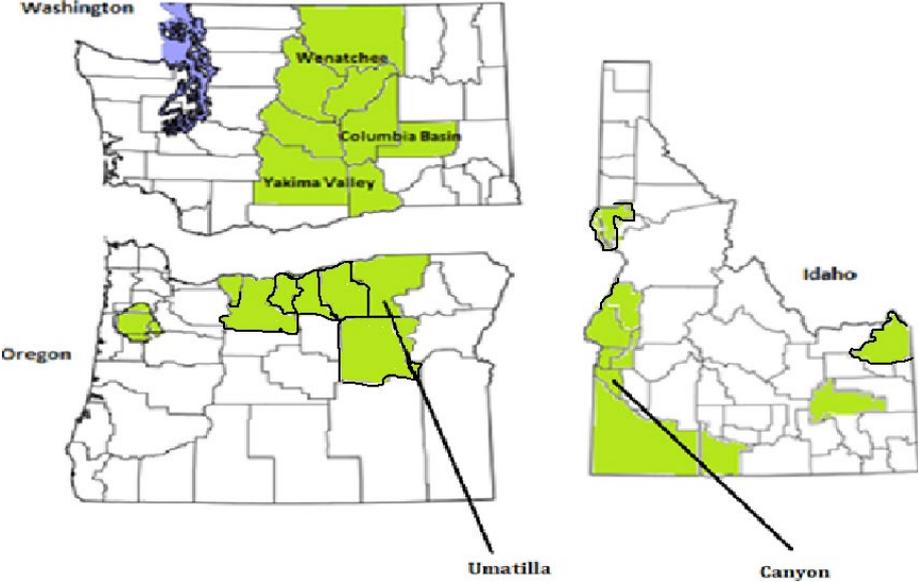
#### 3.2 Apple production areas

The PNW-USA consists of the states of Idaho, Oregon and Washington. Approximately 97% of the PNW apple crop is produced in Washington (USDA-NASS 2017a). The major production regions of Washington are the Yakima Valley, the Wenatchee region and the Columbia Basin, which are all located in the central part of the state (Map 4), east of the Cascade Range (Map 5). Washington state counties are shown in Map 6. Oregon (Map 7) and Idaho (Map 8) produce significantly less apples than Washington. The main production regions in Oregon are Willamette Valley, the Mid-Columbia Valley and Milton-Freewater area (Oregon State University

2020), with Umatilla county being the main production area. In Idaho, Canyon is the major apple producing county (Colt et al. 2001).

In 2019, Oregon and Washington had approximately 2,023 and 69,606 hectares of fruit-bearing apple trees, respectively (USDA NASS 2019a, b). In 2017, Idaho had approximately 850 hectares of fruit-bearing apple trees (USDA NASS 2017).

Map 4 Main apple production areas in the PNW-USA



Source: Based on (USDA NASS 2017, 2019a, b).

Map 5 Washington state, USA



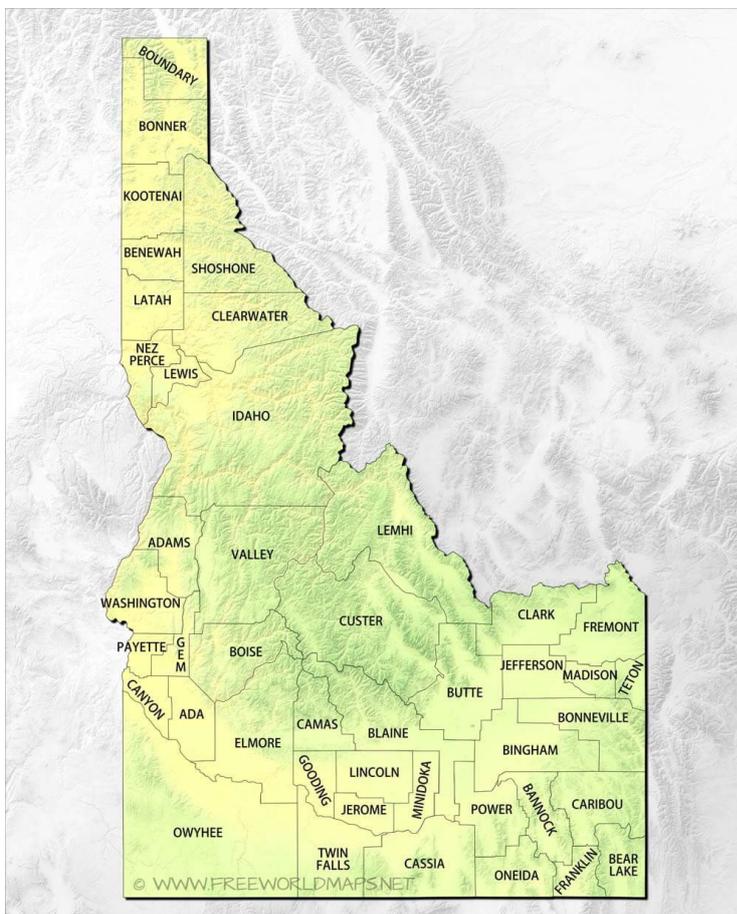
Map 6 Washington state counties



Map 7 Oregon state counties



Map 8 Idaho state counties



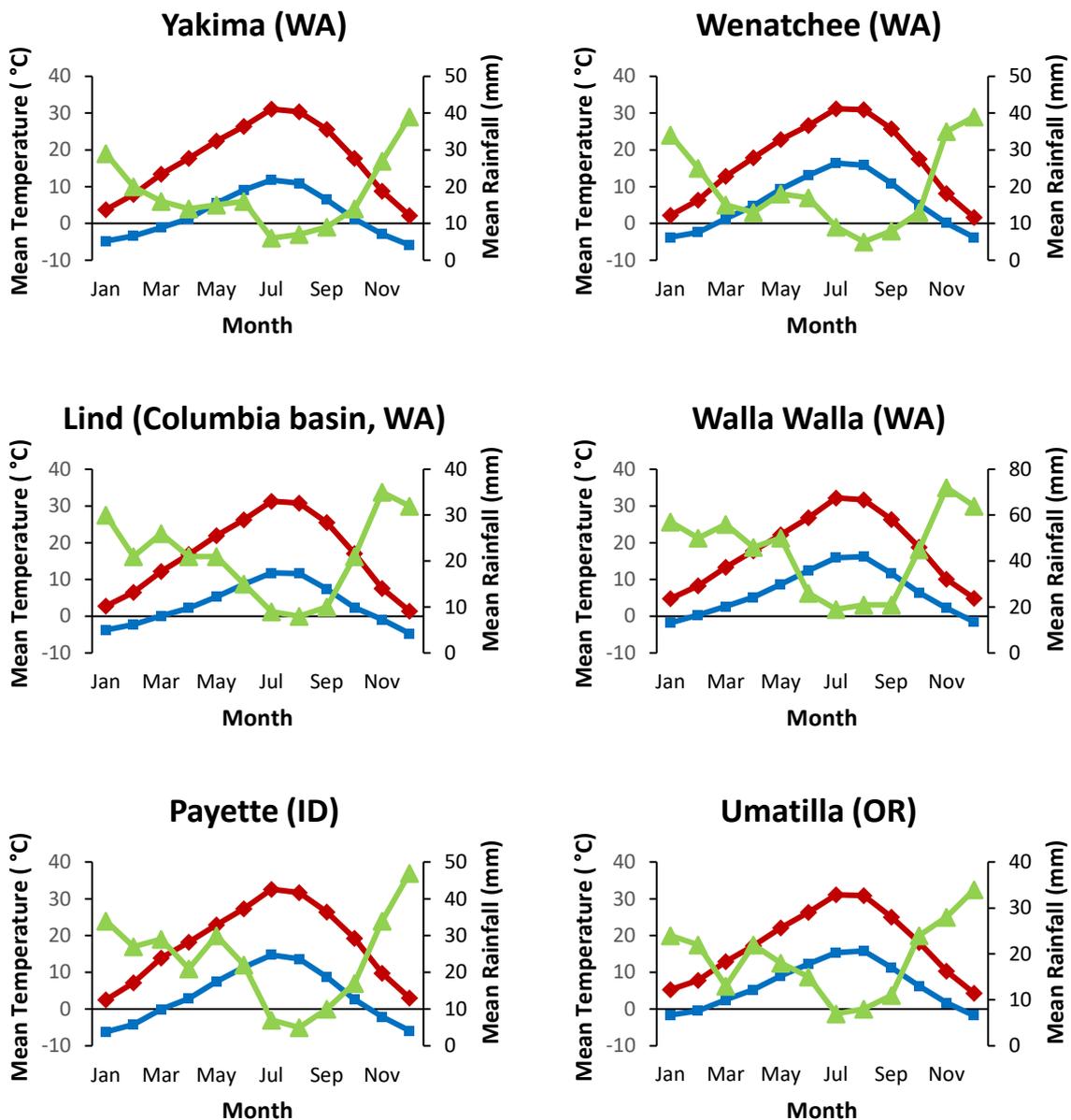
### 3.3 Climate in production areas

The PNW states of Idaho, Oregon and Washington are in the temperate climate zone. The mean monthly maximum temperature in apple growing regions in the PNW-USA can exceed 30°C in summer and the mean monthly minimum temperature can be as low as -5°C in the winter months (Figure 2). Rainfall is low in the summer months, and increases in the winter months, although this varies with location.

In Washington the apple production areas are separated by the Cascade Range, which creates two distinct climatic regions in the state (NCDC 2022). The majority of apple production regions are located east of the Cascade Range, which experience warmer summers, cooler winters and lower precipitation than those located west of the Cascade Range (western Washington), although rainfall varies with elevation (NCDC 2022).

Apple production regions in Idaho and Oregon have similar climatic conditions to those in western Washington State.

**Figure 2 Mean monthly maximum and minimum temperatures and mean monthly rainfall in main apple production areas of the PNW-USA**



Mean monthly maximum (—◆—) and minimum (—■—) temperatures (°C) and mean monthly rainfall (millimetres) (—▲—) from climatic data collected between 2007 and 2018 (<https://www.usclimatedata.com/>) in PNW regions Yakima, Wenatchee, Lind (Columbia basin), Walla Walla, Payette and Umatilla.

### 3.4 Pre-harvest

#### 3.4.1 Cultivars

Almost 100 apple varieties are grown commercially in the USA. In Washington, the major varieties grown are Red Delicious (~24%), Gala (~24%), Fuji (~14%), Granny Smith (~12%) and Honeycrisp (~10%) (USDA-NASS 2017b). Varieties grown in each region vary in number over time as popularity fluctuates.

### 3.4.2 Cultivation practices

The majority of orchards in Washington established prior to 1996 produce the varieties Red Delicious, Gala and Fuji, planted at densities of 900, 769 and 1,753 trees per hectare, respectively (USDA-NASS 2017a). In newer orchards, except for Red Delicious, trees are usually planted at higher densities—approximately 1,900 and 4,330 trees per hectare for Gala and Fuji varieties, respectively (USDA-NASS 2017b). Trees in older orchards are generally taller and wider, making pruning, spraying, fruit thinning and picking more difficult and labour intensive; trees in newer orchards are generally much smaller (Washington State University 2014). Orchards are replaced every 18 to 25 years, depending on cultivar popularity and tree damage over time (Washington State University 2014).

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 (Smith 2001). Optimal pollination requires approximately 20 to 25 bees per tree in mature orchards (Washington State University 2018a). The bees are transported from California to Oregon then Washington, following the cycle of the bloom (Smith 2001).

Fruit thinning occurs every spring (DuPont 2019b) to ensure fruit production and quality remain consistent over growing seasons. Chemical thinners are used during and shortly after the bloom period to manage fruit set, or to remove fruit that may set in clusters. Manual thinning also occurs in June and July to remove low quality fruit and fruit spaced too tightly (Washington State University 2014).

Orchards in the PNW-USA experience very low rainfall during the summer months leading up to harvest (Figure 2). Irrigation is required during the growing season; methods may include high pressure under-tree irrigation, or overhead, drip, trickle or surge irrigation systems. According to APHIS (2008), the use of overhead or high pressure systems has declined in favour of drip irrigation and micro-sprinklers to reduce the likelihood of disease spread, enhance irrigation efficiency, lower the costs of irrigation, and more efficiently apply fertilisers and pesticides. Overhead or high pressure under-tree systems may trigger disease infections, remove pesticides too soon after application, and may leach nitrogen from the soil if over-irrigation occurs (Colt et al. 2001).

Other commercial apple orchard management practices include tree pruning through the winter while trees are dormant (Smith 2001), fertiliser application, general orchard hygiene procedures and weed and pest management (Smith 2001; Washington State University 2014).

### 3.4.3 Pest management and monitoring

Pest management strategies and programs vary between counties throughout the PNW-USA, depending on climate conditions and the pest types and prevalence (Mellott 2021; Smith 2001). Most apple growers use a range of integrated pest management (IPM) practices, including pheromone disruption, timing of pesticide applications, and biological and cultural control methods.

### Arthropod pest management

Chemical control is the main method used for control of arthropod pests, and complete spray schedules of insecticides, including miticides, are available for different growing regions of Washington, Oregon and Idaho (Mellott 2021; Wiman & Stoven 2021b). However, most apple growers use a range of cultural and chemical control practices for arthropod pests.

Specific materials and formulations may be more effective in certain areas of the PNW-USA than in others. Guidance on specific management programs is provided to growers by the county agent or agricultural research centre. The state departments of agriculture license individuals to be pest control advisors. Pest control advisors work closely with the universities and research centres to provide advice to growers during regular orchard consultation and monitoring visits throughout the growing period. It is common for growers to employ one primary advisor for pest control, who also coordinates with the packing house staff.

Tree size, amount of foliage, and type of equipment used are among the factors that are important in determining the amount of spray solution used. To prolong the effectiveness of pesticides, resistance management programs are undertaken as part of IPM programs that involve sampling and monitoring, treatment thresholds, biological and cultural control (Mellott 2021; Wiman & Stoven 2021b). During these programs, the use of pesticides with the same mode of action on successive generations of a pest is not encouraged. Under Federal regulations, it is illegal to apply any pesticide in a manner, rate, or dilution that is not recommended on the label.

Biological control is also used in the PNW-USA. There are many natural enemies of tree fruit pests in the PNW-USA. Broad-spectrum pesticide sprays that disrupt biological control are avoided where possible. For control of leafrollers, parasitoid wasps are used to target eggs, larvae and pupae. Spiders and parasitoid wasps, as well as predators such as the brown lacewing, greatly reduce leafroller populations throughout the year. Parasitism is particularly intense on mature larvae just prior to pupation, a time when insecticide treatments are not effective against leafrollers but when they have a strong negative impact on the natural enemy community (Wiman, Stoven & Bush 2019). Predatory mites, such as *Typhlodromus* spp. commonly keep phytophagous mites under control if broad-spectrum insecticide applications are avoided.

Cultural control, including removal of infested material and control of weeds that provide hosts and refuge for pests, may also be used. For cultural control of phytophagous mites, broadleaf weed hosts such as mallow, bindweed, white clover and knotweed that support mite numbers are suppressed by cultivation. Regular irrigation can help to suppress mite populations, as drought-stressed trees are more susceptible to attack. Conversely, excessive nitrogen applications are avoided as high levels of foliar nitrogen can encourage mites (Wiman & Stoven 2021b). Thinning and disposal of infested or damaged fruit can help in preventing pest development and spread to other branches and trees.

Spider mite infestations can be reduced by using cover crops to reduce dust. For Lygus bugs, cultural control includes elimination of weeds that serve as protection and early season food for the insect. As Lygus bug problems are most likely to occur with alfalfa or other recognised host plants, eliminating these plants can assist with control.

### *Apple maggot regulation and management in the PNW-USA*

Apple maggot (*Rhagoletis pomonella*) is a small tephritid fly native to the northeastern United States and Canada, where it originally fed on hawthorn as a host (Wiman & Stoven 2021b). It was not until 100 years after apples were introduced to North America that it was found feeding on apples. It is now a key pest of apples in northeastern regions of the USA, where multiple insecticide sprays are necessary to produce fruit free from maggot injury and contamination. Apple maggot subsequently established in the PNW-USA, with the first reports of it infesting commercial apple crops in Portland, Oregon in 1979 (Bush et al. 2005; Fisher & Olsen 2009). By 2000 it was found in most western Oregon and western Washington counties. Apple maggot is considered to be a potential threat to the commercial northwest apple industry in the Columbia Basin (Zhao, Wahl & Marsh 2007).

Apple maggot is under official control in the PNW-USA. As per the ISPM definition of official control, PNW-USA states have phytosanitary regulations and procedures to ensure containment of apple maggot to quarantine areas and ensure maintenance of areas free of the pest. The movement of host material, including but not limited to apple fruit, into the states of Idaho, Oregon and Washington is restricted under State quarantine controls. Significant portions of the major apple production areas in Washington, Oregon and Idaho are declared as pest free areas. In order to maintain pest free areas for apple maggot under state legislation, trapping, monitoring and surveillance programs are in place, with eradication programs carried out in the event of pest incursions (Table 3.1). The Washington State Department of Agriculture has developed an extensive state-wide annual survey for apple maggot and traps to provide assurance of freedom from apple maggot flies are in place through much of the state (Beers, Antonelli & LaGasa 1996; Washington State Department of Agriculture 2019). Traps are placed in high risk areas such as host trees in populated areas, roadsides and abandoned orchards, and are inspected regularly from June through September (Beers, Antonelli & LaGasa 1996). Similarly, in the PNW states of Oregon and Idaho, pest free areas are established and maintained for counties or portions of counties through trapping, surveillance and eradication programs.

Areas within the PNW-USA where apple maggot is reported to be present (Yee et al. 2012) are declared as quarantine areas under state legislation, and the pest is monitored through trapping. Traps are best placed in areas where there is a history of activity such as in non-commercial host plants in backyards, roadsides and natural environments. Apple maggot monitoring in areas where the pest is established includes scouting and observing thresholds for action in field. Targeted insecticidal sprays are also used for control of apple maggots in quarantine areas (Yee et al. 2012). Because the pest is controlled in the adult stage prior to the deposition of eggs, contact insecticides are required for good crop protection (Dupont & Brunner 2016). If an orchard is threatened by apple maggot, insecticide applications are recommended starting 7 to 10 days after adults are predicted to emerge from the soil. A predictive model of adult apple maggot emergence is available on the Washington State University (WSU) Decision Aid System (Dupont & Brunner 2016).

While apple maggot is not subject to eradication in quarantine areas where the pest is established, various measures are aimed at preventing its spread (Sansford, Mastro & Reynolds 2016). Movement of fruit fly host materials, including but not limited to apple fruit, into PNW states, is restricted under United States Federal Regulation 7CFR301.32, which applies to species of Tephritidae (USDA-APHIS 2019). The three PNW states each also has regulatory systems as further described.

### *Washington*

The major apple growing regions in Washington have been declared as pest free areas under the Washington Agriculture Code Title 16, Chapter 470–105 (Washington State Legislature 2018). Apple maggot is not established in significant portions of the major fruit production areas east of the Cascade Range, and the state of Washington has declared the counties of Adams, Asotin, Benton, Columbia, Douglas, Ferry, Franklin, Garfield, Grant, Pend Oreille, Stevens, Walla Walla and Whitman, and portions of the counties of Kittitas, Yakima, Chelan, Lincoln and Okanogan as pest free areas for apple maggot.

Washington Agriculture Code, WAC 16-470-101, also sets out requirements for establishing quarantine areas for apple maggot (Washington State Legislature 2019). Areas under quarantine within Washington (where apple maggot is established), include the counties of Clallam, Clark, Cowlitz, Grays Harbor, Island, Jefferson, King, Kitsap, Klickitat, Lewis, Mason, Pacific, Pierce, Snohomish, Spokane, Skagit, Skamania, Thurston, Wahkiakum, and Whatcom, and portions of counties of Kittitas, Yakima, Chelan, Lincoln and Okanogan.

A quarantine status for apple maggot is declared for all US states or foreign countries where apple maggot is established. The area under quarantine includes, but is not limited to, the states of Idaho, Oregon, Utah and California, and, in the eastern United States, all states and districts east of and including North Dakota, South Dakota, Nebraska, Kansas, Oklahoma and Texas, and any other areas where apple maggot is established.

Distribution of infested or damaged fruit is prohibited under the regulation WAC 16-470-101. Regulated commodities that are known or found to be infested or damaged by apple maggot may not be distributed, sold, held for sale, or offered for sale, unless the fruit has undergone cold treatment. Requirements for interstate trade from a state regulated for apple maggot (under quarantine) into the pest free area for apple maggot are set out in WAC 16-470-113 (Washington State Legislature 2019). Shipment of fresh fruit, as specified in WAC 16-470-111(1), from an area under quarantine, as specified in WAC 16-470-105(3), into a pest free area as specified in WAC 16-470-105(1), is prohibited, unless conditions such as cold treatment are met.

Washington Agriculture Code WAC 16-470-101 (Washington State Legislature 2019) has determined that regulation and/or exclusion of fresh fruits grown or originating from areas infested with apple maggot or plum curculio is necessary to protect the environment and agricultural crops of the state.

In addition, commodities and materials regulated for apple maggot from other areas under Washington's state regulations are:

- (1) all fresh fruit of apple (including crabapple), cherry (except cherries that are commercial fruit), hawthorn, pear (except pears that are commercial fruit from California, Idaho, Oregon, Utah and Washington), plum and quince.

Note: 'Commercial fruit' can be defined as fruit produced in commercial capacity orchard blocks and processed in packing houses, both registered with U.S. government or other regulatory authorities, producing export quality fruit that meet the hygiene requirements and are subjected to regulatory controls by the Federal and State authorities. These orchards and facilities are required to have the necessary commercial production and

additional regulatory practices required as appropriate for export. Similarly, the packing houses must have operational systems and processing practices and any regulatory controls in place as required.

- Non-commercially produced fruit are not allowed to move from apple maggot quarantine areas under any circumstances to the pest free areas.
  - Commercially produced cherries are exempted from the prohibition due to this commodity being not a significant host for apple maggot.
  - Commercially produced pears from the states of California, Idaho, Oregon, Utah and Washington are exempted from the prohibition as the pest is not recorded on pears in these states.
  - Any fresh fruit that are known or found to be infested or damaged are not allowed entry.
- (2) municipal solid waste, as defined in WAC 173-350-100. Municipal solid waste from the quarantine area is a potential host medium for apple maggot since it is likely to contain materials from those fruits listed above.
- (3) yard debris, organic feedstocks, organic materials and agricultural wastes, as defined in WAC 173-350-100. As per the municipal waste, yard debris, organic feedstocks, organic materials and agricultural wastes from quarantine areas are potential host media for apple maggot.

#### *Oregon*

Oregon Department of Agriculture legislation declares that portions of the Oregon counties of Gilliam, Grant, Hood River, Morrow, Sherman, Umatilla and Wasco (Oregon Secretary of State 2019) are pest free areas for apple maggot and sets out the requirements for establishing quarantine areas for apple maggot under administrative rule 603-052-0121 (Oregon Secretary of State 2019). Areas under quarantine within the Oregon state (where apple maggot is established) include the counties, or portions of, Benton, Clackamas, Clatsop, Columbia, Coos, Curry, Douglas, Gilliam, Hood River, Jackson, Josephine, Lane, Lincoln, Linn, Marion, Multnomah, Polk, Sherman, Tillamook, Yamhill, Wasco, Washington, and the City of Pendleton in Umatilla County.

Commodities that are regulated from areas under quarantine are all fresh hawthorn fruit, non-commercial fresh pear fruit, and all fresh apple (including crabapple) fruit.

The restrictions on movement within the state include certification requirements for host commodities that are produced in or shipped from the area under quarantine, and prohibition of entry into the commercial apple producing counties of Gilliam, Grant, Hood River, Morrow, Sherman, Umatilla and Wasco counties, unless each lot or shipment is accompanied by a certificate issued by the authorised agricultural official of the state from which the commodity is shipped. In western USA, not all counties in infested states have established populations of apple maggot. Provided each lot or shipment is certified by an authorised agricultural official to have been grown in a county not known to be infested with apple maggot, the commodities may be shipped to the Oregon counties of Gilliam, Grant, Hood River, Morrow, Sherman, Umatilla and Wasco (Oregon Secretary of State 2019).

Reshipments in original containers of commodities grown outside an area under quarantine are permitted if the commodities are in original unopened containers and each bears labels or other identifying marks showing their origin. This includes reshipping to the counties of Gilliam, Grant, Hood River, Morrow, Sherman, Umatilla and Wasco.

Apples exposed to controlled atmosphere storage in approved facilities where temperatures are maintained for a continuous period of 90 days at 3.3°C (38°F) or below or for a continuous period of at least 40 days at 0°C or below are also permitted entry into the counties of Hood River, Morrow, Umatilla and Wasco (Oregon Secretary of State 2019).

#### *Idaho*

Idaho state Department of Agriculture legislation, administrative rule 02.06.05, sets out requirements for apple maggot monitoring (Idaho Department of Agriculture 2021). All fresh fruit of apple (including crabapple), cherry (except cherries that are commercial fruit), hawthorn, pear (except pears that are commercial fruit from California, Idaho, Oregon, Utah and Washington), plum, quince and rose hips are regulated. Regulated articles that are produced in or shipped from infested areas are prohibited movement into or within the state of Idaho. The entire counties of Canyon, Owyhee and Payette, and portions of the counties of Gem and Washington lying south of the quarantine areas are declared pest free areas for apple maggot. Areas (infested) declared by the director to be under quarantine for apple maggot (where the pest is established) include the counties of Franklin, Oneida, Caribou, Ada, Boise and Gooding, and portions of Gem and Washington counties (Idaho Department of Agriculture 2021). Infested areas outside Idaho include all US states or foreign countries, or portions thereof, where apple maggot is known to occur.

Apples exposed to controlled atmosphere storage, where temperatures are maintained at 3.3°C (38°F) or below for a continuous period of 90 days, may be permitted to move from quarantine areas to other areas.

#### *Apple leafcurling midge management*

Apple leafcurling midge (*Dasineura mali*) is a small fly that belongs to the family Cecidomyiidae (gall midges). In the PNW-USA, *D. mali* has a restricted distribution, being only reported in parts of the state of Washington and no reports of the pest in the states of Idaho and Oregon (CABI 2022). In Washington, *D. mali* has only been reported in the counties of Whatcom, Skagit, Okanogan and Adams (Othello region) (Antonelli & Glass 2005; Beers 2017; Eddy 2013; LaGasa 2007). Where *D. mali* occurs in Washington, the apple industry has orchard control practices and packing house procedures in place (CABI 2022).

Insecticides such as abamectin and spinosad are regularly used in the orchards at 14 to 28 days after full bloom and at pre-harvest (summarised in Table 3.1).

In addition to in-field controls, standard packing house procedures in the PNW-USA, including sorting, grading and packing house sanitation (see Section 3.6) contribute to reducing *D. mali* association with commercial apple fruit.

Commercial production practices in the PNW-USA for apple fruit for export also include phytosanitary inspection prior to export (see Section 3.6).

### *Codling moth management*

Codling moth is a lepidopteran pest that belongs to the family Tortricidae; it is a serious pest of apples in the PNW-USA (Wiman & Stoven 2022), especially in warmer, drier areas. Sampling and threshold monitoring predict the development of codling moth by the accumulation of heat units, or degree-days using phenology models. By knowing the stage of the insect, management can be targeted to susceptible life stages. Treatments target the eggs or the wandering larvae during the brief period between egg hatch and the time when the larva is able to penetrate the fruit, where it is protected. Phenology model recommendations are generated by the local extension resources, crop consultants, software systems, or by using an online degree-day calculator.

Applications of biological insecticides of granulosis virus are used (Washington State University 2019a), which is a selective biological agent that must be ingested to be effective; therefore, thorough leaf coverage is important. The virus degrades when exposed to UV light, so where a grower relies on granulosis virus for codling moth control, frequent (every 7 to 10 days) applications are necessary, especially when codling moth pressure is high. The virus controls larvae, but some fruit damage may be evident.

Cultural control of codling moth in small orchards may involve removing and disposing of young, damaged fruit. Throughout the season, fruit are checked for signs of infestation. Removing and destroying infested fruit prior to larval emergence and pupation can help reduce overall pest populations. Removing fallen fruit from the ground can also be an effective sanitation measure (Wiman, Stoven & Bush 2019).

Mating disruption is also used to manage codling moth. Pheromone dispensers placed in the orchard slowly release synthetic pheromones that interfere with mating communication from female to male moths and this prevents or delays mating, thus reducing the number of eggs laid and crop damage. Dispensers are typically applied to trees at densities of 200 to 400 dispensers per acre, sometimes with a higher density of dispensers at orchard borders. Pheromone dispensers can be applied to dormant trees and must be in place before the first moth flight around the time of full bloom. To apply mating disruption successfully, the orchards must be large, ideally greater than 10 acres, and success increases when neighbouring orchards also use the technique. Pheromone dispensers are placed within 0.6 metres of the top of the canopy. If the orchard has a history of codling moth problems, one or more insecticide applications are used against the first generation of larvae. If a codling moth source exists nearby, border sprays (five to six tree-rows) of insecticides are used.

The pheromones used for mating disruption can also be used as a monitoring method through pheromone traps, which are set in the upper third of the orchard canopy. If more than five male moths are captured in a trap over the first generation, the orchard is checked for fruit damage, or a conventional insecticide is applied. If fruit damage exceeds 0.5% at the end of the first generation, conventional insecticides are used to provide supplemental control against the second generation. If more than two male moths are captured in a trap during the second generation, use of a conventional insecticide may also be necessary.

## Pathogen management

### *Fire blight*

Fire blight is an important bacterial disease of apple, pear and other rosaceous hosts caused by *Erwinia amylovora* (Beer 1990; Stockwell, Johnson & Loper 2002) and is reported in the PNW-USA. Infections of developing fruit can occur in the PNW-USA during bloom and in the three-week period following petal fall (Bonn & Van der Zwet 2000; Dupont 2019c; Smith 1999). In Washington there have been minor outbreaks annually since 1991, and serious damage to foliage on about 5 to 10% of orchards was reported in 1993, 1997, 1998, 2005, 2009, 2012, 2015, 2016, 2017 and 2018 (Dupont 2019c). Bacterial growth is minimal below 10°C, and relatively slow at air temperatures between 10°C to 21.1°C. At air temperatures above 21.1°C, the rate of cell division increases rapidly and is highest at 26.7°C. Above 35°C, cell density on and in the plant tends to decline (Pusey & Curry 2004). Smith (2001) reported that the weather during bloom in the PNW-USA is generally too cool (20°C or less daily maxima) for primary blossom infections. In addition to warm temperatures, moisture is required, and as little as two to three hours of wetting is sufficient to trigger infections (Dupont 2019c). There is a risk of fire blight infection of developing fruit any time there are flowers on the tree, the weather is warm, and wetting occurs.

The elements of fire blight management in PNW-USA include keeping field inoculum levels low by use of winter pruning, and application of chemical or biological controls at high-risk times predicted by modelling.

Pacific Northwest growers use temperature risk modelling (CougarBlyt/CougarBlight model) for disease event prediction (Smith 1999; Smith 2006), and the risk of fire blight infections during bloom is calculated based on the temperature and moisture levels in the area. The model assists growers in determining the timing of commencement of control measures in susceptible production areas, as predicted on the basis of the number of hours of moisture at temperatures above 21.1°C over the previous four days (Pusey & Curry 2004). The model then projects risk for the next three days based on predicted temperatures.

In the PNW-USA, in-field management of *E. amylovora* is conducted throughout the year during delayed dormant, pre-pink, pink, bloom, petal fall and pre-harvest stages.

In-field controls during blooming include spray programs with antibiotics, biological control programs (for example, Blossom Protect), and application of fixed copper sanitation prior to and after blooming, to minimise risk of fruit infections (Dupont 2019c). By protecting the secondary blossom using spray during the three weeks after petal fall, infection in the most common periods can be avoided (Dupont 2019c).

The use of lime sulphur as a fruit crop load-thinning agent, as sprayed in early bloom by growers in the PNW-USA, has also proven to be toxic to the pathogen, as well as effective in reducing the number of flowers and thus the number of potential infection sites (Johnson 2014).

Conventional management such as fixed copper sanitation is applied in field at the pre-bloom stage if *E. amylovora* was reported the previous year in the orchard. Blossom Protect, which is a formulation of the yeast *Aureobasidium pullulans*, is applied as a biological control agent by growers in the PNW-USA at the early bloom stage. The yeast colonises flowers when applied as a spray, and provides excellent protection of both stigmas and nectaries from *E. amylovora* (Johnson 2014). During high infection risk periods, antibiotics such as kasugamycin are applied

within a 24-hour window before predicted flower wetting (DuPont 2019a). Kasugamycin and streptomycin can also be applied up to 12 hours after a moisture event, but with reduced effectiveness. Streptomycin has locally systemic activity. Kasugamycin is effective on bacteria that have been washed into the floral cup but not yet invaded the flower. However, antibiotic resistance does occur in the USA.

Winter pruning is used to remove infected woody plant material ('cankers') from the trees while the pathogen is inactive in the dormant host. Summer pruning is undertaken at least 30 to 45 cm around the infection area and more aggressively in young, vigorously growing trees or in susceptible varieties (Dupont 2019c). Elkins (2015) reported that late dormant copper applications may also assist orchard sanitation and reduce inoculum levels into spring. In young orchards, removal of late blooms limits the number of flowers, and thus reduces potential points of infection (Dupont 2019c).

Cultural controls and other in-field management practices to control fire blight include managing weeds and cover crops to limit relative humidity and avoiding irrigation during bloom (Dupont 2019c).

Prior to harvest, fruit maturity is monitored in each variety and orchard block in the PNW-USA using an iodine test to determine the starch pattern index (Washington State University 2019b), which is a measure of starch depletion and as a standard quality control measure for storage of apples (Washington Apple Commission 2020). Other fruit maturity tests including fruit firmness and soluble solids concentration (SSC) are also performed at this time (Washington State University 2019b).

Current in-field controls to manage fire blight by PNW-USA growers are summarised in Table 3.1.

In addition to in-field controls, standard packing house procedures in the PNW-USA, including sorting, grading and packing house sanitation (see Section 3.6) contribute to reducing association of this pest with commercial apple fruit. Commercial production practices in the PNW-USA for apple fruit for export also include phytosanitary inspection prior to export (see Section 3.6).

These practices are comparable to those practices required for apples from New Zealand in the existing policy (Biosecurity Australia 2011b).

#### *Post-harvest rot management*

Post-harvest rot fungi, such as Sphaeropsis rot (*Sphaeropsis pyriputrescens*), speck rot (*Phacidiopycnis washingtonensis*) and Phacidiopycnis rot (*Discula pyri*) are pathogens of post-harvest biosecurity concern in PNW-USA.

PNW-USA has introduced a systems approach in apple production areas for control of post-harvest rot fungi (Xiao 2013a, b). The systems approach involves orchard monitoring and in-field controls, pre-harvest and post-harvest application of fungicides, and pre-export examination of fruit. PNW state authorities have developed guidelines for growers for detecting disease symptoms caused by the rot fungi in the field and on apple fruit. In-field controls in the growing season involve monitoring of Manchurian crabapples (*Malus baccata*), which are planted in apple orchards as pollinisers, and are known to be highly susceptible to post-harvest

rot fungi. Infected branches of crabapple trees are pruned, and infected tissue and dead/dying branches are removed to reduce the inoculum levels. In addition, pre-harvest fungicide applications are used to manage inoculum levels.

Only mature symptomless fruit are picked for export. During packing house processing, apple packers apply a post-harvest fungicide by drenching the fruit when delivered to the packing house and prior to storage, or alternatively applying fungicide as a fogging treatment in cool rooms within 14 days of commencement of storage.

#### *European canker management*

European canker is a disease caused by a fungal pathogen, *Neonectria ditissima*. It is found primarily in high rainfall areas along the coast in the Willamette Valley in western Oregon and in western Washington (Pscheidt & Ocamb 2021a). *Neonectria ditissima* is rarely found in southern, central or eastern parts of Oregon, and has not been reported in eastern Washington or in Idaho. In-field control practices and packing house sanitation are used to manage European canker. In-field control includes cultural control by removing and destroying cankers during dry weather and disinfecting pruning shears. In-field fungicide applications are conducted before autumn rains for fruit rot and European canker control, and during early and/or mid- to late leaf fall for control on branches. The same fungicide applications also protect leaf scars.

In addition to in-field controls, standard packing house procedures in the PNW-USA, including sorting, grading and packing house sanitation (see Section 3.6) contribute to reducing association of this pest with commercial apple fruit. Commercial production practices in the PNW-USA for apple fruit for export also include phytosanitary inspection prior to export (see Section 3.6).

These practices are comparable to those practices required for apples from New Zealand in the existing policy (Biosecurity Australia 2011b).

**Table 3.1 Pest control program for commercially produced apples in the PNW-USA as recommended by APHIS (2014); Washington State Department of Agriculture (2019); Washington State Legislature (2019); Beers (2017); Wiman and Stoven (2022); Yee et al. (2012); Wiman and Stoven (2021a); PNW Pest Management Handbooks (2021); WSU Tree Fruit (2021b); WSU (2021) and Kaur (2022)**

Pest/s to be controlled	Apple stage/period	Control materials
Apple maggot ( <i>Rhagoletis pomonella</i> )	Pre-harvest /growing season	Trapping, monitoring and surveillance for area freedom maintenance. Where the pest is established, targeted insecticide sprays (e.g. acetamiprid, beta-cyfluthrin, chlorantraniliprole).
Fire blight ( <i>Erwinia amylovora</i> )	Pre-pink	Temperature risk models (e.g. CougarBlyt/CougarBlight model) for disease event prediction for in-field control; spray program with antibiotics; biological control agents such as Blossom Protect; fixed copper sanitation; lime sulphur.
	Pink	Temperature risk models (e.g. CougarBlyt/CougarBlight model) for disease event prediction for in-field control; spray program with antibiotics; biological control agents such as Blossom Protect; fixed copper sanitation.
	Bloom	Application of antibiotics; biological control agents such as Blossom Protect.
	Petal-fall	<i>Biological control agents</i> ; copper application; lime sulphur oil spray; application of antibiotics; continued protective programs one to two weeks post-petal fall.
	Pre-harvest	Fruit maturity testing for apples in the field.
European canker ( <i>Neonectria ditissima</i> )	All stages	In-field monitoring, cultural practices, fungicide applications.
Post-harvest rot fungi (e.g. <i>Phacidiopycnis washingtonensis</i> and <i>Sphaeropsis pyriputrescens</i> )	All stages	Systems approach involving in-field monitoring and control; pruning of Manchurian crabapple pollinisers; pre-harvest and post-harvest fungicide applications; sourcing only mature symptomless fruit; pre-export visual inspection post-cold storage.
	Pre-harvest	Fungicide spray (e.g. captan; pyraclostrobin + boscalid; ziram)
	Post-harvest	Fungicide drench or spray in line; alternatively fogging in cool rooms
Mites (e.g. <i>Tetranychus mcdanieli</i> ; <i>Cenopalpus pulcher</i> )	Dormant and delayed-dormant; Pink; Petal-fall; Late spring and summer	Hexithiazox; petroleum-based oil application; sulfur; clofentezine
Scales (e.g. <i>Diaspidiotus perniciosus</i> )	Dormant and delayed-dormant	Buprofezin; chlorpyrifos; diazinon; lime sulfur; Petroleum-based oil application
	Pre-pink	Insecticide and petroleum-based oil application
	Late spring and summer	Insecticide (e.g. diazinon)
Lygus and stink bugs (e.g. <i>Lygus elisus</i> , <i>L. hesperus</i> , <i>L. lineolaris</i> , <i>Euschistus conspersus</i> and <i>Halyomorpha halys</i> )	All stages	Insecticide (e.g. acetamiprid; beta-cyfluthrin)
Aphids (e.g. <i>Dysaphis plantaginea</i> )	Dormant and delayed-dormant	Insecticide (eg. chlorpyrifos; diazinon; and lime sulfur)
	Pre-pink; Bloom; Petal-fall; Late spring and summer	Insecticide (e.g. acetamiprid; diazinon)

<b>Pest/s to be controlled</b>	<b>Apple stage/period</b>	<b>Control materials</b>
Leafhoppers (e.g. <i>Edwardsiana rosae</i> )	14 – 28 days after full bloom Late spring and summer; Pre-harvest	Insecticide (e.g. acetamiprid; buprofezin); kaolin clay Insecticide (e.g. imidacloprid; indoxacarb); kaolin clay
Leafrollers (e.g. <i>Archips argyrospila</i> , <i>A. rosana</i> , <i>Choristoneura rosaceana</i> and <i>Pandemis pyrusana</i> )	All stages	In-field controls through insecticide sprays (e.g. chlorantraniliprole; spinosad; chlorpyrifos; pyriproxyfen; methoxyfenoxide)
Leafminers and apple leafcurling midge ( <i>Dasineura mali</i> )	14 – 28 days after full bloom; Pre-harvest	In-field monitoring and controls including broad spectrum insecticidal sprays.
Mealybugs (e.g. <i>Phenacoccus aceris</i> and <i>Pseudococcus maritimus</i> )	Delayed-dormant Pre-pink; Petal-fall; Late spring and summer	Insecticide (eg. buprofezin; diazinon) Insecticide (e.g. acetamiprid; buprofezin; diazinon)
Codling moth ( <i>Cydia pomonella</i> )	All stages	In-field monitoring, pheromone trapping and controls including insecticide sprays (e.g. chlorantraniliprole; pyriproxyfen; acetamiprid).
Cutworms and fruit moths (e.g. <i>Lacanobia</i> fruitworm)	All stages	Insecticide (e.g. emamectin benzoate; chlorantraniliprole; acetamiprid; phosmet; spinosad)
Western flower thrips ( <i>Frankliniella occidentalis</i> )	14 – 28 days after full bloom	Insecticide (e.g. spinosad)

Notes: Product replacement may occur over time due to pesticide resistance and availability of chemicals. Except for post-harvest rot fungi, this table only includes information relating to in-field controls. Standard packing house procedures used in the PNW-USA are described in Section 3.6.

### 3.5 Harvesting and handling procedures

In the PNW-USA, apple harvest occurs from August until early November, depending on the variety and the environmental conditions in the region (Washington Apple Commission 2019; Washington State University 2019b). Prior to harvest, fruit maturity is monitored in each variety and orchard block by determining the Starch Pattern Index (SPI) using an iodine test as a standard quality control measure (Washington Apple Commission 2019; Washington State University 2019b). In addition to determining SPI, fruit firmness and soluble solids concentration (SSC) are among the primary tests performed at this time (Washington State University 2019b). Fruit size, taste, and skin colouration are also considered when making harvest decisions. Apples are picked by hand, placed in bags or buckets, and emptied into large plywood or plastic bins, which are then packed on trucks and taken to the packing house (Kupferman 1999; Washington Apple Commission 2020). Harvest and packing processes are summarised in Figure 3.

### 3.6 Post-harvest

#### 3.6.1 Packing house

Apples are packed either using a direct pack system or a pre-size system (Kupferman 1996; Washington State University 2018b). The direct pack system takes apples from the bin and in one operation sorts, sizes and packs the fruit into boxes for shipping. The pre-size system packs apples in two separate steps: apples are sorted and sized, and then placed in 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 are packed at any one time in the pre-size system. The pre-size system allows a greater volume of fruit to be processed at one time.

Packing house operations include the following processes, although the order of operations may vary depending on whether the system is a direct or pre-size pack system (Kupferman 1996; Washington Apple Commission 2020):

- Fruit maturity testing - Apples from each variety and orchard block undergo maturity testing on arrival at the packing house (Washington State University 2018b) to determine if apples are at the right maturity for processing and packing for export.
- Washing - Apples are removed from the bin by floating, usually by submersion of the bin in dump tanks for washing.

Sanitiser application - In the dump tank, sanitisers such as sodium hypochlorite or calcium hypochlorite at 100ppm of chlorine are generally applied to wash apples (Kupferman 1999). A food grade detergent may also be added to the dump tank. The chlorine concentration is monitored and replenished as necessary and the pH is maintained at 6 to 8 to ensure effectiveness of the chlorine during sanitation (Amiri 2021). When chlorine is used in the dump tank, this is not combined with any fungicide treatment (Washington State University 2018b). Chlorine is commonly used as a surface disinfectant to inactivate or kill pathogenic fungi and other microorganisms during post-harvest handling of many fruit and vegetables (Brown 2002; Kupferman 1984; Suslow 2004). Roberts and Reymond (1994) showed chlorine at 100 ppm caused 99% mortality of spores of post-harvest fungal rots on tree fruit. Kupferman (1999) recorded chlorine drench at 100 ppm as a common practice in Washington packing houses to prevent post-harvest decays and for removing fungal spores.

- High pressure washing, brushing and rinsing - Apples from the dump tank are washed in a high-pressure water stream and are brushed and rinsed. Washing and brushing are likely to remove most life stages of pests on the surface of the fruit. The use of high pressure and brush-bed apple washing are important components to remove insects and mites in packing houses (Page-Weir et al. 2018; Rogers et al. 2016).
- Treatment - The apples are treated with a fungicide such as thiabendazole mixed with a wetting agent water, and applied as a line of spray (Washington State University 2018b).
- Drying - After washing and treatment, excess water is removed by rollers and brushes and apples are air-dried.
- Waxing - Wax is then applied and at the same time apples may undergo heat drying. Fungicide treatment may be applied with wax in the packing house (Washington State University 2018b), as an alternative to application as a line of spray in the packing line. When used with wax, the fungicide is pre-mixed and the wax is often applied using brushes and air dryers to ensure even application.
- Storage - Apples are usually cold-stored in bins before being sorted, graded and packed, especially if fruit are to undergo long periods of storage. Fungicide treatments may also be undertaken as fogging in the cold room during longer periods of cold storage.
- Sorting and grading - Sorting occurs based on colour and size, and is done either by machine or hand depending on the packing house. Damaged fruit and fruit with signs or symptoms of pests and diseases will also be removed.
- Inspection - Apples are inspected and defective and unwanted fruit are removed. In-house quality control officers may examine the fruit.
- Packing - Apples are manually or automatically placed onto trays, which are placed into boxes, top pads applied and the box is weighed. The boxes are palletised and placed into cold storage prior to shipment.
- Phytosanitary inspection - Prior to export, apples are inspected by regulatory (state and federal) inspectors.
- Export - Apples are transported at cold temperatures mainly by sea freight (WSU Tree Fruit 2021c), and take about five weeks to arrive in Australia.

Apples are usually cold-stored before being packed, and/or after being packed. Apples picked at the beginning of harvest ship and store best; those picked at the end of harvest, at peak ripeness, can only be held a few weeks before being shipped (Smith 2001). Late-season apples contribute about 35% of the fruit sold domestically in the autumn and early winter. The majority of fruit is stored under cold storage and under low oxygen-controlled atmosphere (CA), and is shipped from December until September in the following year (Smith 2001). Storage time may vary from one day to more than 11 months, depending on the quality of the fruit and the marketing program (Kupferman 1996). This process will allow apple fruit from the PNW-USA to be shipped to Australia all year round.

The specific atmosphere for CA storage is set according to the apple variety and capability of the storage facility (Kupferman 2001). For example, optimum levels for CA storage in Washington were reported to be 1.5% oxygen, 0.5% carbon dioxide, and 0°C to 1°C for Braeburn and Granny Smith varieties; 2.0% oxygen, 0.5% carbon dioxide, and 1°C for Fuji apples; and 2% oxygen, 1.5% carbon dioxide, and 0°C to 1°C for Golden Delicious and Royal Gala varieties (Kupferman 2001).

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).

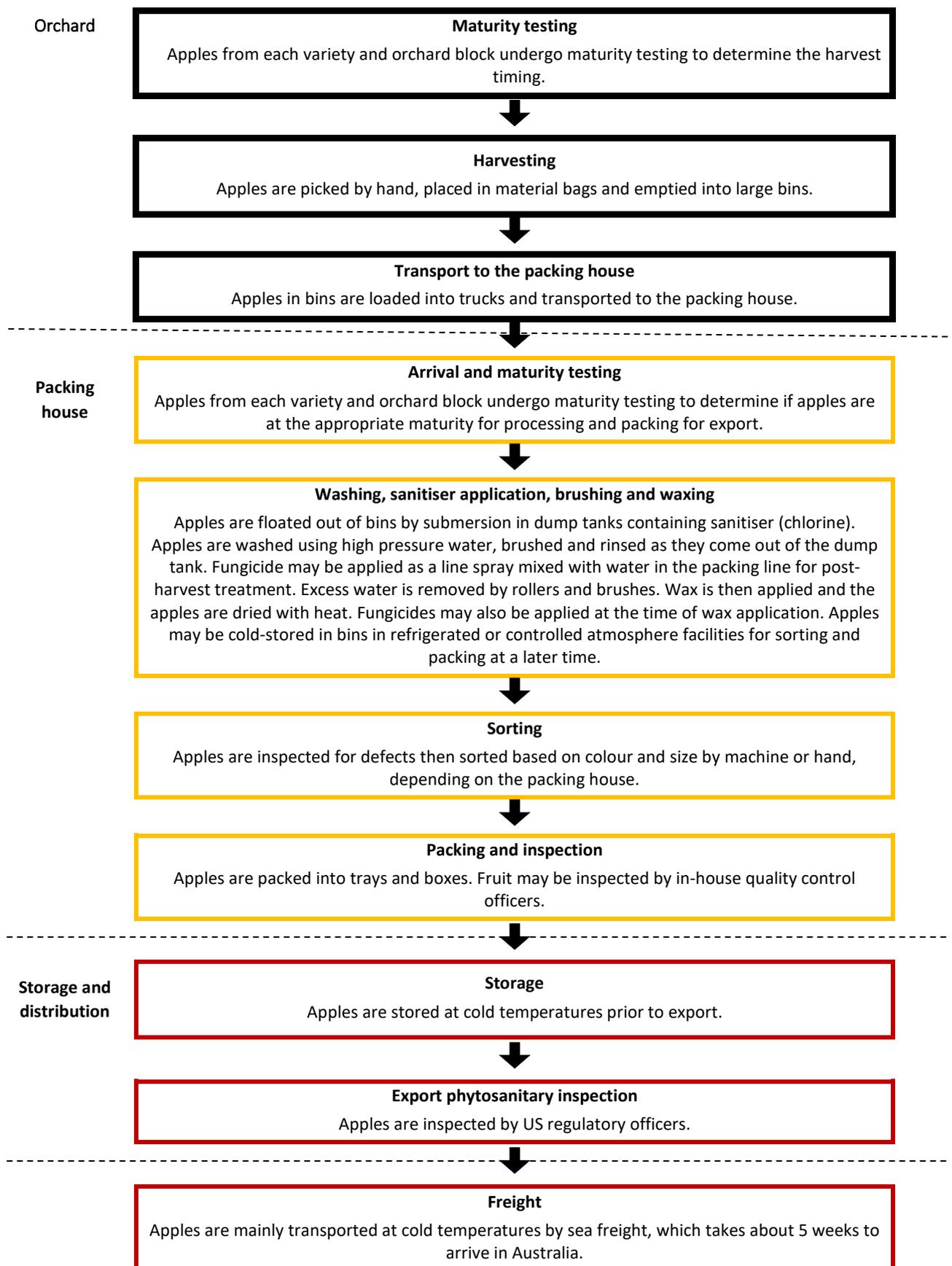
### **Export procedures**

Apples grown in PNW-USA require inspection before export and have minimum grade and size requirements (Schotzko 2005; USDA 2019; Washington State University 2019b). Apples for export are required to meet the USA Condition Standards for Export (USDA 2019), including degrees of maturity, physical injury, injury from pests and disorders, and packing requirements (USDA 2016). The Fruit and Vegetable Inspection Program, within the Commodity Inspection Division of Washington State Department of Agriculture, provides verification services for product quality, condition and volume, as well as certification of freedom from quarantine pests and diseases for international export markets. Similar arrangements are in place for the other PNW states. The program operates on delegated authority from the USDA through the agencies of the Agricultural Marketing Service and APHIS.

### **3.6.2 Transport**

Apples from the PNW-USA destined for export are transported in refrigerated trucks to ports such as Seattle, Tacoma and Portland. Apples are kept under refrigeration during transport to the destination country (Washington Apple Commission 2020). Sea freight takes about five weeks and is likely to be the preferred method of transport of apples from the PNW-USA.

Figure 3 Summary of operational steps for apple fruit grown in the PNW-USA for export



## 3.7 Export capability

### 3.7.1 Production statistics

Apples are one of the most valuable horticultural crops in the USA, valued at close to US\$4 billion per year according to annual USA apple crop statistics for 2017 (USDA-NASS 2017a). In the PNW-USA, total apple production in 2019 was 3.52 million tonnes (USDA-NASS 2020), of which Washington accounted for approximately 96%. Apple production data for 2017–2019 in the PNW-USA are listed in Table 3.2. The value of Washington State apples sold as fresh or processed product is estimated at about US\$2.5 billion annually.

**Table 3.2 PNW Apple production from 2017–2019**

PNW State	Volume in tonnes per year		
	2017	2018	2019
Idaho	21 500	24 494	Not recorded
Oregon	79 469	77 110	68 400
Washington	3 401 943	3 265 865	3 447 300
<b>PNW Total</b>	<b>3 502 912</b>	<b>3 367 469</b>	<b>3 515 700</b>

Source: USDA National Agricultural Statistics Service 2020 (USDA-NASS 2020)

### 3.7.2 Export statistics

The USA is the world's third largest apple exporter behind China and the European Union (FAO 2020). In 2019/20, the USA exported approximately 860,000 tonnes of fresh apple fruit (USDA 2020). The main export markets were Mexico, Canada, India, the Republic of China (Taiwan) and Hong Kong Special Administrative Region of the People's Republic of China (FAO 2020).

Washington State exports the largest volume of USA apples. In 2017, total apple exports from the USA to various overseas markets were 909,920 tonnes (FAO 2020), of which the PNW-USA states contributed 591,448 tonnes.

### 3.7.3 Export season

In the PNW-USA, apples are harvested from August until early November (Washington Apple Commission 2019), depending on cultivar and climate. Because apples can be stored at cold temperatures for long periods, exports may occur throughout the year.

## 4 Pest risk assessments for quarantine pests

Forty-two potential pests of biosecurity concern for Australia (Table 4.1) associated with fresh export-quality apple fruit produced in the Pacific Northwest states of the United States of America (PNW-USA) were identified in the pest categorisation process (Appendix A) as requiring further pest risk assessment. This chapter assesses the likelihood of the entry (importation and distribution), establishment and spread of these pests and the economic, including environmental, consequences these pests may cause if they were to enter, establish and spread in Australia.

Four pests identified in this assessment have been recorded in some regions of Australia but, due to interstate quarantine regulations and their enforcement, are considered regional quarantine pests. The acronym for the state or territory for which the regional quarantine pest status is considered, such as 'WA' (Western Australia), is used to identify these pests. One of these regional quarantine pests is also a regulated article for all Australia and is identified with the acronym RA.

All the pest groups considered here have been assessed previously by the department and of the 42 pest species, 33 have been assessed previously. Where appropriate, the outcomes of previous assessments for these pests have been adopted for this risk analysis, unless new information is available that suggests the risk would be different. The acronym 'EP' is used to identify species assessed previously and for which import policy already exists. The adoption of outcomes from previous assessments is outlined in Section 2.2.6.

The likelihoods of establishment and of spread of a pest in the pest risk analysis (PRA) area are comparable between assessments regardless of the commodity/country pathway on which the pest is imported into Australia, as these likelihoods relate specifically to events that occur in the PRA area. The consequences of a pest are also independent of the importation pathway. For pests that have been assessed previously, the department has also reviewed the latest literature. If there is no new information available that would significantly change the likelihood risk ratings for establishment and for spread, and the consequences the pests may cause, the risk ratings assigned in the previous assessments for these components have been adopted.

The adoption of the likelihood of distribution of pests that have been assessed previously is considered on a case-by-case basis by comparing factors relevant to the distribution of fresh apple fruit from the PNW-USA with those of commodity/country pathways assessed previously. These factors include the commodity type, the ways the imported produce will be distributed within Australia as a result of the processing, sale or disposal of the imported produce, and time of year at which import is anticipated to take place and availability and susceptibility of hosts at that time. After comparing these factors and reviewing the latest literature, previously determined ratings may be adopted if the department considers the likelihood of distribution for fresh apple fruit from the PNW-USA to be comparable to those in previous assessments and there is no new information to suggest that the ratings assigned in the previous assessments have changed.

The adoption of the likelihood of importation of pests that have been assessed previously is also considered on a case-by-case basis by comparing factors relevant to the importation of fresh apple fruit from the PNW-USA with those of commodity/country pathways assessed previously. These factors include the commodity type, prevalence of the pest, and commercial production

practices in the exporting country/region. After comparing these factors and reviewing the latest literature, previously determined ratings may be adopted if the department considers the likelihood of importation for fresh apple fruit from the PNW-USA to be comparable to those in previous assessments and there is no new information to suggest that the ratings assigned in the previous assessments have changed.

The biosecurity risk posed by thrips and the orthospoviruses they transmit from all countries was previously assessed in the *Final group pest risk analysis for thrips and orthospoviruses on fresh fruit, vegetable, cut-flower and foliage imports* (DAWR 2017). Similarly, the biosecurity risk posed by mealybugs, and the viruses they transmit, from all countries was previously assessed in the *Final group pest risk analysis for mealybugs, and the viruses they transmit on fresh fruit, vegetable, cut-flower and foliage imports* (DAWR 2019). Likewise, the biosecurity risk posed by scale insects, from all countries was previously assessed in the *Final group pest risk analysis for soft and hard scale insects on fresh fruit, vegetable, cut-flower and foliage imports* (scales Group PRA) (DAWE 2021). These Group PRAs have been applied to this risk analysis for fresh apples from the PNW-USA.

The acronym 'GP' is used to identify species assessed previously in a Group PRA and for which the Group PRA was applied. The application of the Group PRAs to this risk analysis is outlined in Section 2.2.7. A summary of assessment from the Group PRA is presented for the relevant quarantine pests and regulated articles in this chapter for convenience.

A summary of the likelihood, consequence and URE ratings obtained in each pest risk assessment is provided in Table 4.8.

**Table 4.1 Quarantine pests and a regulated article potentially associated with fresh apple fruit from the Pacific Northwest states, USA, and requiring further pest risk assessment**

<b>Pest</b>	<b>Common name</b>
<b>Flat mite [Trombidiformes: Tenuipalpidae]</b>	
<i>Cenopalpus pulcher</i> (EP)	flat scarlet mite
<b>Spider mites [Trombidiformes: Tetranychidae]</b>	
<i>Tetranychus mcdanieli</i> (EP)	McDaniel spider mite
<i>Tetranychus pacificus</i> (EP)	Pacific spider mite
<i>Tetranychus turkestanii</i> (EP)	strawberry spider mite
<b>Weevil [Coleoptera: Curculionidae]</b>	
<i>Anthonomus quadrigibbus</i>	apple curculio
<b>Gall midge [Diptera: Cecidomyiidae]</b>	
<i>Dasineura mali</i> (EP)	apple leafcurling midge
<b>Fruit fly [Diptera: Tephritidae]</b>	
<i>Rhagoletis pomonella</i> (EP)	apple maggot
<b>Scale insect [Hemiptera: Diaspididae]</b>	
<i>Parlatoria pergandii</i> (GP, WA)	chaff scale
<b>Lygus bugs [Hemiptera: Miridae]</b>	
<i>Lygus elisus</i> (EP)	pale legume bug
<i>Lygus hesperus</i> (EP)	western tarnished plant bug
<i>Lygus lineolaris</i> (EP)	tarnished plant bug
<b>Mealybugs [Hemiptera: Pseudococcidae]</b>	
<i>Phenacoccus aceris</i> (GP)	apple mealybug
<i>Pseudococcus maritimus</i> (GP)	grape mealybug
<b>Cutworm [Lepidoptera: Noctuidae]</b>	
<i>Lacanobia subjuncta</i>	Lacanobia fruitworm
<b>Leafroller and fruit moths [Lepidoptera: Tortricidae]</b>	
<i>Archips argyrospila</i> (EP)	fruit tree leafroller moth
<i>Archips podana</i> (EP)	large fruit tree tortrix
<i>Archips rosana</i> (EP)	rose tortrix
<i>Argyrotaenia franciscana</i> (EP)	orange tortrix
<i>Choristoneura rosaceana</i> (EP)	oblique banded leafroller
<i>Pandemis pyrusana</i> (EP)	apple leafroller
<i>Cydia pomonella</i> (EP, WA)	codling moth
<i>Grapholita molesta</i> (EP, WA)	oriental fruit moth
<i>Grapholita packardii</i> (EP)	cherry fruit worm
<i>Grapholita prunivora</i> (EP)	lesser appleworm
<b>Ermine moth [Lepidoptera: Yponomeutidae]</b>	
<i>Argyresthia conjugella</i> (EP)	apple fruit moth
<b>Thrips [Thysanoptera: Thripidae]</b>	
<i>Frankliniella occidentalis</i> (GP, NT) a	western flower thrips
<i>Frankliniella tritici</i> (GP)	eastern flower thrips

<b>Bacterium</b>	
<i>Erwinia amylovora</i> (EP)	fire blight
<b>Fungi</b>	
<i>Coprinopsis psychromorbida</i>	Coprinus rot
<i>Discula pyri</i>	Phacidiopycnis rot
<i>Gymnosporangium clavipes</i>	cedar-quince rust
<i>Gymnosporangium juniperi-virginianae</i>	cedar apple rust
<i>Gymnosporangium libocedri</i>	Pacific coast pear rust
<i>Neofabraea malicorticis</i> (EP)	bull's-eye rot
<i>Neonectria ditissima</i> (EP)	European canker
<i>Phacidiopycnis washingtonensis</i>	speck rot
<i>Phyllosticta arbutifolia</i> (EP)	apple blotch
<i>Sphaeropsis pyriputrescens</i>	Sphaeropsis rot
<i>Truncatella hartigii</i> (EP)	Truncatella leaf spot
<b>Viroid</b>	
<i>Apple scar skin viroid</i> (EP)	ASSVd
<b>Viruses</b>	
<i>Tobacco necrosis virus A</i> (EP)	tobacco necrosis viruses (TNVs)
<i>Tobacco necrosis virus D</i> (EP)	

**EP** Species has been assessed previously and import policy already exists. **WA** Regional quarantine pest for Western Australia. **NT** Regional quarantine pest for the Northern Territory. **GP** Species has been assessed previously in a Group PRA, and the Group PRA has been applied. **a** Thrips species that is also identified as a regulated article for Australia as it vectors emerging quarantine orthotospoviruses.

## 4.1 Flat scarlet mite

### *Cenopalpus pulcher* (EP)

*Cenopalpus pulcher* belongs to the mite family Tenuipalpidae. It is distributed throughout Europe, Africa, the Middle East, restricted areas of North America and China (Arabuli & Tskitshvili 2008; USDA-APHIS 2000; Vacante 2015). *Cenopalpus pulcher* was originally reported in PNW-USA in Benton and Linn counties in Oregon (Bajwa, Krantz & Kogan 2001) and then became established in most counties of the Willamette Valley of western Oregon (Bajwa & Kogan 2001; Bajwa & Kogan 2003). There are no reports of *C. pulcher* in the states of Washington or Idaho.

Primary hosts of *C. pulcher* are members of the family Rosaceae (Bajwa & Kogan 2003), including apple, quince and stone fruit (Vacante 2015). Other economically important hosts include citrus and grapes (Vacante 2015). *Cenopalpus pulcher* prefers feeding on the lower leaf surface, which may cause stippling of injured tissue, leaf and fruit drop, and/or twig die-back (Jeppson, Keifer & Baker 1975). It may also feed on fruit (Bajwa & Kogan 2003).

*Cenopalpus pulcher* has five life stages: egg, larva, two nymph stages (protonymph and deutonymph) and adult (Zaher, Soliman & El-Safi 1974). The scarlet-coloured adult females are approximately 0.32 mm long and 0.16 mm wide (Dosse 1953; Jeppson, Keifer & Baker 1975). Adult males are shorter and paler than females, and their abdomens are almost transparent and upward curving (Dosse 1953). Females deposit eggs on the striations, natural pits and grooves of leaves, buds, and fruits of apple and other hosts (Bajwa & Kogan 2003; Zaher, Soliman & El-Safi 1974). *Cenopalpus pulcher* is arrhenotokous (Zaher, Soliman & El-Safi 1974), which is a form of parthenogenesis where unfertilised eggs develop into haploid males.

Mating of *C. pulcher* occurs throughout summer until late summer/autumn (Dosse 1953; Zaher, Soliman & El-Safi 1974). *Cenopalpus pulcher* produces one generation per year in the cool-temperate climates of Europe and North America (Bajwa & Kogan 2003; Dosse 1953), compared with three generations per year in the warm-temperate or Mediterranean climates of Egypt (Zaher, Soliman & El-Safi 1974), Iran (Sepasgosarian 1970) and Iraq (Elmosa 1971). Before winter, the short-lived males die, while females, as nymphs or adults, enter hibernation (Bajwa & Kogan 2003; Elmosa 1971; Vacante 2015; Zaher, Soliman & El-Safi 1974). Adults and nymphs of *C. pulcher* are capable of overwintering on old leaves which may remain on the trees in winter, and also on branches and trunks (Elmosa 1971). *Cenopalpus pulcher* has been found to overwinter on the loose bark of branches, but not on smooth areas (Vacante 2015). Approximately 90 to 94% of hibernating adult females shelter under old bud scales on vegetative terminals and readily survive cold conditions (Bajwa & Kogan 2003). In its native habitat, *C. pulcher* is able to survive temperatures as cold as  $-30^{\circ}\text{C}$  (Jeppson, Keifer & Baker 1975; Sepasgosarian 1970; Vacante 2015).

The risk scenario of biosecurity concern is that eggs, nymphs and adults of *C. pulcher* may be imported on the apple fruit from PNW-USA pathway.

*Cenopalpus pulcher* has been assessed previously in the existing policy for fresh apple fruit from the People's Republic of China (China) (Biosecurity Australia 2010a). In that policy, the unrestricted risk estimate for *C. pulcher* was assessed as Low, which does not achieve the ALOP

for Australia. Therefore, specific risk management measures are required for *C. pulcher* on the apples from China pathway.

The department assessed the likelihood of importation of *C. pulcher* on fresh apple fruit from China as High. Due to the restricted distribution of *C. pulcher* in the PNW-USA, it was necessary to assess the likelihood of importation of *C. pulcher* on the fresh apple fruit from PNW-USA pathway.

The previous assessment of *C. pulcher* on apples from China rated the likelihood of distribution as Moderate. Apples from PNW-USA are expected to be distributed in Australia, as a result of processing, sale or disposal, in a similar way to apples from China. Apples can be imported all year round, therefore, there would be no seasonal differences between both import pathways to contribute to variation in the risk rating for likelihood of distribution. Apple fruit are imported for human consumption, and mites may remain on fruit during wholesale and retail distribution in Australia. Apple waste disposed of through managed waste systems is unlikely to distribute *C. pulcher* into the environment. However, apple waste discarded as litter may be deposited throughout Australia into urban, peri-urban and agricultural situations, as well as areas of natural vegetation. Crawling is the most likely mode of movement of *C. pulcher* from fruit waste to host plants, but mobility by crawling is limited due to the small size of the pest. Suitable hosts for *C. pulcher*, including fruit crops (apple, apricot, pear, pomegranate, plum, quince, citrus, grapes and walnut) and amenity trees (sycamore and willow), are commonly found in southern areas of Australia (Hnatiuk 1990). For these reasons, the same rating of Moderate for the likelihood of distribution of *C. pulcher* on the China apple pathway is adopted for the PNW-USA apple pathway.

The likelihoods of establishment and spread of *C. pulcher* in Australia from the PNW-USA apple pathway have been assessed as similar to those of the previous assessments of High and Moderate, respectively, for the apples from China pathway. These likelihoods relate specifically to events that occur in Australia and are principally independent of the import pathway. The consequences of entry, establishment and spread of *C. pulcher* in Australia are also independent of the import pathway, and have been assessed as Moderate. Therefore, the ratings for the likelihoods of establishment and spread, and the rating for the overall consequences of *C. pulcher* previously assessed for the China apple pathway have been adopted for the PNW-USA apple pathway.

In addition, the department has reviewed the latest literature—for example, Abdelgayed et al. (2017); Kontschán and Ripka (2017); Ueckermann et al. (2018) and Vacante (2015). No new information has been identified that would significantly change the risk ratings for distribution, establishment, spread or consequences as set out for *C. pulcher* in the existing policy for apples from China.

#### **4.1.1 Likelihood of entry**

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

##### **Likelihood of importation**

The likelihood that *C. pulcher* will arrive in Australia with the importation of apples from the PNW-USA is assessed as Low.

The following information provides supporting evidence for this assessment.

*Cenopalpus pulcher* is a pest of apple fruit, but has not been reported in most of the PNW-USA.

- Apple is a primary host for *C. pulcher* (Vacante 2015). Although preferring to feed on leaves, nymphs and adults may feed on apple fruit (Bajwa & Kogan 2003).
- Adult females deposit eggs on leaves, buds and fruit of apples (Bajwa & Kogan 2003; Zaher, Soliman & El-Safi 1974).
- *Cenopalpus pulcher* was originally reported on apple fruit in PNW-USA in Benton and Linn counties in Oregon (Bajwa, Krantz & Kogan 2001) and then reported to have spread to most counties of the Willamette Valley of western Oregon (Bajwa, Krantz & Kogan 2001; Bajwa & Kogan 2003; USDA-APHIS 2000).
- There are no reports of *C. pulcher* in the states of Washington or Idaho (Vacante 2015). Approximately 97% of the PNW-USA apples are produced in Washington.

Some *C. pulcher* may not be detected or removed during harvest or post-harvest processing.

- Female *C. pulcher* deposits eggs on leaf, bud and fruit of its hosts, including apples (Bajwa & Kogan 2003; Zaher, Soliman & El-Safi 1974).
- Packing house activities such as washing, brushing and waxing are likely to remove a proportion of *C. pulcher* on the surface of fruit (Jamieson et al. 2010; Page-Weir et al. 2018; Rogers et al. 2016). Some eggs and nymphs may be present in cavities around the stem and calyx (Zaher, Soliman & El-Safi 1974) and are unlikely to be removed by these activities.
- Due to its small size and cryptic nature, it is possible that not all *C. pulcher* present on fruit are likely to be detected or removed during packing house activities (Jamieson et al. 2010).

*Cenopalpus pulcher* is likely to survive cold temperatures during storage in the PNW-USA and transport to Australia.

- Adults and nymphs of *C. pulcher* can overwinter for extended periods with no known loss of fecundity (Vacante 2015). *Cenopalpus pulcher* can withstand temperatures of -30°C under field conditions in Iran (Sepasgosarian 1970).
- Overwintering of *C. pulcher* in Oregon was also reported (Bajwa & Kogan 2003).
- It is expected that *C. pulcher* present on apples are likely to survive cold temperatures during transport to Australia.

*Cenopalpus pulcher* is a pest of apple fruit and due to its small size and cryptic nature, it is likely that some pest stages will not be detected and removed during harvesting and packing house activities. This pest is likely to survive cold temperatures during storage in the PNW-USA and transport to Australia. However, *C. pulcher* has not been reported in most of the PNW-USA and is not present in the states of Washington or Idaho. Due to these reasons, the likelihood of importation of *C. pulcher* on imported apples from the PNW-USA is rated as Low.

#### **Likelihood of distribution**

The likelihood that *C. pulcher* will be distributed within Australia in a viable state as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host is considered to be similar to *C. pulcher* on apples from China. Therefore, the same rating of Moderate for the likelihood of distribution previously assessed for *C. pulcher* on the apples from China pathway is adopted for *C. pulcher* on the apples from PNW-USA pathway.

### Overall likelihood of entry

The overall likelihood of entry is assessed as Low by combining the assessed likelihood of importation of Low with the adopted likelihood of distribution of Moderate, using the matrix of rules in Table 2.2.

#### 4.1.2 Likelihoods of establishment and spread

The likelihoods of establishment and spread for *C. pulcher* are independent of the import pathway and are considered similar to those previously assessed for the apples from China pathway.

Based on the previous assessment for apples from China (Biosecurity Australia 2010a), the likelihoods of establishment and spread for *C. pulcher* are assessed as High and Moderate, respectively.

#### 4.1.3 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that *C. pulcher* will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as Low.

#### 4.1.4 Consequences

The potential consequences of the entry, establishment and spread of *C. pulcher* in Australia are similar to those in the previous assessment for *C. pulcher* on the apples from China pathway, which were assessed as Moderate (Biosecurity Australia 2010a). The overall consequences for *C. pulcher* on the apples from PNW-USA pathway are also assessed as Moderate.

#### 4.1.5 Unrestricted risk estimate

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

<b>Unrestricted risk estimate for <i>C. pulcher</i></b>	
Overall likelihood of entry, establishment and spread	Low
Consequences	Moderate
Unrestricted risk	Low

The unrestricted risk estimate for *C. pulcher* on the apples from PNW-USA pathway is assessed as Low, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for *C. pulcher* on the apples from PNW-USA pathway.

## 4.2 Spider mites

### ***Tetranychus mcdanieli* (EP), *Tetranychus pacificus* (EP) and *Tetranychus turkestanii* (EP)**

*Tetranychus mcdanieli* (McDaniel spider mite), *T. pacificus* (Pacific spider mite) and *T. turkestanii* (strawberry spider mite) belong to the Tetranychidae family. They are commonly referred to as spider mites due to their habit of spinning silken webbing on host plants. These three species have been assessed together because of their similar biology and are predicted to pose similar risks. In this assessment, the term 'spider mites' is used to refer collectively to these three species; a scientific name is used when the information relates to a specific species.

Spider mites generally have a broad host range (Hoyt & Beers 1993). *Tetranychus mcdanieli* attacks most deciduous tree fruits (including, apple, pear, sweet and sour cherry, plum, peach and apricot), raspberries, field and vegetable crops (including squash, asparagus, alfalfa and, clover), and a number of weeds (mallow, milkweed, knotweed, ragweed, mustard, dock, wild buckwheat and, wild lettuce) (Bell & Waters 2021; Hoyt & Beers 1993). *Tetranychus pacificus* and *T. turkestanii* have similar deciduous tree fruit hosts such as *Malus* spp., *Prunus* spp. as well as strawberries, citrus, grapevine and a wide range of agricultural crops (Baker & Tuttle 1994).

Spider mites feed on the contents of leaf cells, including chloroplasts, which results in small yellow-white spots on the upper leaf surface (Caprile 2015; Caprile et al. 2009b; Colt et al. 2001). In heavy infestations, the spots coalesce and the leaf yellows or bronzes resulting in premature defoliation (Wiman & Stoven 2021b). This disrupts the host plant's ability to photosynthesise, and consequently reduces the vitality of the plant (Colt et al. 2001; Wiman & Stoven 2021b). While principally found on the leaves of host plants, spider mites may also be present and feed on fruit, particularly if population densities are high during harvest (Hoyt & Beers 1993; Smith 2001; Wiman & Stoven 2021b). Fruit of infested hosts may fail to colour and form properly, and yields for the following year may decrease (Caprile 2015). Spider mites have been observed within natural cavities such as the calyx of apple fruit (Seeman & Beard 2011; Smith 2001).

Spider mites have five life stages: egg, larva, protonymph, deutonymph and adult. Adult spider mites range from 0.25 to 0.5 mm in length (Wiman & Stoven 2021b). Overwintering female spider mites are a bright orange colour and are typically found under bark, on young twigs, in soil or on weeds (Caprile et al. 2009a; Smith 2001; Wiman & Stoven 2021b). *Tetranychus mcdanieli* has four dark spots on the body. Immature stages are similar in appearance, only smaller. Eggs are round and translucent to opaque (Wiman & Stoven 2021b).

Overwintering females emerge in early spring and lay eggs on the underside of leaves (Smith 2001). Females can lay up to 10 eggs per day and more than 200 during their lifetime (Wiman & Stoven 2021b). A complete life cycle takes approximately one to three weeks, with many overlapping generations in summer, when egg to adult development can occur in 7 to 10 days (Smith 2001; Van de Vrie 1985) and the mites thrive under hot, dry conditions (Wiman & Stoven 2021b). All *Tetranychus* species are capable of both sexual and asexual reproduction, with mated females giving rise to haploid male and diploid female offspring and unmated females producing only haploid male offspring (Helle & Pijnacker 1985). Asexual reproduction (parthenogenesis) may enable a large population of male mites to develop quickly and thus increase the probability of finding a mate. Rapid reproduction occurs in hot, dry weather and the infestation peaks in July and August (Caprile 2015). Dispersal occurs mainly by wind (Wiman & Stoven 2021b).

The risk scenario of biosecurity concern is that eggs, nymphs and adults of spider mites may be imported on the apple fruit from PNW-USA pathway.

These spider mites have been assessed previously in the existing policy for stone fruit from California, Idaho, Oregon and Washington (Biosecurity Australia 2010b). In that policy, the unrestricted risk estimate for spider mites was assessed as Very Low, which achieves the ALOP for Australia. Therefore, no specific risk management measures are required for spider mites on the stone fruit from California, Idaho, Oregon and Washington pathway.

The department has assessed the likelihood of importation of spider mites in the previous policy for stone fruit from California, Idaho, Oregon as Moderate. *Tetranychus mcdanieli* is the most economically important spider mite species associated with apples in the PNW-USA (Wiman & Stoven 2021b). *Tetranychus mcdanieli* is widely distributed in the PNW-USA apple production areas (Wiman & Stoven 2021b) and may be associated with apple fruit as egg, nymphal or adult life stages (Curtis et al. 1992). *Tetranychus pacificus* and *T. turkestanii* are listed in PNW Insect Handbook 2021 (Bell & Waters 2021) as pests of vegetable crops, but can also occur on apples (CABI 2021b; Caprile 2015; Colt et al. 2001; Wiman & Stoven 2021b). Small and cryptic pests such as spider mites present on apples are likely to occupy sheltered positions, such as the calyx sinuses, and are unlikely to be fully dislodged from fruit by harvesting, post-harvest processing and grading activities (Wiman & Stoven 2021b). While extended cold storage may impact viability, their eggs are resilient, and the ability to overwinter could allow surviving females to lay additional eggs after arrival (Veerman 1985).

Due to the differences in morphology between apple fruit and stone fruit, the likelihood of importation has been assessed for these spider mite species on the PNW-USA apple pathway.

Previous assessment of spider mites on the stone fruit from California, Idaho, Oregon and Washington pathway rated the likelihood of distribution as Moderate. Apples from the PNW-USA are expected to be distributed in Australia, as a result of processing, sale or disposal, in a similar way to stone fruit from California, Idaho, Oregon and Washington. Spider mite species assessed here have a wide host range and hosts are continuously available in Australia. Therefore, any differences in time of year when imports on these two pathways occur would have very little impact on the availability and susceptibility of hosts to contribute to variation in the risk rating for likelihood of distribution. For these reasons, the same rating of Moderate for the likelihood of distribution for spider mites on the stone fruit from California, Idaho, Oregon and Washington pathway is adopted for the PNW-USA apple pathway.

The likelihoods of establishment and spread of spider mites in Australia from the PNW-USA apple pathway have also been assessed as similar to those of the previous assessments of High and High for the stone fruit from California, Idaho, Oregon and Washington pathway. Those likelihoods relate specifically to events that occur in Australia, and are essentially independent of the import pathway. The consequences of entry, establishment and spread of spider mites in Australia are also independent of the importation pathway and have been assessed as being similar between the pest risk assessments, and are rated as Low. The ratings for the likelihoods of establishment and spread of High and High, and for overall consequences of Low for spider mites on the stone fruit from California, Idaho, Oregon and Washington pathway have been adopted for the PNW-USA apple pathway.

In addition, the department has reviewed the latest literature—for example, Dar et al. (2017); Migeon and Dorkeld (2017); Perry (2014); Sutton et al. (2014); Vacante (2016) and Wiman and Stoven (2021b). No new information has been identified that would significantly change the risk ratings for distribution, establishment, spread and consequences as set out for spider mites in the existing policy for stone fruit from California, Idaho, Oregon and Washington.

#### 4.2.1 Likelihood of entry

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

##### Likelihood of importation

The likelihood that *T. mcdanieli* will arrive in Australia with the importation of apples from the PNW-USA is assessed as High. The likelihood that *T. pacificus* and *T. turkestanii* will arrive in Australia with the importation of apples from the PNW-USA is assessed as Moderate.

The following information provides supporting evidence for this assessment.

All three spider mite species, *T. mcdanieli*, *T. pacificus* and *T. turkestanii* are present in the PNW-USA and are associated with apples.

- *Tetranychus mcdanieli* is a pest of apples in production areas of the PNW-USA (Colt et al. 2001; Hoyt & Beers 1993; Seeman & Beard 2011; Smith 2001; Wiman & Stoven 2021b). Tanigoshi et al. (1975) reported that *T. mcdanieli* is a serious pest in certain years in limited areas.
- *Tetranychus pacificus* is present in the PNW-USA (Baker & Tuttle 1994). This pest can feed on apple (Baker & Tuttle 1994; Caprile 2015) but is not reported to be a pest of apples in the PNW-USA (CABI 2021b; Colt et al. 2001; Wiman & Stoven 2021b).
- *Tetranychus turkestanii* is present in the PNW-USA (Baker & Tuttle 1994) and is reported as a pest of vegetable crops in the Pacific Northwest Insect Handbook (Bell & Waters 2021). Although apple is recorded as a host for *T. turkestanii* (Balykina, Rybareva & Yagodinskaya 2021; CABI 2022; Marić et al. 2018), there are no records of this pest on apples in the PNW-USA.

*Tetranychus mcdanieli*, *T. pacificus* and *T. turkestanii* can rapidly form large populations and may be difficult to control.

- Rapid reproduction occurs in hot, dry weather and infestations peak in July and August (Caprile et al. 2009a). In warm summer conditions, *T. mcdanieli* females can lay 100 to 200 eggs during their 30-day lifetime and generations may take as few as 7 days to complete, allowing the population to increase rapidly (Colt et al. 2001; Seeman & Beard 2011; Smith 2001; Wiman & Stoven 2021b).
- Spider mites at levels of less than 15 to 20 mites per leaf are unlikely to cause economic damage (Wiman & Stoven 2021b), which may allow the build-up of mite populations before treatment is applied.
- Management of spider mites can involve a combination of methods including biological, cultural and chemical controls (Caprile 2015).
- Spider mites spin heavy mats of webbing over leaves and fruit (Hoyt & Beers 1993; Smith 2001), preventing effective chemical control (Hoyt & Beers 1993).

- Spider mites are known to rapidly develop resistance to chemical controls (Van de Vrie 1985; Wiman & Stoven 2021b).
- *Tetranychus mcdanieli* may be a serious problem on apple fruit at harvest time (Wiman & Stoven 2021b).

Some *T. mcdanieli*, *T. pacificus* and *T. turkestanii* may not be removed during post-harvest processing. Spider mites could survive cold temperatures during storage in the PNW-USA and transport to Australia.

- Packing house activities such as washing, brushing and waxing are likely to remove a proportion of mites among other pests on the surface of fruit (Jamieson et al. 2010; Page-Weir et al. 2018; Rogers et al. 2016).
- However, some spider mites are likely to survive packing house activities because their small size allows access to protected locations on fruit (Wiman & Stoven 2021b).
- Overwintering female spider mites, including *T. mcdanieli*, hide inside natural cavities of fruit (Curtis et al. 1992; Seeman & Beard 2011) and inside the calyx of apples (Hoyt & Beers 1993) where they are unlikely to be detected or removed by packing house processes.
- While cold temperatures can reduce mobility, feeding and reproduction, it is unlikely to control spider mites as female spider mites are the overwintering stage and can survive sub-zero temperatures (Veerman 1985).

For the reasons outlined above, and in recognition of the high prevalence of *T. mcdanieli* on apple fruit in the PNW-USA, the likelihood of importation of *T. mcdanieli* on apples from the PNW-USA is rated as High. However, the likelihood of importation of *T. pacificus* and *T. turkestanii* on imported apples sourced from PNW-USA is rated as Moderate due to their lesser association with apples in the PNW-USA.

#### **Likelihood of distribution**

The likelihood that spider mites will be distributed within Australia in a viable state as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host is considered to be similar to spider mites on stone fruit from California, Idaho, Oregon and Washington. Therefore, the same rating of Moderate for the likelihood of distribution previously assessed for spider mites on the stone fruit from California, Idaho, Oregon and Washington pathway is adopted for spider mites on the apples from PNW-USA pathway.

#### **Overall likelihood of entry**

The overall likelihood of entry for *T. mcdanieli* is determined as Moderate by combining the assessed likelihood of importation of High with the adopted likelihood of distribution of Moderate, using the matrix of rules in Table 2.2. The overall likelihood of entry for *T. pacificus* and *T. turkestanii* is determined as Low by combining the assessed likelihood of importation of Moderate with the adopted likelihood of distribution of Moderate.

#### **4.2.2 Likelihoods of establishment and spread**

The likelihoods of establishment and spread for spider mites are independent of the import pathway and are considered similar to those previously assessed for the stone fruit from California, Idaho, Oregon and Washington pathway.

Based on the previous assessment for stone fruit from California, Idaho, Oregon and Washington (Biosecurity Australia 2010b), the likelihoods of establishment and spread for spider mites are assessed as High and High, respectively.

#### 4.2.3 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that *T. mcdanieli* will enter Australia on apples from the PNW-USA, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as Moderate. The overall likelihood that *T. pacificus* and *T. turkestanii* will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as Low.

#### 4.2.4 Consequences

The potential consequences of the entry, establishment and spread of spider mites in Australia are similar to those in the previous assessment for spider mites on the stone fruit from California, Idaho, Oregon and Washington pathway, which were assessed as Low (Biosecurity Australia 2010b). The overall consequences for spider mites on the apples from PNW-USA pathway are also assessed as Low.

#### 4.2.5 Unrestricted risk estimate

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

<b>Unrestricted risk estimate for <i>T. mcdanieli</i></b>	
Overall likelihood of entry, establishment and spread	Moderate
Consequences	Low
Unrestricted risk	Low

The unrestricted risk estimate for *T. mcdanieli* on the PNW-USA apple pathway is assessed as Low, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for *T. mcdanieli* on the PNW-USA apple pathway.

<b>Unrestricted risk estimate for <i>T. pacificus</i> and <i>T. turkestanii</i></b>	
Overall likelihood of entry, establishment and spread	Low
Consequences	Low
Unrestricted risk	Very low

The unrestricted risk estimate for *T. pacificus* and *T. turkestanii* on the apples from PNW-USA pathway is assessed as Very Low, which achieves the ALOP for Australia. Therefore, no specific risk management measures are required for these 2 spider mites on the apples from PNW-USA pathway.

### 4.3 Apple curculio

#### ***Anthonomus quadrigibbus***

*Anthonomus quadrigibbus* (apple curculio) is a beetle of the weevil family Curculionidae and is native to North America (St. Pierre & Lehmkuhl 1990). It is associated with a wide range of plants in the Rosaceae and Cornaceae families (Burke & Anderson 1989; CABI 2021a; EPPO 2021), and its host plants include apple (*Malus domestica*), hawthorn (*Crataegus* spp.), cherry and sour cherry (*Prunus* spp.), Saskatoon berry (*Amelanchier alnifolia*), sweet crabapple (*Malus coronaria*), quince (*Cydonia oblonga*) and pear (*Pyrus* spp.) (Burke & Anderson 1989; CABI 2020a; DEFRA 2020; Jeger et al. 2018; MAFRI 2008; MOA BC 2016; St. Pierre & Lehmkuhl 1990).

*Anthonomus quadrigibbus* is distributed throughout Canada (Nova Scotia to British Columbia), Mexico (Burke & Anderson 1989; Jeger et al. 2018) and the USA, including in the PNW-USA (Burke & Anderson 1989; CABI 2021a; EPPO 2021).

*Anthonomus quadrigibbus* has four life stages: egg, larva, pupa and adult. Adults are 5 mm to 11 mm long, with the rostrum constituting one-third to one-half of the overall body length (Hammer 1936), and are reddish-brown in colour. *Anthonomus quadrigibbus* has a univoltine life cycle, completing only one generation per year (CABI & EPPO 2021; Jeger et al. 2018). Adults of *A. quadrigibbus* overwinter under debris on the ground near host trees (MAFRI 2008; University of Missouri 2008), and emerge in the spring when the ground temperature reaches 15.5°C to 16°C (CABI 2022; EPPO 2021; Hammer 1936; MAFRI 2008; University of Missouri 2008). Adults fly and disperse actively in spring, seeking suitable hosts. Adults feed on leaf petioles, flower buds, blossoms and newly-set fruits (EPPO 2021). During May to June (spring to early summer) mated females lay eggs in punctures made in small fruitlets (Davidson & Peairs 1966; Hammer 1936; Jeger et al. 2018). A female will puncture a host fruit and create a cavity with her rostrum. The cavity is sealed with frass to protect the egg (Jeger et al. 2018; St. Pierre & Lehmkuhl 1990). Females can oviposit for up to 60 days, and lay 4 to 122 eggs during their lifetime (Crandall 1905; University of Missouri 2008).

After about 5 to 7 days of incubation, the eggs hatch and larvae begin to feed within the fruit by enlarging the oviposition cavity (University of Missouri 2008) into irregular tunnels by feeding on the fruit flesh (Jeger et al. 2018). After completing three larval instars, larvae pupate in the cavity enlarged by feeding, and fully developed adults typically emerge from the fruit in mid-July to mid-August (mid-summer) (CABI 2021a; Davidson & Peairs 1966; EPPO 2021).

*Anthonomus quadrigibbus* has also been recorded as pupating in soil and debris around the base of trees (Davidson & Peairs 1966), and pupae in soil may be spread on products or machinery. *Anthonomus quadrigibbus* adults can spread from one host to another by crawling or flying. Although adults are capable of flight, they usually do not migrate very far and are relatively immobile after settling in a preferred host (MOA BC 2016; Steeves, Lehmkuhl & Bethune 1979). As a result, one part of an orchard may be severely infested while another part remains undamaged (Jeger et al. 2018), with most damage occurring in the outer two to three rows (MOA BC 2016).

The primary damage caused by apple curculio is associated with adult and larval feeding and oviposition activities. Early season feeding damage by adults results in deeply pitted, scarred

and misshapen apple fruit, while late season injury appears as depressed and darkened patches with holes (Hammer 1936).

The risk scenario of biosecurity concern is that larvae and pupae of *A. quadrigibbus* may be on imported apple fruit from the PNW-USA.

#### 4.3.1 Likelihood of entry

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

##### Likelihood of importation

The likelihood that *A. quadrigibbus* will arrive in Australia with the importation of apples from the PNW-USA is assessed as Low.

The following information supports this assessment.

*Anthonomus quadrigibbus* is a known pest of apples and is present in the PNW-USA, but is not currently considered a pest of concern of commercially produced apples in the PNW-USA.

- *Anthonomus quadrigibbus* has been recorded from Washington, Idaho and Oregon in the PNW-USA (Burke & Anderson 1989; CABI 2021a; EPPO 2021).
- Species of various genera in the Rosaceae family, such as *Amelanchier*, *Crataegus*, *Prunus*, *Pyrus* and *Sorbus*, as well as *Malus*, serve as hosts for *A. quadrigibbus*. However, cherry, Saskatoon berry, hawthorn and crabapple are recognised as being more favoured hosts of *A. quadrigibbus* than apple (Burke & Anderson 1989; Hammer 1936; MOA BC 2016).
- Pest management specialists have not recorded the pest in Washington apple orchards (Beers 2007b). Pacific Northwest Insect Management Handbooks (Hollingsworth 2019) do not record this species as a pest of concern for commercially produced apple.
- *Anthonomus quadrigibbus* is considered to be mainly a pest of wild or uncultivated apples (Campbell, Sarazin & Lyons 1989; Hammer 1936).
- (CABI 2022) reported that there is little recent information about the importance of *A. quadrigibbus* from North America, suggesting that modern control regimes have reduced it to minor pest significance.

*Anthonomus quadrigibbus* may be associated with harvested mature apples.

- *Anthonomus quadrigibbus* mated females prefer to lay eggs in small fruitlets (Davidson & Peairs 1966; Jeger et al. 2018) and larvae feed internally within the apple (Campbell, Sarazin & Lyons 1989; Davidson & Peairs 1966).
- Infested fruit generally drop prematurely from the tree; however, some infested apples may remain on the tree, in which larvae could continue their development (Burke & Anderson 1989; CABI 2020a; Campbell, Sarazin & Lyons 1989; MAFRI 2008). Pupation usually takes place in fruit, from which adults emerge and leave the fruit (Burke & Anderson 1989; CABI 2020a; Jeger et al. 2018; MAFRI 2008).
- Adults typically emerge from fruit prior to harvest in mid-July to mid-August (mid-summer) (CABI 2021a; Davidson & Peairs 1966; EPPO 2021). However, Hammer (1936) showed that adult emergence occurs later in infested apples that remain on the tree, with adults emerging until mid-September. Therefore, larvae and pupae could be present in apples at the time of harvest.

Infested apples are likely to be detected and discarded during harvesting and packing house procedures.

- Both adults and larvae of *A. quadrigibbus* cause visible feeding damage to apple fruit (Jeger et al. 2018). Infestation can be seen as small, round oviposition punctures (Jeger et al. 2018) and feeding damage by adults appears as raised russeted areas on apple fruit or as circular depressed areas around small, dark, corky spots or holes (MAL 2006). Frass on the surface of the fruit deposited by adult females covering oviposition holes (Jeger et al. 2018) can be seen. Larval feeding within the fruit enlarges the oviposition cavity (University of Missouri 2008).
- Visual inspection of host fruit can detect damage symptoms, and fruit suspected of being infested can be cut open for closer inspection (Jeger et al. 2018).

*Anthonomus quadrigibbus* larvae and pupae in fruit are not likely to survive cold temperatures during storage and transport.

- The adult is the only overwintering stage of *A. quadrigibbus*. Adults can survive sub-zero winter temperatures in north America near the host tree in the ground or under litter (Hammer 1936). There is no evidence of adults overwintering in fruit.
- Larvae and pupae are not reported to overwinter in the fruit. Any larvae and pupae in infested fruit that do not complete their development by autumn, die within the fruit due to decreasing temperatures (Hammer 1936).
- Larvae and pupae are therefore not likely to survive extended periods of cold temperature during storage and transport of apples. Harvested apples are normally cold stored at 0°C to 2°C from one day to more than 11 months prior to export (Good Fruit Grower 2014; Iowa State University Extension and Outreach 2008; Kupferman 1996; University of Maine 2020; WSU Tree Fruit 2021c). Sea freight, which takes about five weeks, is likely to be the preferred method of transport of apples from the PNW-USA to Australia, during which apples will be maintained at similarly cold temperatures.

*Anthonomus quadrigibbus* is widespread in the USA, and recorded from Washington, Idaho and Oregon. *Anthonomus quadrigibbus* is associated with a wide range of plants in the Rosaceae family, including apples, however it is not currently considered a pest of concern of commercially produced apple in the PNW-USA. Larvae and adults are known to feed on early growing fruit, which typically leads to infested fruit dropping from the tree. However, infested fruit may continue to grow on the tree. Although adults typically emerge from apples prior to harvest, there is a chance that *A. quadrigibbus* larvae and pupae may be present in fruit at the time of harvest. Signs of feeding damage are highly visible, and any infested apple fruit are likely to be discarded during harvesting and packing house processes. Any *A. quadrigibbus* larvae or pupae in fruit are unlikely to survive cold temperatures during storage and transport.

For the reasons outlined, the likelihood of importation of *A. quadrigibbus* on imported apples sourced from PNW-USA is rated as Low.

### Likelihood of distribution

The likelihood that *A. quadrigibbus* will be distributed in Australia in a viable state as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host, is assessed as Moderate.

The following information provides supporting evidence for this assessment.

Imported fresh PNW-USA apples will likely be distributed throughout Australia for retail trade. Infested apple fruit showing signs of infestation are likely to be removed from distribution.

- It is expected that fresh apples imported from PNW-USA into Australia will likely be distributed for retail sale in many areas in Australia. The major population centres are likely to receive the majority of the imported apples.
- Any larvae or pupae in infested fruit are not likely to survive cold temperatures during storage and transport of fresh PNW-USA apples in Australia.
- However, once in retail stores, fruit are likely to be kept at room temperature for some of the time, which could allow any surviving *A. quadrigibbus* to resume or complete development.
- Infested fruit showing signs of infestation are likely to be removed from distribution.

Most fruit waste will be discarded in managed waste systems, but a small proportion of fruit waste may be discarded outside managed waste systems, including near suitable host plants.

- Most commercial and residential waste will be discarded into managed waste systems, from where *A. quadrigibbus* is unlikely to distribute into the environment and find a suitable host plant.
- A small portion of fruit waste may be discarded as litter in urban, rural or natural environments. Fruit waste could be discarded near suitable host plants, including commercially grown, home garden or wild host plants.

Larvae and pupae of *A. quadrigibbus* are unlikely to complete development within discarded infested fruit in Australia.

- Fresh apple fruit from PNW-USA are likely to be imported throughout the year. Temperatures in many parts of Australia and at many times of the year are likely to be suitable for the successful development of surviving larvae and pupae and emergence of adults.
- Survival and development of larvae may be affected by desiccation or decomposition of the discarded fruit. Larvae inside discarded fruit may not complete their development before the fruit desiccates or rots.
- Mortality of larvae in fallen apples has also been reported to be caused by fungi and insects (Hammer 1936).

The limited dispersal behaviour and preference to stay on the same host are likely to reduce the ability of *A. quadrigibbus* to find a suitable host.

- *Anthonomus quadrigibbus* is associated with a wide range of plants in the Rosaceae and Cornaceae families (Burke & Anderson 1989; CABI 2021a; EPPO 2021). Host plants include apple (*Malus domestica*), hawthorn (*Crataegus* spp.), cherry and sour cherry (*Prunus* spp.), Saskatoon berry (*Amelanchier alnifolia*), sweet crabapple (*Malus coronaria*), quince (*Cydonia oblonga*), pear (*Pyrus* spp.) and red osier dogwood (*Cornus sericea*) (Burke & Anderson 1989; DEFRA 2020; Jeger et al. 2018; MAFRI 2008; MOA BC 2016). Host plants in the Rosaceae and Cornaceae families are distributed throughout Australia.
- Although *A. quadrigibbus* adults are known to be able to fly at least 400 m (Crandall 1905; Hammer 1936), they usually do not migrate very far and are relatively immobile after settling on a preferred host (MOA BC 2016; Steeves, Lehmkuhl & Bethune 1979).

Apple fruit from PNW-USA will likely arrive and be distributed in Australia throughout the year. Cold temperatures during storage and transport of fresh PNW-USA apples around Australia are

likely to inhibit development or kill any immature stages of *A. quadrigibbus* within infested fruits. A small proportion of infested apples may be discarded in natural environments, including near suitable host plants. While temperatures in many parts of Australia and at many times of the year are likely to be suitable for the development and emergence of *A. quadrigibbus*, larvae within infested discarded fruit may not complete their development due to desiccation or decomposition of the fruit. Host species and fruiting stage preferences and limited dispersal behaviour are factors likely to further restrict the distribution of *A. quadrigibbus*.

For the reasons outlined, the likelihood of distribution of *A. quadrigibbus* on imported apples sourced from PNW-USA is rated as Moderate.

### Overall likelihood of entry

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

The likelihood that *A. quadrigibbus* will enter Australia as a result of trade in apples from the PNW-USA and be distributed in a viable state to a susceptible part of a host is assessed as Low.

### 4.3.2 Likelihood of establishment

The likelihood that *A. quadrigibbus* will establish in Australia based on a comparison of factors in the source and destination areas that affect pest survival and reproduction is assessed as Moderate.

The following information provides supporting evidence for this assessment.

*Anthonomus quadrigibbus* feeds on a broad range of host plants that are widely available in Australia.

- *Anthonomus quadrigibbus* is associated with a wide range of plants in the Rosaceae and Cornaceae families (Burke & Anderson 1989; CABI 2021a; EPPO 2021). Host plants include apple (*Malus domestica*), hawthorn (*Crataegus* spp.), cherry and sour cherry (*Prunus* spp.), Saskatoon berry (*Amelanchier alnifolia*), sweet crabapple (*Malus coronaria*), quince (*Cydonia oblonga*), pear (*Pyrus* spp.) and red osier dogwood (*Cornus sericea*) (Burke & Anderson 1989; CABI 2020a; DEFRA 2020; Jeger et al. 2018; MAFRI 2008; MOA BC 2016).
- Host plants in the Rosaceae and Cornaceae families are widely distributed in Australia.
- Small fruit or fruitlets are preferred over large or mature fruit (Crandall 1905; Hammer 1936; Jeger et al. 2018). The climate in some areas of Australia is suitable for the establishment of *A. quadrigibbus*.
- *Anthonomus quadrigibbus* is distributed throughout Canada (Nova Scotia to British Columbia), the USA (except Nevada and Wyoming), and Mexico (Burke & Anderson 1989; Jeger et al. 2018). Similar climatic conditions are present in some areas of Australia (Peel, Finlayson & McMahon 2007).

*Anthonomus quadrigibbus* has a relatively low rate of reproduction.

- *Anthonomus quadrigibbus* has a univoltine life cycle, completing only one generation per year (CABI 2022; Davidson & Peairs 1966; Jeger et al. 2018; MAFRI 2008). Females lay 4 to 122 eggs during their lifetime (Crandall 1905; University of Missouri 2008).
- Limited reproduction and low development success (Crandall 1905; Hammer 1936) are likely to minimise population growth and establishment of the pest.

*Anthonomus quadrigibbus* requires sexual reproduction to produce offspring and the chance of adults finding a mate is limited due to the expected low number of adults emerging from discarded, infested fruit and their relatively limited dispersal behaviour.

- *Anthonomus quadrigibbus* reproduces sexually (CABI 2022). Reproduction requires the successful mating between male and female adults before viable eggs are produced.
- Although adult *A. quadrigibbus* are known to be able to fly at least 400 m (Crandall 1905; Hammer 1936), they usually do not migrate very far and are relatively immobile after settling in a preferred host (MOA BC 2016; Steeves, Lehmkuhl & Bethune 1979). However, their greatest flight activity occurs when they come out of hibernation and during the mating season (Hammer 1936).
- Any adults emerging and surviving from larvae and pupae associated with discarded, infested apple fruit are likely to be low in number, which would further reduce the chance of finding a mate.

*Anthonomus quadrigibbus* can reproduce on a wide range of hosts across a broad range of climates. However, the likelihood of establishment of *A. quadrigibbus* is moderated by factors including host preference, limited chance of adult mating due to relatively limited dispersal and expected low adult numbers, and its univoltine reproductive cycle.

For the reasons outlined, the likelihood of *A. quadrigibbus* establishing in Australia from imported apples sourced from PNW-USA is rated as Moderate.

#### 4.3.3 Likelihood of spread

The likelihood that *A. quadrigibbus* will spread within Australia, based on a comparison of factors in the source and destination areas that affect the expansion of the geographic distribution of the pest, is assessed as Moderate.

The following information provides supporting evidence for this assessment.

The host range, habitat and Australian climate are favourable for the spread of *A. quadrigibbus*.

- *Anthonomus quadrigibbus* is associated with a wide range of plants in the Rosaceae and Cornaceae families (Burke & Anderson 1989; CABI 2021a; EPPO 2021). Host range includes apple (*Malus domestica*), hawthorn (*Crataegus* spp.), cherry and sour cherry (*Prunus* spp.), Saskatoon berry (*Amelanchier alnifolia*), sweet crabapple (*Malus coronaria*), quince (*Cydonia oblonga*), pear (*Pyrus* spp.) (Burke & Anderson 1989; CABI 2020a; DEFRA 2020; Jeger et al. 2018; MAFRI 2008; MOA BC 2016) and *Cornus sericea* (CABI 2022). Host plants in the Rosaceae and Cornaceae families are widely distributed in Australia.
- *Anthonomus quadrigibbus* is widespread throughout Canada and the USA, and many regions where this pest is prevalent have similar climates to parts of Australia.

Autonomous flight and movement are unlikely to be favourable for *A. quadrigibbus* to spread long distances.

- *Anthonomus quadrigibbus* can spread from one host to another by crawling or flying. Although adults are capable of flight, they usually do not migrate very far, and one part of an orchard may be severely infested while another part remains undamaged (Jeger et al. 2018).
- *Anthonomus quadrigibbus* adults are relatively immobile after settling on a preferred host. Recent reports suggest that *A. quadrigibbus* adults rarely travel far from the hosts on which they developed (MOA BC 2016).

- *Anthonomus quadrigibbus* do not migrate far in any one season (Steeves, Lehmkuhl & Bethune 1979) and may only spread to several rows of trees over a period of several years. Most orchard damage occurs in the outer 2 to 3 rows (MOA BC 2016).
- In orchards, the spread of *A. quadrigibbus* can occur through improper disposal of infested fruit. Australian standard agricultural practices in commercial orchards will reduce the likelihood of this occurring.

*Anthonomus quadrigibbus* has a low rate of survival during development.

- *Anthonomus quadrigibbus* is univoltine (CABI 2022) and has a low rate of successful development to adults (Crandall 1905; Hammer 1936), which is likely to minimise population growth and spread of the pest.

The favourable climatic conditions and availability of suitable hosts across Australia support the potential for spread of *A. quadrigibbus*. However, *A. quadrigibbus* does not readily fly long distances. Moreover, Australian standard agricultural practices, and limited pest reproductive behaviours are likely to limit its spread.

For the reasons outlined, the likelihood estimate of spread of *A. quadrigibbus* within Australia is assessed as Moderate.

#### **4.3.4 Overall likelihood of entry, establishment and spread**

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

The likelihood that *A. quadrigibbus* will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible part of a host, establish in that area and subsequently spread within Australia is assessed as Low.

#### **4.3.5 Consequences**

The potential consequences of the entry, establishment and spread of *A. quadrigibbus* in Australia have been estimated according to the methods described in Table 2.3.

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

Criterion	Estimate and rationale
<b>Direct</b>	
Plant life or health	<p>D – Significant at the district level</p> <p><i>Anthonomus quadrigibbus</i> is associated with a wide range of plants in the Rosaceae and Cornaceae families (Burke &amp; Anderson 1989; CABI 2021a; EPPO 2021). Host plants include apple (<i>Malus domestica</i>), hawthorn (<i>Crataegus</i> spp.), cherry and sour cherry (<i>Prunus</i> spp.), Saskatoon berry (<i>Amelanchier alnifolia</i>), sweet crabapple (<i>Malus coronaria</i>), quince (<i>Cydonia oblonga</i>), pear (<i>Pyrus</i> spp.) (Burke &amp; Anderson 1989; CABI 2020a; DEFRA 2020; Jeger et al. 2018; MAFRI 2008; MOA BC 2016) and <i>Cornus sericea</i> (CABI 2022).</p> <p><i>Anthonomus quadrigibbus</i> can feed on the fruit of several hosts including apples and pears (Davidson &amp; Peairs 1966), affecting fruit quality and plant health.</p> <p>Damage may result from both feeding and oviposition. Feeding damage by adults appears as raised russeted areas on apple fruit or as circular depressed areas around small, dark, corky spots or holes (MAL 2006), making the fruit unmarketable. After eggs hatch, larvae feed internally within apples, which may result in a total cessation of growth of apples and lead to malformed, knotty and undersized fruit (Davidson &amp; Peairs 1966).</p> <p>Prior to the introduction of modern pesticides and IPM programs, <i>A. quadrigibbus</i> was recorded as one of the most destructive insect pests of apple in Ontario and Quebec. <i>Anthonomus quadrigibbus</i> has steadily declined in incidence and has become a less important pest in Canada, with only occasional outbreaks in apples reported (Jeger et al. 2018; MacNay 1953), despite it not being the target of a control program.</p>
Other aspects of the environment	<p>A – Indiscernible at the district level</p> <p>There are no currently known direct consequences of this pest on any other aspects of the natural environment.</p>
<b>Indirect</b>	
Eradication, control etc.	<p>D – Significant at the district level</p> <p>Additional programs to eradicate <i>A. quadrigibbus</i> on host plants may be necessary. Existing control programs may be effective for some hosts (e.g. broad spectrum pesticide applications), but not for all hosts (e.g. apple and pear where specific integrated pest management programs are used) (APAL 2009).</p> <p>It is considered that current measures recommended in North America result in effective control of the pest. In Australia it is likely that similar pest management measures would effectively control the pest.</p> <p>Existing IPM programs may be disrupted because of the need to re-introduce or increase the use of broad-spectrum 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.</p>
Domestic trade	<p>D – Significant at the district level</p> <p>The presence of this pest in commercial production areas of commodities, such as apples and pears, may be significant at the district level due to resulting trade restrictions on the sale or movement of a wide range of commodities. These restrictions may lead to a loss of markets.</p>
International trade	<p>D – Significant at the district level</p> <p>The presence of <i>A. quadrigibbus</i> in commercial production areas of a range of commodities could have significant effects at the district level due to limitations of accessing international markets where this pest is absent. The European Union and the United Kingdom have import conditions for apples and pears from Australia that recognise Australia is free from <i>A. quadrigibbus</i>.</p>

Criterion	Estimate and rationale
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 (APVMA 2018). Additional pesticide applications or other control activities may be required to control <i>A. quadrigibbus</i> on susceptible host plants. Any additional insecticide usage may affect the environment.

#### 4.3.6 Unrestricted risk estimate

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

<b>Unrestricted risk estimate for <i>Anthonomus quadrigibbus</i></b>	
Overall likelihood of entry, establishment and spread	Low
Consequences	Low
Unrestricted risk	Very Low

The unrestricted risk estimate for *A. quadrigibbus* has been assessed as Very Low, which achieves the ALOP for Australia. Therefore, no specific risk management measures are required for this pest.

## 4.4 Apple leafcurling midge

### *Dasineura mali* (EP)

*Dasineura mali*, commonly known as the apple leafcurling midge, is a small fly that belongs to the family Cecidomyiidae (gall midges). Apple trees, including crabapple (*Malus baccata*) (Beers 2017; LaGasa 2007; Ministry of Agriculture 2016) and ornamental *Malus* species (Dupont 2020b) are the only known hosts of *D. mali*.

*Dasineura mali* is native to Europe (Antonelli & Glass, 2005). It has spread to New Zealand, Argentina, Canada and the United States where it has been present in New York and Massachusetts since the 1960s and the state of Washington since 1994. In the PNW-USA, *D. mali* has a restricted distribution, with the species only reported in parts of Washington and no reports of the species in Idaho and Oregon (Beers 2017; CABI 2022). In Washington, *D. mali* has only been reported in the counties of Whatcom, Skagit, Okanogan and Adams (Othello region) (Antonelli & Glass 2005; Beers 2017; Eddy 2013; LaGasa 2007). In areas where *D. mali* does occur, it is generally not considered an economic pest of established orchards (Beers 2017; LaGasa 2007). Maps 4-8 provide more detail on the states comprising the PNW-USA.

*Dasineura mali* can cause severe damage to foliage of developing trees where it occurs (Beers 2017; Collyer & Van Geldermalsen 1975; Kolbe 1982). Terminal shoots become stunted as a result of leaf damage. Severe defoliation may also occur if fresh terminal growth is available late in the season and if midge populations are high (Todd 1959).

*Dasineura mali* has four life stages: egg, larva (or maggot), pupa and adult. In the PNW-USA, *D. mali* produces two to three overlapping generations each season (Beers 2017; LaGasa 2007). The adult female deposits eggs in the leaf folds of immature apple leaves. After hatching, the tiny legless pinkish-orange larvae begin feeding, causing the margins of the apple leaves to become tightly curled. Infested leaves eventually roll into distorted tubes or galls, and may discolour, becoming red to brown and then brittle, before finally dropping from the tree. Fully-grown larvae are 1.5 to 2.5 mm in length (LaGasa 2007). Pupation takes place in a white silken cocoon 2 to 2.5 mm in length, usually in the ground (LaGasa 2007). There are no reports of *D. mali* larvae or pupae occurring on apple fruit in the USA (Antonelli & Glass 2005; LaGasa 2007). However, it has been reported in New Zealand that larvae falling from leaves may become caught on apple fruit, where they pupate. Under these circumstances, pupae may attach to the apple at either the stalk or calyx end of the fruit, as reported by Lowe (1993) in Smith and Chapman (1995).

The risk scenario of biosecurity concern is that larvae and/or pupae of *D. mali* may be imported on the apple fruit from PNW-USA pathway.

*Dasineura mali* has been assessed previously in the existing policy for fresh apple fruit from New Zealand (Biosecurity Australia 2011b). In that policy, the unrestricted risk estimate for *D. mali* was assessed as Negligible when certain industry commercial practices such as in-field controls and packing house procedures were routinely applied, which achieved the ALOP for Australia. Therefore, no specific risk management measures are required for *D. mali* on that pathway. Similar commercial production practices are routinely applied to PNW-USA apples (see Chapter 3), and the assessment of likelihood of importation explicitly relies on their continued implementation.

The department assessed the likelihood of importation of *D. mali* on fresh apple fruit from New Zealand as Moderate (Biosecurity Australia 2011b). However, differences in pest prevalence, climate and horticultural practices between the export areas make it necessary to assess the likelihood of importation of *D. mali* associated with the PNW-USA apple pathway.

Previous assessment of *D. mali* on the fresh apple fruit from New Zealand pathway rated the likelihood of distribution as Very Low. Fresh apple fruit from the PNW-USA is expected to be distributed in Australia (as a result of processing, sale or disposal) in a similar way to apples from New Zealand. Apples from New Zealand are harvested in February to May (AgFirst 2022) and can be exported year-round to Australia via either sea freight or air freight. In the PNW-USA, apples are harvested from August until early November (Washington Apple Commission 2019) and could be exported year-round to Australia. As apples from both New Zealand and PNW-USA may be imported throughout the year, there would be no seasonal differences between both import pathways to contribute to variation in the risk rating for likelihood of distribution.

For *D. mali* to successfully distribute within Australia and reach a susceptible part of a host in Australia, pupae entering Australia would need to survive until emergence, and be in sufficient proximity to both a host plant and an individual of the opposite sex, within a limited time window of opportunity. A very large quantity of commercially produced apples would need to be disposed in a single location, and be within flight range of an apple tree (or crabapple tree) which could serve as a host plant. It is considered that this sequence of events would be unlikely to occur. Therefore, the same rating of Very Low for the likelihood of distribution for *D. mali* on the apples from New Zealand pathway is adopted for the PNW-USA apple pathway.

The likelihoods of establishment and spread of *D. mali* in Australia from the PNW-USA apple pathway have been assessed as similar to those of the previous assessments of Moderate and Moderate, respectively, for apple fruit from New Zealand. These likelihoods relate specifically to events that occur in Australia and are principally independent of the import pathway. The consequences of entry, establishment and spread for *D. mali* are also independent of the import pathway, and have been assessed as being similar between pest risk assessments, and rated as Low. Therefore, the existing ratings for likelihoods of establishment and spread of Moderate and Moderate, respectively, and the rating for the overall consequences of *D. mali* of Low have been adopted for the PNW-USA apple pathway.

In addition, the department has reviewed the latest literature—for example, Beers (2017); He and Wang (2015); Lo and Walker (2017); Ministry of Agriculture (2016); Page-Weir et al. (2018); Wearing et al. (2013) and Yuan (2014). No new information has been identified that would significantly change the risk ratings for distribution, establishment and spread and consequences as set out for *D. mali* in existing policy.

#### **4.4.1 Likelihood of entry**

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

##### **Likelihood of importation**

The likelihood that *D. mali* will arrive in Australia with the importation of apples from the PNW-USA is assessed as Low.

The following information provides supporting evidence for this assessment.

*Dasineura mali* is present and associated with apple production in the PNW-USA.

- Although *D. mali* is present in the PNW-USA, it is reported only in parts of the state of Washington, in the counties of Whatcom, Skagit, Okanogan and Adams (Othello region) (Antonelli & Glass 2005; Beers 2017; Eddy 2013; LaGasa 2007).
- Where *D. mali* does occur in Washington, it is generally not considered an economic pest of established apple trees; orchards in those areas are subjected to several pest management practices including monitoring, insecticidal sprays and biological control (LaGasa 2007).

*Dasineura mali* may be associated with apples at the time of harvest.

- *Dasineura mali* is a foliage feeder and primarily pupates in the ground, but in cases of heavy infestation, mature larvae may occasionally pupate on fruit (Beers 2017; LaGasa 2007; Tomkins 1998). In those cases, pupae attach to the fruit at either the stalk or calyx end, as reported by Lowe (1993) in Smith and Chapman (1995)
- However, association of *D. mali* pupae with fruit is generally considered incidental, occurring when mature larvae exiting leaf-rolls get caught around the stem or calyx of fruit when attempting to drop to the ground.
- During trials of the Integrated Pest Management program in New Zealand that involved a total of 88 orchards where *D. mali* is widespread and abundant, *D. mali* infestation of apple fruit in orchards, was found to range from 0.05 to 1.4%, with an average of 0.6% over all growing regions (Walker et al. 1997).
- Lo, Walker and Suckling (2015) presented research on the prospects of *D. mali* being controlled by mass trapping with pheromone lures in New Zealand. The paper noted that populations of *D. mali* can be very high in New Zealand with an average of 900,000 adults trapped per hectare over an 11-week period. The research also noted the infestation of apple fruit by *D. mali* was low with a total of 4 infested apples found in 4,000 fruits inspected from untreated plots.
- Infested leaves may drop into and contaminate orchard bins during harvesting, providing additional opportunity for larvae to move from leaves to fruit. However, the general absence of new leaf growth on apple trees during the harvest period would suggest that incidence of such contamination would be very low.

Larvae and pupae in the stalk or calyx end of apple fruit may not be detected during harvesting and packing house processes.

- *Dasineura mali* larvae and pupae are small in size (1.5 to 2.5 mm) (Beers 2017). Therefore, infestations on apple fruit may not be visually detected during harvesting and packing house processes.
- Pupae attached to the calyx or stalk end of apples are difficult to remove even when high pressure washing is performed (Page-Weir et al. 2018).
- Interceptions of *D. mali* were reported by California Department of Food and Agriculture (CDFA 2015) at the state's border stations 89 times during 2000 to 2015, typically as pupae on apple fruit from New Zealand or PNW-USA. It was not specified what proportion of these detections was on apple fruit from the PNW-USA and if these detections occurred on commercial or non-commercial fruit. The average interception rate derived from the data is 6 detections per year.

- *Dasineura mali* has been detected on New Zealand apples exported to the USA during pre-clearance and on-arrival inspections. This indicates that *D. mali* is, at least occasionally, associated with export consignments.

*Dasineura mali* may survive cold storage in the PNW-USA and during transport to Australia.

- Harvested apples are normally cold stored at 0°C to 2°C (Kupferman 1996; WSU Tree Fruit 2021c).
- Sea freight, which takes about five weeks, is likely to be the preferred method of transport of apples from the PNW-USA to Australia, and fruit will be maintained at very low temperatures.
- While the cold tolerance of *D. mali* has not been determined, this pest overwinters as a mature larva or pupa (Beers 2017; Tomkins 1998). Mature larvae and pupae of *D. mali* may, therefore, survive cold storage and transport as they overwinter in the PNW-USA in winter temperatures.

*Dasineura mali* is a foliage feeder and pupates primarily in the ground. Association of *D. mali* pupae with fruit is considered incidental, occurring under conditions of heavy infestation when mature larvae exiting leaf-rolls attempt to drop to the ground, but become caught around the stem or calyx of apple fruit. There may also be occasional contamination by mature larvae from infested leaves in the field bins during harvesting. Pupae may survive harvesting and packing house procedures and cold storage and transport. However, *D. mali* is reported only from parts of the state of Washington and is not reported from most production areas in the PNW-USA. Where *D. mali* occurs in the state of Washington, it is generally not recognised as an economic pest of commercial apple production. For the reasons outlined, the likelihood of importation of *D. mali* on the PNW-USA apple pathway is assessed as Low.

#### **Likelihood of distribution**

The likelihood that *D. mali* will be distributed within Australia in a viable state as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host is considered to be similar to *D. mali* on apples from New Zealand. Therefore, the same rating of Very Low for the likelihood of distribution previously assessed for *D. mali* on the apples from New Zealand pathway is adopted for *D. mali* on the apples from PNW-USA pathway.

#### **Overall likelihood of entry**

The overall likelihood of entry is determined as Very Low by combining the assessed likelihood of importation of Low with the adopted likelihood of distribution of Very Low, using the matrix of rules in Table 2.2.

#### **4.4.2 Likelihoods of establishment and spread**

The likelihoods of establishment and spread for *D. mali* are independent of the import pathway and are considered similar to those previously assessed for the apples from New Zealand pathway.

Based on the previous assessment for apples from New Zealand (Biosecurity Australia 2011b), the likelihoods of establishment and spread for *D. mali* are assessed as Moderate and Moderate, respectively.

#### 4.4.3 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that *D. mali* will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as Very Low.

#### 4.4.4 Consequences

The potential consequences of the entry, establishment and spread of *D. mali* in Australia are similar to those in the previous assessment for *D. mali* on the apples from New Zealand pathway, which were assessed as Low (Biosecurity Australia 2011b). The overall consequences for *D. mali* on the apples from PNW-USA pathway are also assessed as Low.

#### 4.4.5 Unrestricted risk estimate

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

<b>Unrestricted risk estimate for <i>D. mali</i></b>	
Overall likelihood of entry, establishment and spread	Very Low
Consequences	Low
Unrestricted risk	Negligible

When industry commercial practices such as in-field controls are taken into consideration, the unrestricted risk estimate for *D. mali* on apples from the PNW-USA has been assessed as Negligible, which achieves the ALOP for Australia. Therefore, no additional practices or specific risk management measures are required for *D. mali* on the apples from PNW-USA pathway.

## 4.5 Apple maggot

### *Rhagoletis pomonella* (EP)

*Rhagoletis pomonella* belongs to the family Tephritidae and is native to eastern North America (Beers, Antonelli & LaGasa 1996; Michigan State University 2019; Weems & Fasulo 2021; Wiman, Stoven & Bush 2019; Zhao, Wahl & Marsh 2007). *Rhagoletis pomonella* is widespread in the USA, and has a restricted distribution in Canada and Mexico (Sansford, Mastro & Reynolds 2016). It was first reported to have made the transition from its native host, hawthorn (*Crataegus* spp.), to apples (*Malus pumila*) in the north-eastern USA (Michigan State University 2019; Porter 1928) in 1857. The first reports of *R. pomonella* infesting commercial apple crops in the PNW-USA were in Oregon in 1979 (Beers, Antonelli & LaGasa 1996; Bush et al. 2005; Fisher & Olsen 2009; PNW Handbooks 2019c). During the early 1980s, *R. pomonella* became established in other states of the PNW-USA (Washington and Idaho) and California, Utah and Colorado (Michigan State University 2019). By 2000, it was found in most western Oregon and Washington counties (PNW Handbooks 2019c). *Rhagoletis pomonella* is a major quarantine pest of apples in the PNW-USA (Sansford, Mastro & Reynolds 2016; Wiman, Stoven & Bush 2019; Yee 2007; Yee et al. 2012). It is recognised as a serious economic pest (Beers et al. 1993b; Sansford, Mastro & Reynolds 2016; Zhao, Wahl & Marsh 2007), and remains a potential threat to the commercial northwest apple and pear industry. There are over 30 host records for this species, all from the Rosaceae family, including apples and crabapples (*Malus* spp.), pears (*Pyrus* spp.), plums, cherries and apricots (*Prunus* spp.) and hawthorns (*Crataegus* spp.) (Bush et al. 2005; Sansford, Mastro & Reynolds 2016; Weems & Fasulo 2021; Yee & Goughnour 2006; Zhao, Wahl & Marsh 2007). However, *R. pomonella* has only been reported to attack apple and hawthorn in the PNW-USA (Oregon and Washington) (PNW Handbooks 2019c).

Details of *R. pomonella* regulation and management in the PNW-USA, which include apple fruit movement controls within and between states, establishment of pest free areas in counties or parts of counties within each of the three states under assessment here, and trapping and monitoring procedures, are summarised in Section 3.4.3 of this report. The risk assessment presented here has therefore been conducted for fresh apples sourced from areas within PNW-USA where *R. pomonella* is present, but will also apply to other areas within the PNW-USA where pest freedom status has been suspended.

*Rhagoletis pomonella* has four life stages: egg, larva, pupa and adult. Adult flies are largely black in colour, approximately 3 mm in length, and have clear wings marked with four characteristic oblique black bands (Weems & Fasulo 2002). They have a pronounced white spot on the back of the thorax and the black abdomen has white bands, of which females have four and males have three (Beers, Antonelli & LaGasa 1996; Weems & Fasulo 2002). The female has an ovipositor that can puncture fruit skin. Larvae are coloured white to yellow (Beers, Antonelli & LaGasa 1996; Weems & Fasulo 2002), and are approximately 1.0 to 1.5 cm in length, with a blunt posterior and a tapered front end that contains two black mouth hooks (Michigan State University 2019). The brownish-yellow puparia are about 4 mm long (Michigan State University 2019).

Newly emerged flies are sexually immature and spend considerable time on apple leaves feeding on honeydew excreted by aphids and other insects (Reissig 1991). Adult flies mature sexually 7 to 10 days after emergence and then congregate on fruit, where mating occurs (Michigan State University 2019). After mating, females puncture the fruit skin with their ovipositors to lay eggs.

Eggs are deposited singly under the skin of the fruit (Kaur 2022a), causing development of small brown decayed areas (PNW Handbooks 2019c), and hatch within a few days (Brunner 2016). Larvae develop through three instars as they tunnel through the fruit (Beers, Antonelli & LaGasa 1996; Dupont & Brunner 2016). Larval development times range from two weeks to several months depending on the apple variety and fruit maturing times (Weems & Fasulo 2021). Once fully developed and having completed their third-instar feeding, larvae exit the fruit, drop to the ground (Beers, Antonelli & LaGasa 1996), burrow into the soil (Beers, Antonelli & LaGasa 1996; Dupont & Brunner 2016) and molt to a fourth instar. This is quickly followed by another molt to the pupal stage, which remains in the upper levels of the soil (Michigan State University 2019).

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, initiating development of a second generation (Bush et al. 2005; Dupont & Brunner 2016). A proportion of pupae may also overwinter for two (or more) winters (Brunner 2016; Michigan State University 2019). Diapausing pupae of *R. pomonella* are reported to be the most heat and cold tolerant stage of *R. pomonella* (Sansford, Mastro & Reynolds 2016). Cold tolerance of diapausing pupae was observed at temperature range of -23°C to -25°C (Sansford, Mastro & Reynolds 2016).

Adults begin emerging from the soil from mid-June to early July (Dupont & Brunner 2016; Reissig 1991) and may survive for up to 30 days. Peak emergence occurs during mid- to late July and is usually completed by the end of August (Michigan State University 2019). Adults are present in the field from June to October (Fisher & Olsen 2009). During these months, commercial apple trees in the PNW-USA are bearing fruit (USDA-NASS 2006).

The risk scenario of biosecurity concern is that eggs and/or larvae of *R. pomonella* may be imported with apple fruit from the PNW-USA.

*Rhagoletis pomonella* has been assessed previously in the existing import policy for stone fruit from California, Idaho, Oregon and Washington (Biosecurity Australia 2010b). In that policy, the unrestricted risk for *R. pomonella* was estimated, for plums and apricots, as Moderate, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for *R. pomonella* for plums and apricots from California, Idaho, Oregon and Washington pathway. However, in that policy, the unrestricted risk was estimated, for peaches and nectarines, as Negligible due to their poor host status.

The existing policy for stone fruit from California, Idaho, Oregon and Washington recognises the differences in association of apple maggot with different commodities. As a result, the likelihood of importation of apple maggot has been assessed as Moderate for plums and apricots, and as Negligible for peaches and nectarine. Apple is considered to be the main commercial host for *R. pomonella* (Yee & Goughnour 2006), therefore the likelihood of importation of *R. pomonella* is specifically assessed for the PNW-USA apple pathway in this risk analysis.

The assessment of *R. pomonella* on stone fruit from California, Idaho, Oregon and Washington rated the likelihood of distribution as Moderate. Fresh apple fruit from the PNW-USA is expected to be distributed in Australia, as a result of processing, sale or disposal, in a similar way to stone fruit from California, Idaho, Oregon and Washington. It is expected that once apple fruit has arrived, it will be distributed throughout Australia for wholesale or retail sale. There is some possibility that imported fresh apple fruit may contain *R. pomonella* eggs or larvae (PNW Handbooks 2019c). Apple maggot eggs or larvae would need to develop into mature larvae, find

a suitable pupation site and then develop into adults to find a host. Larvae may take from two weeks to three months to complete development (Weems & Fasulo 2021). Discarded fruit waste is likely to degrade quickly and become unsuitable for larvae to complete development. Imported apples disposed of as waste through managed waste systems are considered unlikely to distribute *R. pomonella* into the environment. However, a small proportion of apple waste may be disposed of as litter throughout Australia in urban, peri-urban and agricultural situations, as well as areas of natural vegetation. In these environments, primary *R. pomonella* hosts are likely to be available for infestation from March to October. Apples from the PNW-USA can be exported all-year-round. On this basis, the same rating of Moderate for the likelihood of distribution of *R. pomonella* on stone fruit from California, Idaho, Oregon and Washington pathway is also adopted for the PNW-USA apple pathway.

The likelihoods of establishment and spread of *R. pomonella* in Australia from the PNW-USA apple pathway are considered to be similar to the assessments of High and Moderate, respectively, for the stone fruit from California, Idaho, Oregon and Washington pathway. These likelihoods relate specifically to events that occur in Australia and are principally independent of the import pathway. The consequences of entry, establishment and spread for *R. pomonella* are also independent of the import pathway, and are assessed as High.

The department has reviewed the latest literature—for example, Linn Jr et al. (2012); Mattsson et al. (2015); PNW Handbooks (2019c); Sansford, Mastro and Reynolds (2016); Wiman, Stoven and Bush (2019) and Yee et al. (2012). No new information has been identified that would significantly change the risk ratings for distribution, establishment, spread and consequences as set out for *R. pomonella* in existing policy for stone fruit from California, Idaho, Oregon and Washington.

#### 4.5.1 Likelihood of entry

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

##### Likelihood of importation

The likelihood that *R. pomonella* will arrive in Australia with the importation of apples from the PNW-USA is assessed as High.

The following information provides supporting evidence for this assessment.

*Rhagoletis pomonella* is a pest of apple fruit in PNW-USA.

- *Rhagoletis pomonella* is present in the three PNW states of the USA (PNW Handbooks 2019c; Sansford, Mastro & Reynolds 2016; Thornburg 2003; White & Elson-Harris 1992; Yee & Goughnour 2006).
- Apple is a preferred host for *R. pomonella* (Sansford, Mastro & Reynolds 2016), providing suitable host material for the survival and development of *R. pomonella* eggs and larvae (Weems & Fasulo 2021; Yee 2007).
- Host material can be green (Weems & Fasulo 2021) or ripening fruit (McPherson, Smith & Berlocher 1988), however larval mortality is lower in earlier-maturing, soft cultivars than in firmer fleshed, later-ripening apples (Michigan State University 2019).

- *Rhagoletis pomonella* is under official control in the PNW-USA states of Washington, Oregon and Idaho where some counties or parts of counties are declared and maintained as pest free areas (Sansford, Mastro & Reynolds 2016).
- Not all apple production areas in the PNW-USA are free of *R. pomonella*, and where the pest is present in Washington, populations of *R. pomonella* can be common in both apple orchards and wild hawthorn (Yee et al. 2012).
- Infestation levels were reported to be significant (Yee et al. 2012), however, Sansford et al. (2016) reported infestation to be less than 5% of orchards surveyed from 2005 to 2015.

*Rhagoletis pomonella* is active in apple orchards prior to and at the time of harvest

- Adult emergence from pupae in soil commences from mid-June to early July. Peak emergence occurs during mid- to late July and is usually completed by the end of August (Michigan State University 2019). Adults may survive for up to 30 days.
- Adults are expected to be present in the field from June to October (Fisher & Olsen 2009). During these months, commercial apple trees in the PNW-USA are bearing fruit (USDA-NASS 2006).
- Adult flies of *R. pomonella* congregate on fruit, where mating occurs. Females puncture the apple skin with their ovipositors to lay eggs and can lay an average of about 300 eggs over a 30-day life span (Brunner 2016; Dupont & Brunner 2016; Michigan State University 2019).
- A large degree of variability in levels of infestation per apple is reported (Chapman & Hess 1941; Prokopy & Boller 1976), ranging from one to 89 punctures per fruit with a single egg associated with each puncture.
- Eggs hatch after a 2 to 10-day incubation period at ambient temperatures (Michigan State University 2019), which will be hot summer temperatures in July to August in the PNW-USA ranging from 30°C to 38°C.
- Larvae develop rapidly while tunnelling through the apple fruit; total larval development times range from two weeks to several months (Beers, Antonelli & LaGasa 1996; Weems & Fasulo 2021).
- Due to the fact that *R. pomonella* may undergo a second generation with adults emerging in late summer or early autumn (PNW Handbooks 2019c; Weems & Fasulo 2021), commercial apples are susceptible to attack and can become infested throughout the harvest period (August to November).

Infestation of fruit may not be detected during harvesting and post-harvest handling processes.

- *Rhagoletis pomonella* lays its eggs under the skin of the apple. Cells around the minute ovipositor punctures show decay and browning (Brunner & Klaus 1993; Michigan State University 2019; Porter 1928).
- Fruit containing late instar larvae may show obvious signs of infestation; in some cases, as the apple develops it becomes dimpled (Beers, Antonelli & LaGasa 1996) and distorted. These fruit may be culled during harvesting.
- Post-harvest sorting, grading and inspection procedures in the packing house are also likely to cull fruit showing obvious symptoms of infestation with late instar larvae.
- Fruit with low levels of infestation, or infested with eggs and early instar larvae may not show obvious symptoms and are unlikely to be detected during these processes.

Some eggs and larvae of *R. pomonella* may survive cold temperatures during storage in the PNW-USA and transport to Australia.

- Following harvest, apples may be stored prior to or after sorting and packing. Storage time may vary from one day to more than 11 months (Kupferman 1996). Apples may be kept in refrigerated storage (0°C to 2°C, depending on variety) (Good Fruit Grower 2014; Iowa State University Extension and Outreach 2008; University of Maine 2020) or in controlled atmosphere (CA) storage with 0.7 to 2.5% oxygen, 0.03 to 4.0% carbon dioxide (Kupferman 1996) and the rest as nitrogen. Optimum temperatures for CA storage in Washington were reported to be 0°C to 1°C (Kupferman 2001).
- Options for cold treatment against *R. pomonella* are reported (Sansford, Mastro & Reynolds 2016) as being a continuous period of at least 90 days at 3.3°C or less, or as a continuous period of 40 days or more at 0°C or lower (Hallman 2004). Both of these cold treatment schedules are currently mandated options for certain fruit movements from non-regulated to regulated areas in the PNW-USA.
- Elevated levels of carbon dioxide have been shown to be effective in killing the immature life stages of *R. pomonella* (Agnello et al. 2002).
- Sea freight of about 5 weeks' duration is the most likely mode of transportation to Australia. The duration of the sea voyage and the cold storage temperatures during sea freight may not cause complete mortality of immature life stages of *R. pomonella*.

Where *R. pomonella* is present in the PNW-USA, it is a major economic pest of apples. Mature apple fruit provides a suitable host for survival and development of *R. pomonella* eggs and larvae. Eggs are laid under the skin of the fruit and developing larvae tunnel through the pulp (Dupont & Brunner 2016). Eggs and early larval infestations in fruit are unlikely to be detected during harvesting or post-harvest packing house procedures. Some *R. pomonella* may survive long periods of cold temperatures while apples are being stored or transported. For the reasons outlined, the likelihood estimate for importation of *R. pomonella* on the PNW-USA apple pathway is assessed as High.

#### **Likelihood of distribution**

The likelihood that *R. pomonella* will be distributed within Australia in a viable state as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host is considered to be similar to *R. pomonella* on fresh stone fruit (plums and apricots) from California, Idaho, Oregon and Washington. Therefore, the same rating of Moderate for the likelihood of distribution previously assessed for *R. pomonella* on the fresh stone fruit (plums and apricots) from California, Idaho, Oregon and Washington pathway is adopted for *R. pomonella* on the apples from PNW-USA pathway.

#### **Overall likelihood of entry**

The overall likelihood of entry is determined as Moderate by combining the assessed likelihood of importation of High with the adopted likelihood of distribution of Moderate, using the matrix of rules in Table 2.2.

#### **4.5.2 Likelihoods of establishment and spread**

The likelihoods of establishment and spread for *R. pomonella* are independent of the import pathway and are considered similar to those previously assessed for the fresh stone fruit from California, Idaho, Oregon and Washington pathway.

Based on the previous assessment for fresh stone fruit from California, Idaho, Oregon and Washington (Biosecurity Australia 2010b), the likelihoods of establishment and spread for *R. pomonella* are assessed as High and Moderate, respectively.

#### 4.5.3 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that *R. pomonella* will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as Low.

#### 4.5.4 Consequences

The potential consequences of the entry, establishment and spread of *R. pomonella* in Australia are similar to those in the previous assessment for *R. pomonella* on the stone fruit from California, Idaho, Oregon and Washington pathway, which were assessed as High (Biosecurity Australia 2010b). The overall consequences for *R. pomonella* on the apples from PNW-USA pathway are also assessed as High.

#### 4.5.5 Unrestricted risk estimate

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

<b>Unrestricted risk estimate for <i>R. pomonella</i></b>	
Overall likelihood of entry, establishment and spread	Low
Consequences	High
Unrestricted risk	Moderate

The unrestricted risk estimate for *R. pomonella* on apples from the PNW-USA has been assessed as Moderate, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for *R. pomonella* on the PNW-USA apple pathway.

## 4.6 Chaff scale

### *Parlatoria pergandii* (GP, WA)

*Parlatoria pergandii* (chaff scale), a hard scale species, was identified as a pest of apples in the PNW-USA. *Parlatoria pergandii* is not present in Western Australia and is a regional quarantine pest for that state.

The indicative likelihood of entry for all hard scales is assessed in the scales Group PRA (DAWE 2021) as Moderate, which is comprised of indicative likelihoods of importation and distribution of High and Moderate, respectively. The indicative likelihood of importation of High may not be appropriate for *P. pergandii* on the PNW-USA apple pathway because apple is a minor host for *P. pergandii* and commercial production practices, in orchards and packing houses, for apples in the PNW-USA are likely to reduce the likelihood of this pest being associated with apples for export. Therefore, the likelihood of importation of *P. pergandii* on apples from the PNW-USA is assessed here.

#### 4.6.1 Likelihood of entry

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

##### Likelihood of importation

The likelihood that *P. pergandii* will arrive in Western Australia with the importation of apples from the PNW-USA is assessed as Low.

The following information provides supporting evidence for this assessment.

*Parlatoria pergandii* is present in the PNW-USA and apple is a minor host.

- *Parlatoria pergandii* is widespread in the USA and has been recorded in the state of Washington in the PNW-USA (Davidson & Miller 1990; Miller & Davidson 2005; Miller & Gimpel 2009). There are no reports of this pest in Oregon or Idaho.
- *Parlatoria pergandii* has been recorded feeding on species from more than 30 plant families, with *Citrus* spp. being primary hosts (Miller & Gimpel 2009; Watson 2022).
- Apple is recorded as a host for *P. pergandii*, but is not considered a primary host (CABI 2022).
- *Parlatoria pergandii* is not listed as a pest of apples in the PNW-USA (Wiman & Stoven 2022), suggesting that its incidence on apple fruit is likely to be relatively low.

*Parlatoria pergandii* will be managed in orchards. Infested fruit are likely to be detected and/or removed during post-harvest processing, but some infested fruit may survive post-harvest processing.

- The principal scale pest in most PNW-USA production regions is *Diaspidiotus perniciosus*, which is a non-quarantine pest for Australia. Insecticide sprays and biological control are generally effective in controlling this pest and other species of scale insects, including *P. pergandii*.
- Scales cause blemishing on fruit, particularly if infestation takes place during development of the fruit (Manners 2016). Infested apples could therefore be readily distinguished from healthy unaffected fruit, and discarded during packing house processes.

- On fruit, *P. pergandii* is also readily visually detected through its purple-coloured body and irregular oval-shaped scale cover (García Morales et al. 2020), which will be likely noticed during packing house inspections and the infested fruit discarded.
- The washing and brushing processes would likely dislodge the earliest life stages ('crawlers') that may be present on the surface of fruit or associated fruit parts.
- Adult scales are unlikely to be killed by the washing solution, as the physical properties of their protective covers provide an effective barrier against contact toxicants (Foldi 1990).

*Parlatoria pergandii* may survive cold temperatures during storage in PNW-USA and transport to Australia.

- Harvested apples are normally cold-stored at 0° to 2°C (Good Fruit Grower 2014; Iowa State University Extension and Outreach 2008; Kupferman 1996; University of Maine 2020; Washington Apple Commission 2020) prior to export. The storage period may vary from 1 day to more than 11 months (Kupferman 1996).
- Sea freight, which takes about five weeks, is likely to be the preferred method of transport of apples from the PNW-USA to Australia and the fruit will be maintained at low temperatures to maintain fruit quality (Iowa State University Extension and Outreach 2008; University of Maine 2020; WSU Tree Fruit 2021c).
- *Parlatoria pergandii* is likely to survive extended periods at cold temperatures as the species overwinters for extended periods at sub-zero temperatures in the PNW-USA.
- In Italy, *P. pergandii* has been reported to overwinter as adult females (Miller & Davidson 2005). Depending on the area, winter temperatures in Italy can be as low as -15°C.
- *Parlatoria pergandii* occurs in regions with cold climates, which suggests that some life stages are likely to be able to survive cold temperatures during storage and transport.

*Parlatoria pergandii* is present in Washington in the PNW-USA, but apple is considered a minor host for the species. Standard commercial practices for management of scales in the PNW-USA would lower the prevalence of *P. pergandii* in apple orchards in PNW-USA. Infested fruit, which have obvious symptoms such as blemishing, would be easily detected and discarded during harvesting and packing house procedures. In addition, packing house processes of washing, brushing and waxing would remove or kill a proportion of scales on fruit. For the reasons outlined, the indicative likelihood of importation of High for all hard scales is not considered to be appropriate for *P. pergandii* on the PNW-USA apple pathway. The likelihood estimate for importation of *P. pergandii* on the PNW-USA apple pathway is assessed as Low.

#### **Likelihood of distribution**

The indicative likelihood of distribution for all hard scales is assessed as Moderate in the scales Group PRA. The likelihood that *P. pergandii* will be distributed within Australia in a viable state as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host is considered to be similar to hard scale insects on fresh fruit, vegetable, cut-flower and foliage imports. The likelihood of distribution of Moderate was verified as appropriate for *P. pergandii* on this pathway (Table 4.2).

#### **Overall likelihood of entry**

The overall likelihood of entry is determined as Low by combining the assessed likelihood of importation of Low with the verified likelihood of distribution of Moderate, using the matrix of rules in Table 2.2.

A summary of the risk assessment for this quarantine hard scale is presented in Table 4.2 for convenience.

**Table 4.2 Risk estimates for chaff scale, *Parlatoria pergandii***

<b>Risk component</b>	<b>Rating for scales in the scales Group PRA</b>	<b>Rating for chaff scale on apples from PNW-USA</b>
Likelihood of entry (importation x distribution)	Moderate (High x Moderate) (indicative)	Low (Low x Moderate)
Likelihood of establishment	High	High (a)
Likelihood of spread	High	High (a)
Overall likelihood of entry, establishment and spread	Low	Low
Consequences	Low	Low (a)
<b>Unrestricted risk</b>	<b>Low</b>	<b>Very Low</b>

(a): risk estimates adopted from the scales Group PRA (DAWR 2019).

The indicative unrestricted risk estimate for all hard scales is assessed as Low in the scales Group PRA, which does not achieve the ALOP for Australia and therefore specific risk management measures are required. However, based on the likelihood of importation of Low for *P. pergandii* on the fresh apple fruit from PNW-USA pathway, the URE of this species on this pathway is assessed as Very Low, which achieves the ALOP for Australia. Therefore, no specific risk management measures are required for *P. pergandii* on the PNW-USA apple pathway.

## 4.7 Lygus bugs

### ***Lygus elisus* (EP), *Lygus hesperus* (EP) and *Lygus lineolaris* (EP)**

*Lygus elisus* (lucerne plant bug or the green lygus bug), *L. hesperus* (western tarnished plant bug or the brown lygus bug) and *L. lineolaris* (tarnished plant bug) belong to the Miridae family. These three species have been grouped together on the basis of their related biologies and are predicted to pose similar biosecurity risks. In this assessment, the term Lygus bugs is used to refer to these three species collectively; a scientific name is used when the information relates to a specific species.

*Lygus elisus*, *L. hesperus* and *L. lineolaris* are present throughout the United States (Antwi & Rondon 2018), and are recognised as pests of apple in the PNW-USA states (Anthon 1993a; Wiman & Stoven 2022). Lygus bugs are also present in Europe, Asia and southern Canada (Anthon 1993a).

Members of the genus *Lygus* are pests of more than 130 economically important plants, including a wide range of field and vegetable crops, and fruit trees (Anthon 1993a; Broadbent et al. 2006). Lygus bugs are found in areas near uncultivated land or lucerne fields (Wiman & Stoven 2022), and feed on developing leaves, flowers and fruit. Lygus bugs can cause damage to their host plants in multiple ways, including by leaf maceration, browning and discolouration of tissue, and premature drop of buds, flowers and fruitlets; they can also cause increased numbers of vegetative branches, formation of multiple crowns, elongation of internodes, split stem lesions, swollen nodes, leaf crinkling and reductions in meristematic tissue (Tingey & Pillemer 1977) and secondary stems (Conti & Bin 2001; Mirab-balou & Khanjani 2008). Most fruit damage occurs on fruitlets shortly after bloom. Dimpling and deep pitting of fruit are indications of early feeding damage, which can develop into fruit deformities that occur when the cells surrounding dead cells at the feeding site continue to grow as the fruit matures (Wiman & Stoven 2022).

Lygus bugs have three life stages: egg, nymph (five instars) and adult. Lygus bugs overwinter as adults in protected areas such as leaf debris, in bark cracks, or beneath weeds (Fye 1982) or litter on the orchard floor or in nearby uncultivated areas (Anthon 1993a; Wiman & Stoven 2022). During spring, adults become active and fly to fruit trees, where they feed on developing flower buds (Anthon 1993a; Caprile et al. 2009a). Adult females lay eggs in stems and other tissues on a wide variety of plants after mating, beginning about 10 days after emerging from the final nymphal stage. Lygus bugs prefer to lay eggs on plants about to flower, and thus move from host to host according to the timing of bloom (Anthon 1993a). Females are known to occasionally deposit eggs in young pome fruit, causing shallow pitting and deformities (Anthon 1993a). Apples are most susceptible to damage from early pink stage of bud development through to two weeks after petal fall (Anthon 1993a). Lygus bugs are primarily generalist herbivores, but are also known to be facultative predators (Hagler, Jackson & Blackmer 2010). *Lygus lineolaris* has a lifespan of around 30 days, usually with three to four generations per year in crop plants in the PNW-USA (Anthon 1993a) and two to three generations in lucerne (Broadbent et al. 2006; CABI 2019).

The risk scenario of biosecurity concern is that nymphs and/or adults of Lygus bugs may be imported with apple fruit from the PNW-USA.

The three Lygus bugs assessed here have been assessed previously in the existing import policy for stone fruit from California, Idaho, Oregon and Washington (Biosecurity Australia 2010b), and Californian table grapes to Western Australia (DAFF 2013a). In these existing policies, the unrestricted risk estimate for Lygus bugs was assessed as Very Low, which achieves the ALOP for Australia. Therefore, no specific risk management measures are required for these pests on those pathways.

The department has assessed the likelihood of importation of Lygus bugs on the PNW-USA apple pathway as being similar to the previous assessment of Very Low for stone fruit from California, Idaho, Oregon and Washington (Biosecurity Australia 2010b). While both adult and nymphal Lygus bugs may feed on fruit of their hosts, they are highly mobile, easily disturbed and unlikely to remain on fruit during fruit picking, processing and transportation. Apple fruit are not a preferred substrate for oviposition. Females preferentially lay their eggs on plant parts of flowering vegetable crops and field plants and only occasionally lay eggs in young fruit, causing pitting and deformities (Anthon 1993a). Deformed fruits do not develop further (Anthon 1993a) and are expected to be removed during harvesting and packing house processes. There is no information to suggest that the pest status of the three species of Lygus bugs in the PNW-USA has changed since the previous assessment for stone fruit from California, Idaho, Oregon and Washington. For these reasons, the previous assessment of Very Low in the existing policy for the likelihood of importation of Lygus bugs is adopted for the PNW-USA apple pathway.

Previous assessment of Lygus bugs on the stone fruit from California, Idaho, Oregon and Washington pathway (Biosecurity Australia 2010b) rated the likelihood of distribution as Moderate. Apples from the PNW-USA are expected to be distributed in Australia, as a result of processing, sale or disposal, in a similar way to stone fruit from the California, Idaho, Oregon and Washington pathway (Biosecurity Australia 2010b). Lygus bugs have a wide host range, and host material is likely to be continuously available in Australia. Therefore, any differences in time of year when imports of these 2 pathways occur would have very little impact on the availability and susceptibility of hosts at the time of imports to contribute to variation in the risk rating for likelihood of distribution. Imported apples disposed of as waste through managed waste systems are considered unlikely to distribute Lygus bugs into the environment. However, a small proportion of apple waste may be disposed of as litter throughout Australia in urban, peri-urban and agricultural situations, as well as areas of natural vegetation. Lygus bugs, if present in fruit waste discarded in the environment, may be capable of finding suitable hosts and laying eggs to start the life cycle. For these reasons, the same rating of Moderate for the likelihood of distribution for Lygus bugs on the stone fruit from California, Idaho, Oregon and Washington pathway is adopted for the PNW-USA apple pathway.

The likelihoods of establishment and spread of Lygus bugs in Australia from the PNW-USA apple pathway have been assessed as similar to those of the previous assessments, which were rated as High and Moderate respectively, for the stone fruit from California, Idaho, Oregon and Washington pathway (Biosecurity Australia 2010b). These likelihoods relate specifically to events that occur in Australia and are principally independent of the import pathway. The consequences of entry, establishment and spread of Lygus bugs are also independent of the import pathway and are considered to be similar between pest risk assessments, and rated as Moderate. Therefore, the existing ratings for the likelihoods of entry, of establishment and of spread, and the rating for the overall consequence of the three species of Lygus bugs have been adopted for the PNW-USA apple pathway.

In addition, the department has reviewed the latest literature—for example, Allen et al. (2018); Antwi and Rondon (2018); Cooper and Spurgeon (2015); EPP0 (2019); Hagler, Jackson and Blackmer (2010) and Ugine (2012). No new information has been identified that would significantly change the risk ratings for importation, distribution, establishment, spread and consequences as set out for Lygus bugs in existing policy.

#### **4.7.1 Likelihood of entry**

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

##### **Likelihood of importation**

The likelihood that Lygus bugs will be imported into Australia in a viable state on apples from the PNW-USA is considered to be similar to Lygus bugs on fresh stone fruit from California, Idaho, Oregon and Washington. Therefore, the same rating of Very Low for the likelihood of importation previously assessed for Lygus bugs on the fresh stone fruit from California, Idaho, Oregon and Washington pathway is adopted for Lygus bugs on the apples from PNW-USA pathway.

##### **Likelihood of distribution**

The likelihood that Lygus bugs will be distributed within Australia in a viable state as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host is considered to be similar to Lygus bugs on fresh stone fruit from California, Idaho, Oregon and Washington. Therefore, the same rating of Moderate for the likelihood of distribution previously assessed for Lygus bugs on the fresh stone fruit from California, Idaho, Oregon and Washington pathway is adopted for Lygus bugs on the apples from PNW-USA pathway.

##### **Overall likelihood of entry**

The overall likelihood of entry is determined as Very Low by combining the adopted likelihood of importation of Very Low with the adopted likelihood of distribution of Moderate, using the matrix of rules in Table 2.2.

#### **4.7.2 Likelihoods of establishment and spread**

The likelihoods of establishment and spread for Lygus bugs are independent of the import pathway and are considered similar to those previously assessed for the fresh stone fruit from California, Idaho, Oregon and Washington pathway.

Based on the previous assessment for fresh stone fruit from California, Idaho, Oregon and Washington (Biosecurity Australia 2010b), the likelihoods of establishment and spread for Lygus bugs are assessed as High and Moderate, respectively.

#### **4.7.3 Overall likelihood of entry, establishment and spread**

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that Lygus bugs will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as Very Low.

#### 4.7.4 Consequences

The potential consequences of the entry, establishment and spread of Lygus bugs in Australia are similar to those in the previous assessment for Lygus bugs on the stone fruit from California, Idaho, Oregon and Washington pathway, which were assessed as High (Biosecurity Australia 2010b). The overall consequences for Lygus bugs on the apples from PNW-USA pathway are also assessed as Moderate.

#### 4.7.5 Unrestricted risk estimate

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

<b>Unrestricted risk estimate for Lygus bugs</b>	
Overall likelihood of entry, establishment and spread	Very Low
Consequences	Moderate
Unrestricted risk	Very Low

The unrestricted risk estimate for Lygus bugs on apples from the PNW-USA has been assessed as Very Low, which achieves the ALOP for Australia. Therefore, no specific risk management measures are required for Lygus bugs on the PNW-USA apple pathway.

## 4.8 Mealybugs

### *Phenacoccus aceris* (GP) and *Pseudococcus maritimus* (GP)

Two mealybug species were identified on the fresh apple fruit from PNW-USA pathway as quarantine pests for Australia, *Phenacoccus aceris* (apple mealybug) and *Pseudococcus maritimus* (grape mealybug).

The indicative likelihood of entry for all mealybugs is assessed in the mealybugs Group PRA as Moderate (DAWR 2019). *Phenacoccus aceris* is reported to be present in Oregon and Washington (Beers 2007a, 2008), and is reported to feed on apple fruit, often in the calyx region (Beers 2007a, 2008). *Pseudococcus maritimus* is reported to be present in Idaho, Oregon and Washington (APHIS 2007; García Morales et al. 2016). Standard packing house procedures and transportation are not expected to eliminate these mealybugs from the pathway. After assessment of relevant pathway-specific factors (Sections 2.2.6 and 2.2.7) for apples from the PNW-USA, the likelihood of entry of Moderate was verified as appropriate for these mealybugs on this pathway (Table 4.3).

**Table 4.3 Quarantine mealybug species for fresh apple fruit from the PNW-USA**

Pest	In mealybug Group PRA	Quarantine pest	On apple pathway	Likelihood of entry
<i>Phenacoccus aceris</i>	Yes	Yes	Yes	Moderate
<i>Pseudococcus maritimus</i>	Yes	Yes	Yes	Moderate

A summary of the risk assessment for quarantine mealybugs is presented in Table 4.4 for convenience.

**Table 4.4 Risk estimates for quarantine mealybugs**

Risk component	Rating for quarantine mealybugs
Likelihood of entry (importation x distribution)	Moderate (High x Moderate)
Likelihood of establishment	High
Likelihood of spread	High
Overall likelihood of entry, establishment and spread	Moderate
Consequences	Low
<b>Unrestricted risk</b>	<b>Low</b>

As assessed in the mealybugs Group PRA, the indicative unrestricted risk estimate for mealybugs is assessed as Low (Table 4.4), which does not achieve the ALOP for Australia. This indicative unrestricted risk estimate is considered to be applicable for the quarantine mealybugs on the fresh apple fruit from PNW-USA pathway. Therefore, specific risk management measures are required for these quarantine mealybugs on this pathway.

This risk assessment, which is based on the mealybugs Group PRA, applies to all quarantine mealybugs on the PNW-USA apple pathway, irrespective of the species identification in this document. This is explained in Section 2.2.7.

## 4.9 *Lacanobia* fruitworm

### *Lacanobia subjuncta*

*Lacanobia subjuncta* (Grote & Robinson) belongs to the moth family Noctuidae, which is one of the largest families in the order Lepidoptera.

*Lacanobia subjuncta* is widely distributed in North America (Doerr & Brunner 2007; McCabe 1980). It is present in Nova Scotia, Canada and the US states from Virginia, Missouri and North Dakota to New Mexico, Arizona and California. It is also present in the PNW-USA in Washington and Oregon (Landolt 1998), and in Idaho (Idaho Department of Fish and Game 2020). *Lacanobia subjuncta* is reported at low to middle altitudes throughout the Pacific Northwest, including in dry interior steppe habitats and areas west of the coastal range and Cascade Range (Crabo et al. 2019). Although *L. subjuncta* is native to Washington, it was not considered a pest in orchards in the state until the mid-1990s (Doerr & Brunner 2007). During the mid-1990s, it was reported attacking apple orchards in the Columbia basin, and was recognised as a pest of apple orchards causing crop loss in Washington and northeast Oregon (Doerr & Brunner 2007; Doerr, Brunner & Schrader 2004).

Larvae of *L. subjuncta* have been found to feed and develop on a wide variety of plants, including trees, shrubs and herbaceous plants (Crabo et al. 2019). Recorded hosts include apple (Doerr, Brunner & Jones 2005; Landolt 1998; Sutton et al. 2014; Wistermann et al. 2016), pear and plum (Landolt 1998), and various plants in the cabbage family, blueberry, maple, asparagus, strawberry and corn (Scott 2006). Ground cover weed species such as dandelion, sow thistle, mallow and bindweed, which are commonly found in tree fruit orchards, are also hosts of *L. subjuncta* (Doerr & Brunner 2007; Landolt 1998, 2002), and on which this pest completes its development cycle.

*Lacanobia subjuncta* has four life stages: egg, larva (with 6 larval instars) (Doerr & Brunner 2002), pupa and adult, and has two generations per year (Doerr & Brunner 2007; Landolt 1998). The first adult flight occurs in North America from late May through to July with a second adult flight from late July to September (Brunner et al. 2000; Doerr, Brunner & Jones 2005; Landolt 2002). For the first generation, oviposition begins in mid-June and lasts for about 6 weeks. Eggs are laid on the undersides of leaves in masses of around 100 (Doerr & Brunner 2007). First generation larvae appear in June and July (Wiman & Stoven 2021a). Larvae feed principally on foliage (Wiman & Stoven 2021a). Larvae are reported to feed on the lower leaf surfaces and, as they mature, disperse to the lower canopy, then drop and feed on ground cover weed species before pupating in the soil (Doerr & Brunner 2007).

Second generation adults emerge in late July and are active through until October. Second generation larval feeding starts in mid-August and continues until October (Doerr & Brunner 2007; Wiman & Stoven 2021a). The final larval instar grows to approximately 5 cm in length (Wiman, Stoven & Bush 2019). Adult *L. subjuncta* are 2.5 cm long (Wiman, Stoven & Bush 2019) and have a distinctive light brown to black colour pattern of scales on their wings, and a wing span of 5 cm (Doerr & Brunner 2007). This pest is reported to overwinter as pupae in the soil (Landolt 2002; Wiman, Stoven & Bush 2019) near the host plant (Doerr & Brunner 2007). Pupation in or on fruit under field conditions has not been reported, however, (Doerr & Brunner 2007) noted the possibility of larvae remaining on the tree to complete development.

The most destructive life stage of *L. subjuncta* is the larva. Larvae primarily feed on apple leaf tissue causing partial defoliation (Landolt 2002; Wiman, Stoven & Bush 2019), with fruit damage being incidental to foliage feeding (Doerr & Brunner 2007; Landolt 1998). Larval feeding damage ranges from holes in leaves to consumption of entire leaves leaving the vein (Doerr & Brunner 2007). Older larvae may feed on fruit (Landolt 2002; Wiman, Stoven & Bush 2019). On apple fruit, larval feeding cavities can be as large as a fingertip, appearing as hollowed-out scoops on the fruit surface with severe fruit damage occurring when larval densities are high in the orchard (Doerr & Brunner 2007). When larvae feed directly on fruit (Landolt 2002), the feeding cavity and larvae at the stem end (Wiman & Stoven 2021a), the calyx end (Doerr & Brunner 2007) or on the fruit surface (Sutton et al. 2014) are commonly highly visible.

The development of *L. subjuncta* is temperature-dependant. The lower threshold for development of larvae under laboratory trials is reported to be 6.7°C (Doerr & Brunner 2002). Eggs, larvae and pupae of *L. subjuncta* have been reared at constant temperatures between 10°C and 30°C (Doerr & Brunner 2002).

The risk scenario of biosecurity concern is that larvae of *L. subjuncta* may be present on imported apple fruit from the PNW-USA.

#### 4.9.1 Likelihood of entry

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

##### Likelihood of importation

The likelihood that *L. subjuncta* will arrive in Australia with the importation of apples from the PNW-USA is assessed as Low.

The following information provides supporting evidence for this assessment.

*Lacanobia subjuncta* is a common pest across the PNW-USA and apple is a host.

- *Lacanobia subjuncta* is native to North America and since the mid-1990s (Doerr & Brunner 2007; Landolt et al. 2011) it has become an important pest of apple in central Washington, north-east Oregon (Doerr, Brunner & Jones 2005) and Idaho (Colt et al. 2001).
- *Lacanobia subjuncta* is also reported to feed on other crop species as well as several ground cover weed species in orchards (Doerr & Brunner 2007).
- The first generation of larvae occurs from early June through to July, with the second generation occurring from mid-August through to October (Doerr & Brunner 2007; Wiman & Stoven 2021a). In the PNW-USA, apple fruit development generally occurs during May to August and harvest occurs from August until early November, depending on the variety and the environmental conditions in the region (Washington Apple Commission 2019). Therefore, it is likely that larvae could be present in apple orchards during the fruit development and harvest periods.

*Lacanobia subjuncta* is primarily associated with apple foliage and only incidentally feeds on fruit.

- Larvae are primarily foliage feeders (Wiman & Stoven 2021a) and fruit feeding is considered incidental to foliage feeding (Doerr & Brunner 2002, 2007; Landolt 2002).

- When population densities of the larvae are high in orchards, or when the fruit cluster is in close proximity to dense foliage or tall growing weeds, fruit damage may occur and may be severe (Brunner et al. 2000; Doerr & Brunner 2007).

Fruit infested by *L. subjuncta* larvae are likely to be removed during production, harvest and post-harvest processing.

- Orchards in PNW-USA have standard in-field management practices for control of *L. subjuncta* (Wiman & Stoven 2021a).
- First generation larvae present in June and July may attack early-stage immature fruits (Doerr & Brunner 2007; Wiman & Stoven 2021a). It is likely that infested immature fruits will fall from trees or will be removed from apple orchards during routine inspections of the commercial orchards.
- Feeding on the fruit by second generation larvae could occur during mid-August through to October when fruit are harvested. Feeding by larvae results in a highly visible hollowed-out scoop, approximately the size of a fingertip, on the surface of apple fruit (Doerr & Brunner 2007; Landolt 2002). Although larvae may feed at the calyx end (Doerr & Brunner 2007), or the stem end (Wiman & Stoven 2021a) of the fruit, damage is highly visible and there is no evidence to indicate larvae hide and feed deep within the calyx. It is likely that infested fruit will be detected and removed during harvest and packing house procedures.
- Secondary rots often follow initial damage caused by surface feeding, and affected fruit are likely to be detected and removed during harvest and packing house procedures.
- Post-harvest cleaning processes including washing and brushing of the fruit are likely to remove any larvae present on the external surface of the apple.

Larvae that are not detected or removed during packing house processes will not develop and are likely to experience high rates of mortality at cold temperatures during storage and transport to Australia.

- Harvested apples are normally cold stored at 0°C to 2°C, depending on variety (Good Fruit Grower 2014; Iowa State University Extension and Outreach 2008; Kupferman 1996; University of Maine 2020). Sea freight, which takes about five weeks, is likely to be the preferred method of transport of apples from the PNW-USA to Australia, during which fruit will be maintained at similar temperatures.
- The development of *L. subjuncta* is temperature-dependant (Doerr & Brunner 2002) and the lower threshold for larval development is reported to be 6.7°C (Doerr & Brunner 2007).
- In laboratory studies, the larval mortality rate was greatest (91.3%) when reared at a constant 10°C compared to mortality rates of 12.5 to 47.1% at higher constant temperatures between 12.5°C and 30.0°C (Doerr & Brunner 2002). This indicates that cold temperatures during storage and transport to Australia are likely to adversely affect the survival of larvae. However, some larvae may survive.

*Lacanobia subjuncta* is recognised as an abundant pest of apple in PNW-USA. However, this pest is primarily a foliage feeder. Larvae feeding on apple foliage disperse as they mature, and leave the trees in favour of ground cover preceding pupation, which occurs in soil. Larval feeding on fruit is incidental and leaves obvious symptoms. The highly visible nature of larvae and feeding holes on mature apples are easily detected during harvest and post-harvest processes, so that infested fruit are likely to be removed from the pathway. Any larvae present on apples are likely to experience high rates of mortality at cold temperatures during storage and transport of apples to Australia. For the reasons outlined, the likelihood estimate for importation of *L. subjuncta* on the PNW-USA apple pathway is assessed as Low.

### Likelihood of distribution

The likelihood that larvae of *L. subjuncta* will be distributed within Australia in a viable state, as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host is assessed as Moderate.

The following information provides supporting evidence for this assessment:

Apples imported from PNW-USA will likely be distributed throughout Australia for retail sale. Cold temperatures during storage and transport of fresh apple in Australia are unsuitable for larval development and survival. Fruit showing signs of infestation are likely to be removed from further distribution. Some infested fruit may not be detected.

- It is expected that fresh apples imported from PNW-USA into Australia will be distributed for retail sale in many areas in Australia. Major population centres are likely to receive the majority of the imported apples.
- *Lacanobia subjuncta* larval development ceases at temperatures around 6°C (Doerr & Brunner 2002). In laboratory studies, larval mortality was 91.3% when reared at a constant 10°C (Doerr & Brunner 2002; Doerr, Brunner & Jones 2002). It is likely that similar cold temperatures of 0°C to 2°C will be used during storage and transport of PNW-USA apples in Australia. Cold temperatures during storage and transport within Australia are likely to adversely affect the viability of larvae. However, some larvae may survive.
- Packed apple fruit may not be processed or handled until they arrive at retail points. Once in retail stores, fruit are likely to be kept at room temperature for some of the time which could allow some *L. subjuncta* to survive and resume development. Any fruit showing symptoms of infestation at this point are likely to be removed from further distribution and discarded into managed waste systems.
- Apple fruit with no obvious signs of infestation are unlikely to be removed and may be sold to consumers.

Distribution of imported apples will be for retail sale for human consumption. A small proportion of apple fruit waste may be discarded into the environment.

- Commercial waste of imported fresh apples may be generated prior to, or during, retail sale. Most commercial waste will be discarded into managed waste systems, from where *L. subjuncta* would be unlikely to transfer to a suitable host or reach a suitable pupation site.
- Most of the fruit, other than the core and seed, will be consumed. Fruit waste may be discarded in managed residential waste systems, from where *L. subjuncta* would be unlikely to transfer to a suitable host or reach a suitable pupation site.
- Some fruit waste may be discarded into domestic compost where the larvae may leave the discarded fruit and pupate in the ground (Doerr & Brunner 2007).
- A small proportion of fruit waste may be discarded as litter in urban, rural or natural environments near suitable host plants, including commercially grown, household or wild host plants.
- Damaged, infested fruit are particularly susceptible to colonisation by microorganisms. Colonisation of discarded, infested fruit by saprophytic fungi or bacteria would quickly rot the fruit, depleting the food source potentially needed for larvae to survive. However, if larvae come into contact with suitable weed hosts, there is a possibility they could complete their development and pupate in the ground (Doerr & Brunner 2007). Pupation may also occur if fruit infested by late instar larvae are discarded near suitable pupation sites. Adults may emerge and move to suitable hosts given their capacity of independent flight.

Warm to hot summer temperatures in Australia are unsuitable for larval development and survival.

- Although importation of PNW-USA apples is likely to occur throughout the year, apple imports during the hot, dry summer months may not be suitable for larval development, as complete larval mortality has been observed in the laboratory at or above constant temperatures of 32.5°C (Doerr & Brunner 2002). Larvae in infested fruit discarded during times of high temperatures in summer may not survive. However, due to the wide range of temperatures that the pest can tolerate (estimated lower and upper development thresholds of 6.7°C and 32.2°C, respectively), most Australian regions could support further development of larvae throughout large parts of the year.

Suitable hosts for *Lacanobia subjuncta* are widely available in Australia.

- *Lacanobia subjuncta* has a wide variety of host plants, including trees, shrubs and herbaceous plants (Landolt 2002). Recorded hosts include apple, cherry, blueberry, cabbage, asparagus, corn and strawberry (Landolt 2002).
- *Lacanobia subjuncta* is also reported to feed on a wide variety of weed species such as dandelion, mallow and bindweed that are common ground cover species in tree fruit orchards (Doerr & Brunner 2007) and sowthistle (Landolt 2002).
- Host plants, including weed hosts, are widely distributed throughout Australia in domestic, commercial and natural environments and are likely to be available throughout the year.

Suitable hosts for *L. subjuncta* are widely available in Australia and infested fruit discarded near potential hosts or potential pupation sites may assist the distribution of the pest. However, decomposition of infested, discarded fruit and adverse effects due to cold storage and transport as well as hot temperatures during summer are likely to reduce the survival and successful development of the pest. For the reasons outlined, the likelihood of distribution of *L. subjuncta* on the PNW-USA apple pathway is assessed as Moderate.

#### Overall likelihood of entry

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

The likelihood that *L. subjuncta* will enter Australia as a result of trade in apples from the PNW-USA and be distributed in a viable state to a susceptible host is assessed as Low.

#### 4.9.2 Likelihood of establishment

The likelihood that *L. subjuncta* will establish in Australia based on a comparison of factors in the source and destination areas that affect pest survival and reproduction is assessed as High.

The following information provides supporting evidence for this assessment:

Host plants of *L. subjuncta* are widespread and abundant in Australia.

- Larvae of *L. subjuncta* have been found to feed and develop on a wide variety of plants, including trees, shrubs and herbaceous plants (Landolt 2002). Recorded hosts include apple, cherry, peach, blueberry, cabbage, asparagus, corn and strawberry (Landolt 2002). *Lacanobia subjuncta* is also reported to feed on ground cover weeds such as dandelion, sow thistle, mallow and bindweed (Doerr & Brunner 2007; Landolt 2002; McCabe 1980).

- These host plants are widely distributed throughout Australia, providing potential for establishment of this pest.

Australia has suitable climatic conditions for *L. subjuncta* development.

- Lower and upper development thresholds of *L. subjuncta* are estimated at 6.7°C and 32.2°C, respectively (Doerr & Brunner 2007), and the optimal temperature for development is between 25°C and 30°C (Doerr & Brunner 2002; Doerr, Brunner & Jones 2002).
- *Lacanobia subjuncta* is found across the temperate climatic regions of North America (Doerr & Brunner 2007; Landolt 1998; McCabe 1980). *Lacanobia subjuncta* is reported at low to middle elevations throughout the Pacific Northwest, including in dry interior steppe habitats and areas west of the Coast range and Cascade Range (Crabo et al. 2019). Many of these regions have similar climatic conditions to parts of Australia (Peel, Finlayson & McMahon 2007).
- The temperatures in temperate southern Australia are similar to those in the PNW-USA for some parts of the year (Bureau of Meteorology 2018; National Weather Service 2008).
- However, the hot, dry Australian summer may not be suitable for larval development, as complete mortality of larvae and eggs were reported at constant temperatures of 32.5°C and 35.0°C, respectively (Doerr & Brunner 2002; Doerr, Brunner & Jones 2002).
- *Lacanobia subjuncta* is native to North America (McCabe 1980) and has not been reported to have spread to other countries, which may suggest a limited ability of the pest to establish in new regions.

*Lacanobia subjuncta* has effective reproduction and adaptation systems.

- After successful pupation, adults need to locate a mate to establish a viable population. *Lacanobia subjuncta* adults are capable of independent flight, aiding dispersal and potential mate-finding behaviours.
- One mated female can oviposit a mass of 100 eggs (Doerr & Brunner 2007), which hatch 1 to 2 weeks later. The fecundity of this species increases the potential for establishment of *L. subjuncta*.
- There are two generations of *L. subjuncta* per year in the USA (Doerr & Brunner 2007), which may also be the case under Australian conditions.

There are suitable hosts available across Australia to enable *L. subjuncta* to establish. The pest has high fecundity and is capable of independent flight. Potentially favourable climatic conditions for reproduction and survival of *L. subjuncta* exist across Australia. For the reasons outlined, the likelihood estimate for establishment of *L. subjuncta* on the PNW USA apple pathway is assessed as High.

#### 4.9.3 Likelihood of spread

The likelihood that *L. subjuncta* will spread within Australia, based on a comparison of factors in the source and destination areas that affect the expansion of the geographic distribution of the pest is assessed as High.

The following information provides supporting evidence for this assessment.

Climatic conditions suitable for spread of *L. subjuncta* occur in Australia.

- *Lacanobia subjuncta* is present in the temperate regions of North America (Landolt 1998; McCabe 1980). *Lacanobia subjuncta* is reported at low to middle elevations throughout the

Pacific Northwest, including in dry interior steppe habitats and areas west of the Coast range and Cascade Range. The PNW-USA has similar climatic conditions to parts of southern Australia and if *L. subjuncta* was to establish, the climatic conditions in southern parts of Australia would likely be suitable for the spread of this pest.

Widespread and abundant host plants across Australia could promote the spread of *L. subjuncta*.

- *Lacanobia subjuncta* larvae are reported to feed and develop on a variety of crops and ground cover weed species (Doerr & Brunner 2007; Landolt 1998, 2002). These hosts are distributed widely throughout Australia. The prevalence of multiple suitable hosts may promote local spread between areas.
- Apple is a primary host of *L. subjuncta* and commercial apple fruit crops are grown in many regions of Australia. It is a garden plant in many households across Australia (AgriFutures Australia 2017).

Spread would be aided by adult moth flight.

- *Lacanobia subjuncta* adults are capable of independent flight. Adult males are considered strong fliers (Doerr & Brunner 2002), aiding dispersal and potential mate-finding behaviours.

Domestic movement of infested apple and other host plants and planting materials may aid the spread of *L. subjuncta* in Australia.

- Domestic trade of apple fruit and other host plants may aid the spread of *L. subjuncta*. However, the presence of larvae on apple fruit is incidental except at high population densities (Doerr & Brunner 2007). This reduces the likelihood of *L. subjuncta* being present on fruit and spreading to new areas through human-mediated transport.
- Infested apple fruit often show visible symptoms (Klem & Zaspel 2019). Therefore, infested fruit are likely to be discarded prior to transportation and during distribution to retailers.
- Host material could be distributed across Australia. Movement of infested host material may facilitate the local spread of *L. subjuncta* across Australia.

Favourable climatic conditions across southern parts of Australia and an abundance of suitable hosts, together with the human-assisted movement of apple fruit, other hosts and planting materials through domestic trade, as well as adaptive life cycle characteristics, support the potential for *L. subjuncta* to spread in Australia. For these reasons, the likelihood of spread of *L. subjuncta* on the PNW-USA apple pathway is assessed as High.

#### 4.9.4 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, establishment and spread using the matrix of rules shown in Table 2.2.

The overall likelihood that *L. subjuncta* will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible host, establish in Australia and subsequently spread within Australia is assessed as Low.

#### 4.9.5 Consequences

The potential consequences of the entry, establishment and spread of *L. subjuncta* in Australia have been estimated according to the methods described in Table 2.3.

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

Criterion	Estimate and rationale
<b>Direct</b>	
Plant life or health	<p>D – Significant at district level:</p> <p>The primary commercially grown host of <i>L. subjuncta</i> is apple. The pest has also been recorded to feed and develop on a wide variety of host plants, including trees, shrubs and herbaceous plants (Landolt 1998, 2002).</p> <p>The pest is capable of causing direct damage to host plants through feeding activities of larvae. Larvae of <i>L. subjuncta</i> have been known to cause serious defoliation in apple orchards (Doerr &amp; Brunner 2007; Landolt 2002; Wiman, Stoven &amp; Bush 2019) and larvae may incidentally feed on fruit. Larval feeding holes can be as large as a fingertip, appearing as hollowed-out scoops on the fruit surface with severe fruit damage occurring when larval densities are high in the orchard (Doerr &amp; Brunner 2007).</p> <p>Since 1995, <i>L. subjuncta</i> has been recognised as a pest in Washington apple orchards. Since this time, it has occurred in high and sometimes damaging densities in several apple production areas in Washington, and research has been undertaken to manage the pest (Doerr &amp; Brunner 2002). Pacific Northwest regions recognise <i>L. subjuncta</i> as an important pest of commercial apple orchards and management practices have been recommended (Landolt 1997; Wiman &amp; Stoven 2022).</p> <p>Australia's apple and pear industry alone produces fruit worth more than \$580 million annually (APAL 2020).</p> <p>In addition to apple and pear, hosts of <i>L. subjuncta</i> include cherry, blueberry, cabbage, asparagus, corn, strawberry (Landolt 2002) and plum (Landolt 1998).</p>
Other aspects of the environment	<p>A – Indiscernible:</p> <p>There are currently no known direct consequences of <i>L. subjuncta</i> on other aspects of the natural environment, but its introduction into a new environment may lead to some competition for resources with native species.</p>
<b>Indirect</b>	
Eradication, control	<p>D– Significant at district level:</p> <p>Programs in the United States to contain, eradicate, and/or minimise the impact of <i>L. subjuncta</i> on host plants include visual inspection, population monitoring, biological control, pheromone trapping, larvae sampling and pesticide application (Doerr &amp; Brunner 2007; Hollingsworth 2019). These control programs are likely to be costly and may disrupt existing integrated pest management (IPM) and other pest management programs for other pests in Australia because of the need to re-introduce or increase the use of insecticides for the control of <i>L. subjuncta</i>.</p> <p>However, Australia's existing pest management practices using insecticides (e.g., methidathion, indoxacarb etc) for similar lepidopteran pests (Sutton, Collie &amp; Learmonth 2014) may control <i>L. subjuncta</i> in Australia.</p> <p><i>Lacanobia subjuncta</i> adults are capable of independent flight. Adult males are considered strong fliers (Doerr &amp; Brunner 2002), aiding dispersal and potential mate-finding behaviours. Due to the flight capacity of the adults, this pest could easily attack other non-commercial hosts which are available in surrounding areas. The control of this pest on these hosts will be difficult and most likely costly.</p> <p>In Washington State, <i>L. subjuncta</i> has developed resistance to organophosphate pesticides (Brunner &amp; Doerr 2000; Colt et al. 2001). Resistance to chemicals would make it difficult to eradicate or control this pest if the resistant population were introduced to Australia.</p>

Domestic trade	D – Significant at district level: The apple and pear industry is a major horticultural industry in Australia (APAL 2020). The presence of <i>L. subjuncta</i> in commercial production areas of apple or other hosts in Australia may result in interstate trade restrictions on fresh apples and other hosts, potential loss of markets and significant industry adjustment at the district level.
International trade	D – Significant at district level: Australia exports approximately 5,000 tonnes of apples per year (APAL 2020). The presence of <i>L. subjuncta</i> in commercial production areas of a range of host commodities such as apples and pears may limit access to international markets where this pest is not present.
Non-commercial and environmental	B – Minor significance at local level: Minor indirect impact on the environment. Existing insecticidal controls in the pest management systems for other moths will likely control <i>Lacanobia</i> fruit worm as well.

#### 4.9.6 Unrestricted risk estimate

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

##### Unrestricted risk estimate for *Lacanobia subjuncta*

Overall likelihood of entry, establishment and spread	Low
Consequences	Low
Unrestricted risk	Very Low

The unrestricted risk estimate for *L. subjuncta* on the apples from PNW-USA pathway has been assessed as Very Low, which achieves the ALOP for Australia. Therefore, no specific risk management measures are required for this pest on this pathway.

#### 4.10 Leafroller moths

##### ***Archips argyrospila* (EP), *Archips podana* (EP), *Archips rosana* (EP), *Argyrotaenia franciscana* (EP), *Choristoneura rosaceana* (EP) and *Pandemis pyrusana* (EP)**

*Archips argyrospila* (fruit-tree leafroller), *Archips podana* (great brown twist moth), *Archips rosana* (European leafroller), *Argyrotaenia franciscana* (orange tortrix), *Choristoneura rosaceana* (oblique banded leafroller) and *Pandemis pyrusana* (Pandemis leafroller) belong to the Tortricidae or 'leafroller' family. Tortricidae, a large family of over 5,000 described species, are mostly found in temperate and tropical upland regions throughout the world (Meijerman & Ulenberg 2000).

These 6 leafroller species have been assessed together based on their similar biologies. All 6 species cause similar damage to host plants and are predicted to pose similar risks. In this assessment, the term 'leafrollers' is used to refer collectively to these 6 species; a scientific name is used when the information relates to an individual species.

Globally, *Arc. argyrospila* is present in the USA and Canada, *Arc. podana* is present in Asia, Europe, Canada and the USA, *Arc. rosana* is present in the USA and Europe, *Arg. franciscana* is present in North America, mostly along the Pacific Coast from southern British Columbia to northern Baja California, *C. rosaceana* is widely distributed throughout the continental United States and southern Canada, and *P. pyrusana* is present in Canada and the USA (Brunner 1993; Ferree & Warrington 2003; Gilligan, Baixeras & Brown 2018; Hill 1987; Landry, Powell & Sperling 1999).

These leafrollers have a wide collective host range including apple, stone fruit, berries, walnut and oak (Brunner 1993; Gilligan, Baixeras & Brown 2018; University of California 2010). All 6 leafroller species have been reported in association with apples in the PNW-USA (APHIS 2007; Brunner 1993; Coop, Knight & Fisher 1989; LaGasa et al. 2003; Wiman & Stoven 2022).

Larvae of leafrollers generally feed on foliage, particularly tender new leaves. They also roll and tie leaves with silk threads and then often feed and pupate within this protected environment (University of California 2010; Wiman & Stoven 2022). Larvae also feed on young fruit, just after fruit formation, causing drop of immature fruit (University of California 2010). Less severely damaged fruit may remain on the tree and continue to grow, while developing characteristically deep, bronze-coloured scars with roughened, netlike surfaces. The damaged fruit may also become deformed. Reports indicate that larvae do not bore into the fruit (Brunner 1993; University of California 2010). Larvae may also cause damage to fruit late in the season by attaching leaves to apple fruit or by feeding in sheltered sites created by closely clustered fruit (Brunner 1993).

The leafroller species assessed here have four life stages: egg, larva, pupa and adult. Leafroller pests are usually divided into either 'single generation' moths or 'two-generation' moths. In this assessment, single generation leafroller moths are *Arc. argyrospila*, *Arc. rosana* and *Arc. podana* (Brunner 1993; Gilligan & Epstein 2014a; Wiman & Stoven 2022). The single generation leafrollers overwinter as egg masses on twigs and branches of host plants. The overwintering eggs are laid in July and eggs hatch in the following spring. The larvae feed for 4 to 6 weeks, then pupate and emerge as moths in early summer (Wiman & Stoven 2022).

Two-generation moths considered in this assessment are *Arg. franciscana*, *C. rosceana* and *P. pyrusana* (Brunner 1993; Gilligan & Epstein 2014a; Wiman & Stoven 2022). Some of the two-generation leafrollers may only complete one generation in cooler areas or complete three or more generations in a year in warmer areas. Cooler conditions promote overlapping generations (Gilligan, Baixeras & Brown 2018). Two-generation leafrollers overwinter as second or third instar larvae within a silken case. Larvae become active in spring as fruit buds open. By mid- to late May, larvae become fully grown and pupate. Adults of the first generation appear from late May and oviposit in June. Larvae of the second generation begin hatching in late June and commence pupation from late July. Adults of the second generation are most active during August when oviposition generally occurs. Second generation larvae hatch from September and feed on foliage and fruit for a short while before moving to hibernacula in October (Brunner 1993; Wiman & Stoven 2022).

The risk scenario of biosecurity concern is that eggs, larvae and pupae of leafrollers may be imported on apple fruit from the PNW-USA.

Leafrollers have been assessed previously in the existing policy for stone fruit from California, Idaho, Oregon and Washington (Biosecurity Australia 2010b). In that policy, the unrestricted risk estimate for leafrollers was assessed as Low, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for leafrollers on the stone fruit from California, Idaho, Oregon and Washington pathway.

The department assessed the likelihood of importation of leafrollers on the PNW-USA apple pathway as being similar to the previous assessment of Moderate for stone fruit from California, Idaho, Oregon and Washington. Apples and stone fruit are grown in similar regions in the PNW-USA and both are major hosts of leafrollers (Brunner 1993; Gilligan & Epstein 2014a; University of California 2010). The in-field management practices in the PNW-USA are also similar for apples and stone fruit (Wiman & Stoven 2022). Harvest and post-harvest processes for stone fruit and apples are similar, and are expected to have a similar impact on association of leafrollers with packed commercially grown fruit. Leafrollers can complete their life cycle in diverse temperature regimes, and it is therefore likely for eggs or juvenile stages of leafroller species to survive cold temperatures for extended periods during storage and transport (Swain, Judd & Cory 2017; Yokoyama & Miller 2000). It is noted, however, that leafrollers are primarily foliage feeders (University of California 2010; Wiman & Stoven 2022). For these reasons, the previous assessment of Moderate from the existing policy for the likelihood of importation of leafrollers is adopted for the PNW-USA apple pathway.

Previous assessment of leafrollers on the stone fruit from California, Idaho, Oregon and Washington pathway rated the likelihood of distribution as Moderate. Apples from the PNW-USA are expected to be distributed in Australia, as a result of processing, sale or disposal, in a similar way to stone fruit from California, Idaho, Oregon and Washington. Leafrollers have a wide host range, and host material is likely to be continuously available in Australia. Also, apples can be exported all year round. Therefore, any differences in time of import between the two import pathways are unlikely to contribute to variation in the risk rating for likelihood of distribution. The life stages that may be present on the pathway are eggs, larvae and pupae. There are climatic conditions suitable for the development of leafrollers in some parts of Australia. For these reasons, the same rating of Moderate for the likelihood of distribution for

leafrollers on the stone fruit from California, Idaho, Oregon and Washington pathway is adopted for the PNW-USA apple pathway.

The likelihoods of establishment and spread of leafrollers in Australia for the PNW-USA apple pathway have been assessed as being similar to those of the previous assessments for the stone fruit from California, Idaho, Oregon and Washington pathway of High and High, respectively. These likelihoods relate specifically to events that occur in Australia and are principally independent of the import pathway. The consequences of entry, establishment and spread of leafrollers are also independent of the importation pathway and have been assessed as similar between pest risk assessments and rated as Moderate. Therefore, the ratings for the likelihoods of entry, establishment and spread, and the rating for the overall consequences of leafrollers previously assessed for the stone fruit from California, Idaho, Oregon and Washington pathway have been adopted for the PNW-USA apple pathway.

In addition, the department has reviewed the latest literature—for example, Gilligan, Baixeras and Brown (2018); Hollingsworth (2019); Sial, Brunner and Garczynski (2011); Suckling and El-Sayed (2017) and Swain, Judd and Cory (2017). No new information has been identified that would significantly change the risk ratings for importation, distribution, establishment, spread and consequences as set out for leafrollers in the existing policy for stone fruit from California, Idaho, Oregon and Washington.

#### **4.10.1 Likelihood of entry**

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

##### **Likelihood of importation**

The likelihood that leafrollers will be imported into Australia in a viable state on apples from the PNW-USA is considered to be similar to leafrollers on fresh stone fruit from California, Idaho, Oregon and Washington. Therefore, the same rating of Moderate for the likelihood of importation previously assessed for leafrollers on the fresh stone fruit from California, Idaho, Oregon and Washington pathway is adopted for leafrollers on the apples from PNW-USA pathway.

##### **Likelihood of distribution**

The likelihood that leafrollers will be distributed within Australia in a viable state as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host is considered to be similar to leafrollers on fresh stone fruit from California, Idaho, Oregon and Washington. Therefore, the same rating of Moderate for the likelihood of distribution previously assessed for leafrollers on the fresh stone fruit from California, Idaho, Oregon and Washington pathway is adopted for leafrollers on the apples from PNW-USA pathway.

##### **Overall likelihood of entry**

The overall likelihood of entry is determined as Low by combining the adopted likelihood of importation of Moderate with the adopted likelihood of distribution of Moderate, using the matrix of rules in Table 2.2.

#### 4.10.2 Likelihoods of establishment and spread

The likelihoods of establishment and spread of leafrollers in Australia from the PNW-USA apple pathway have been assessed as similar to those for the stone fruit from California, Idaho, Oregon and Washington pathway (Biosecurity Australia 2010b), which were rated as High and High respectively. These likelihoods relate specifically to events that occur in Australia and are principally independent of the import pathway.

#### 4.10.3 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that leafrollers will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as Low.

#### 4.10.4 Consequences

The potential consequences of the entry, establishment and spread of leafrollers in Australia are similar to those in the previous assessment for leafrollers on the stone fruit from California, Idaho, Oregon and Washington pathway, which were assessed as Moderate (Biosecurity Australia 2010b). The overall consequences for leafrollers on the apples from PNW-USA pathway are also assessed as Moderate.

#### 4.10.5 Unrestricted risk estimate

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

<b>Unrestricted risk estimate for leafrollers</b>	
Overall likelihood of entry, establishment and spread	Low
Consequences	Moderate
Unrestricted risk	Low

The unrestricted risk estimate for *Arc. argyrospila*, *Arc. podana*, *Arc. rosana*, *Arg. franciscana*, *C. rosaceana* and *P. pyrusana* on the PNW-USA apple pathway is assessed as Low, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for the leafrollers on the PNW-USA apple pathway.

## 4.11 Codling moth

### *Cydia pomonella* (EP, WA)

*Cydia pomonella* (codling moth) belongs to the family Tortricidae, an economically important group, containing many species that cause economic damage to agricultural, horticultural and forestry industries (Meijerman & Ulenberg 2000).

*Cydia pomonella* is present in nearly all temperate pome fruit-growing regions of the world, except for Japan and Korea (Gilligan & Epstein 2014a). *Cydia pomonella* is considered a serious pest of apples and pears in the PNW-USA (Wiman & Stoven 2022). *Cydia pomonella* can also affect a wide range of other hosts in the plant families, Rosaceae (*Prunus* spp., *Cydonia* sp. and *Crataegus* sp.), Ebenaceae (*Diospyros* sp.), Sapindaceae (*Litchi* sp.) and Myrtaceae (*Psidium* sp.) (Gilligan, Baixeras & Brown 2018). Depending on the apple variety and location, *C. pomonella* can cause damage to most of the crop if not managed (Brunner 2018; Caprile & Vossen 2005).

This species is present in eastern Australia but is absent from Western Australia (ALA 2020), and is a regional quarantine pest for that state (Government of Western Australia 2022).

*Cydia pomonella* has four life stages: egg, larva, pupa and adult (Caprile & Vossen 2005). Each female lays 30 to 70 eggs on the fruit, leaves or spurs of apples (Caprile & Vossen 2005). Eggs are 1 mm in length, disk-shaped, and opaque white (University of California 2017; Williams 2000). Incubation of eggs takes one to two weeks (Brunner 2018). On hatching, larvae are 2.5 mm long, reaching 20 mm in length at maturity. Immature larvae are whitish with a black head, while mature larvae are pinkish with a brown head (Wiman & Stoven 2022). The larval stage comprises five instars that all feed on fruit. They may bore to the centre of developing fruit to feed on the flesh and seeds. As larvae mature, they push frass out of their entry hole. After three to four weeks, the larvae leave the fruit and drop from the tree to seek a sheltered spot in which to spin a cocoon and pupate (Caprile & Vossen 2005; Wiman & Stoven 2022).

Depending on the time of year, larvae in cocoons either form pupae from which adults emerge about two to three weeks later, or diapause until the following spring, before pupating and emerging as adults around bloom time (Williams 2000; Wiman & Stoven 2022). In Washington, *C. pomonella* typically has two generations per year, with a third generation observed in warmer years (Brunner 2018). In Washington, second-generation adults begin emerging in early July, with adult activity peaking in mid-July to early August and continuing through early September (Brunner 2018).

Adult moths are about 12 mm long, with a wingspan of 15 to 20 mm (Caprile & Vossen 2005; University of California 2017; Wearing 2004; Williams 2000). Adult moths are only active for a few hours before and after sunset, when temperatures are above 15.5°C (Brunner 2018). Adult females begin laying eggs within a day of emerging (Brunner 2018).

The risk scenario of biosecurity concern is that larval stages of *C. pomonella* may be imported with apple fruit from PNW-USA.

*Cydia pomonella* has been assessed previously in existing policies for fresh apple fruit from the People's Republic of China (Biosecurity Australia 2010a), and fresh apple fruit from New Zealand (Biosecurity Australia 2006a). In these policies the unrestricted risk estimate for

*C. pomonella* was assessed as Low, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for this pest on these pathways.

The department has assessed the likelihood of importation of *C. pomonella* on fresh apple fruit from China as Low, and from New Zealand as Moderate (Biosecurity Australia 2006a, 2010a). However, differences in pest prevalence, climate and horticultural practices between export areas make it necessary to reassess the likelihood of importation of *C. pomonella* associated with the PNW-USA apple pathway.

Fresh apple fruit from the PNW-USA are expected to be distributed in Australia, as a result of processing, sale or disposal, in a similar way to apples from China and New Zealand. Apples can be imported all year round, therefore, there would be no seasonal differences between import pathways to contribute to variation in the risk rating for likelihood of distribution.

*Cydia pomonella* has hosts (e.g. apples and pears) available across Australia and host fruit on trees are likely to be available between spring and autumn in parts of Western Australia. Larvae may emerge from fruit discarded as waste in Western Australia and may pupate in a suitable substrate. This species is able to overwinter as larvae within thick, silken cocoons under loose bark and in soil or debris around the bases of trees (Caprile & Vossen 2005) for extended periods. These mechanisms can significantly enhance the ability of *C. pomonella* to complete its life cycle and find a new host. Previous assessments of *C. pomonella* on the apple from China (Biosecurity Australia 2010a) and New Zealand (Biosecurity Australia 2006a) pathways rated the likelihood of distribution as Moderate. The same rating of Moderate for the likelihood of distribution for *C. pomonella* is adopted for *C. pomonella* on the PNW-USA apple pathway.

The likelihoods of establishment and spread of *C. pomonella* in Australia from the PNW-USA apple pathway have been assessed as similar to those of the previous assessments for apples from China and New Zealand of High and High, respectively. These likelihoods relate specifically to events that occur in Australia and are principally independent of the import pathway. The consequences of entry, establishment and spread for *C. pomonella* are also independent of the import pathway, and have been assessed as being similar between pest risk assessments, and rated as Moderate. Therefore, the ratings for likelihoods of establishment and spread, and the rating for the overall consequences of *C. pomonella* previously assessed for apples from China and New Zealand have been adopted for the PNW-USA apple pathway.

In addition, the department has reviewed the latest literature—for example, Antwi and Rondon (2018); Gilligan, Baixeras and Brown (2018); Juszczak et al. (2013); Men et al. (2013) and Wiman and Stoven (2022). No new information has been identified that would significantly change the risk ratings for distribution, establishment, spread and consequences as set out for *C. pomonella* in the existing policies.

#### **4.11.1 Likelihood of entry**

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

##### **Likelihood of importation**

The likelihood that *C. pomonella* will arrive in Western Australia with the importation of apples from the PNW-USA is assessed as Moderate.

The following information provides supporting evidence for this assessment.

*Cydia pomonella* is a key pest of apple in the PNW-USA.

- *Cydia pomonella* is a pest of pome fruit and one of the most destructive apple pests in the world (Jiang et al. 2018).
- *Cydia pomonella* is reported to be the most serious insect pest of apple in the PNW-USA, especially in warmer and drier areas (Brunner et al. 2002; Wiman & Stoven 2022).

The biology and life cycle of *C. pomonella* is closely associated with apple fruit.

- It is reported that volatiles from mature apple fruit stimulate oviposition of female codling moths and attract newly hatched codling moth larvae (Yan et al. 2003). Female *C. pomonella* lay their eggs on or near developing fruits (CABI 2022).
- In Washington, up to three generations of codling moths per year have been reported, which coincide with fruit development (Brunner 2018).
- Larvae of *C. pomonella* may enter the fruit from any point on the surface, stem end or calyx end, and feed by boring directly into the fruit (Brunner 2018; English 2001; University of California 2017; Wearing 2004; Wiman & Stoven 2022).

Current in-field practices and control methods are likely to reduce pest populations in orchards.

- In the PNW-USA, the activity of *C. pomonella* can be predicted by phenology models or monitoring using pheromone traps (Wiman & Stoven 2022). Using these methods, targeted insecticide applications and biocontrol releases can be used to manage adults, eggs and larvae in orchards (Wiman & Stoven 2022).
- Mating disruption may also be used to manage *C. pomonella*. Pheromone dispensers placed in the orchard interfere with communication between female and male codling moths, and this prevents or delays mating, reducing the number of eggs laid and crop damage. Dispensers are typically applied to trees at densities of 50 to 100 per 1,000m<sup>2</sup> (Wiman & Stoven 2022).

Some *C. pomonella* larvae may not be detected or removed during harvest and post-harvest operations.

- After three to four weeks of feeding, mature larvae leave the fruit by pushing out the frass from the entry hole (Wiman & Stoven 2022), or by creating an exit hole (CABI 2022). This damage may cause premature fruit drop and fruit rots (Brunner 2018; DPIRD 2016; Wearing 2004).
- *Cydia pomonella* larvae may leave fruit prior to harvest to seek sheltered spots on the tree to spin cocoons and overwinter (Wiman & Stoven 2022).
- Quality inspection in the packing house is likely to remove infested fruit with obvious symptoms. The entrance hole and frass can easily be detected (Curtis et al. 1992) and deep entry holes may enhance fruit rot.
- On pome fruit, the larvae often enter through the calyx and bore into the core of the fruit (CABI 2022; Wiman & Stoven 2022). *Cydia pomonella* entry holes into the calyx are often difficult to detect without cutting into the fruit (English 2001).
- Because codling moth larvae feed internally within the apple, they would not be removed by washing, brushing or waxing of the apple fruit.

Larvae of *C. pomonella* may survive cold temperatures during storage in the PNW-USA and transport to Australia.

*Cydia pomonella* larvae are cold tolerant, especially diapausing larvae that are able to overwinter in the soil, leaf litter and under bark in orchards at cold temperatures for up to several months (Neven 1999). Moffitt and Albano (1972) reported that diapausing larvae survived cold storage for 133 days at around 2°C. However, there is no evidence of *C. pomonella* larvae diapausing within fruit (Brunner 2018; Moffitt & Albano 1972).

- Non-diapausing larvae in fruit are less cold tolerant than diapausing larvae, however, they are still able to tolerate cold temperatures for extended periods of time.
- Complete mortality of non-diapausing larvae of all stages was achieved in immature apples held in controlled atmosphere conditions and cold temperatures of 0°C ± 0.28°C for 13 weeks (Toba & Moffitt 1991).
- Yokoyama & Miller (1989) showed that complete mortality of codling moth eggs was achieved after 14 days at 0°C, whereas only 30% mortality of non-diapausing fifth instar larvae was achieved with exposure of 21 days at 0°C. Adults from larvae that survived 21 days at 0°C suffered no negative effects on fecundity.
- Moffitt and Albano (1972) showed that nearly all non-diapausing larvae and pupae died after only 30 days and 60 days, respectively, at 2°C.
- Harvested apples are normally stored and transported at temperatures of 0°C to 2°C (Kupferman 1996; WSU Tree Fruit 2021c). Storage time may vary from one day to more than 11 months (Kupferman 1996). Sea freight will be the more common method of transport of apples from the PNW-USA to Australia and will take about five weeks. Larvae of *C. pomonella*, if present in imported apples from the PNW-USA, may survive such cold temperatures during storage and transport.

*Cydia pomonella* is an economically important pest of apple fruit in the PNW-USA. *Cydia pomonella* undergoes multiple generations per year that coincide with apple fruit development. However, codling moth populations are typically well managed in apple orchards in the PNW-USA. Fruit with obvious symptoms are likely to be detected and removed during harvest and packing house processes. Larvae that have entered the fruit via the calyx may not be detected or removed during harvest and post-harvest processes. Larvae may survive cold temperatures during storage and transportation for an extended period of time. For the reasons outlined, the likelihood of importation of *C. pomonella* on apples from the PNW-USA is assessed as Moderate.

#### **Likelihood of distribution**

The likelihood that *C. pomonella* will be distributed within Australia in a viable state as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host is considered to be similar to *C. pomonella* on apples from China and New Zealand. Therefore, the same rating of Moderate for the likelihood of distribution previously assessed for *C. pomonella* on the apples from China and New Zealand pathways is adopted for *C. pomonella* on the apples from PNW-USA pathway.

#### **Overall likelihood of entry**

The overall likelihood of entry is determined as Low by combining the adopted likelihood of importation of Moderate with the adopted likelihood of distribution of Moderate, using the matrix of rules in Table 2.2.

#### 4.11.2 Likelihoods of establishment and spread

The likelihoods of establishment and spread of *C. pomonella* in Western Australia for the PNW-USA apple pathway have been assessed as similar to those of the previous assessments of High and High, respectively, for *C. pomonella* on apples from China and New Zealand. These likelihoods relate specifically to events that occur in Australia and are principally independent of the import pathway.

#### 4.11.3 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2

The overall likelihood that *C. pomonella* will enter Western Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible part of a host, establish in Western Australia and subsequently spread within Western Australia is assessed as Low.

#### 4.11.4 Consequences

The potential consequences of the entry, establishment and spread of *C. pomonella* in Australia are similar to those in the previous assessments for *C. pomonella* on apples from China and New Zealand, which were assessed as Moderate and Moderate, respectively. The overall consequences for *C. pomonella* on the apples from PNW-USA pathway are also assessed as Moderate.

#### 4.11.5 Unrestricted risk estimate

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

<b>Unrestricted risk estimate for <i>Cydia pomonella</i></b>	
Overall likelihood of entry, establishment and spread	Low
Consequences	Moderate
Unrestricted risk	Low

The unrestricted risk estimate for *C. pomonella* on the PNW-USA apple pathway is assessed as Low, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for *C. pomonella* on the PNW-USA apple pathway.

## 4.12 Grapholita moths

### ***Grapholita molesta* (EP, WA), *Grapholita packardi* (EP) and *Grapholita prunivora* (EP)**

*Grapholita molesta* (Oriental fruit moth), *Grapholita packardi* (cherry fruitworm) and *G. prunivora* (lesser appleworm) are fruit moths belonging to the Tortricidae family.

These *Grapholita* moths have been assessed together because of their related biologies, on the basis of which they are predicted to pose similar risks. In this assessment, the term ‘*Grapholita* moths’ is used to collectively refer to all 3 species; a scientific name is used when the information relates to that species.

*Grapholita molesta* is thought to have originated in northwest China, and spread from Japan to eastern Australia, central Europe, the east coast of the USA and Brazil at the beginning of the twentieth century (Gonzalez 1978). The first records of the presence of *G. molesta* in North America were from 1913 to 1915 (Gilligan & Epstein 2014a). The pest is now widely distributed throughout all states in the USA where stone fruit is grown (Gilligan, Baixeras & Brown 2018). *Grapholita molesta* is not present in Western Australia and is a regional quarantine pest for that state (Government of Western Australia 2020).

*Grapholita prunivora* is native to northeastern USA and was first reported in the Pacific Northwest in the 1940s (WSU Tree Fruit 2021a). In North America, *G. prunivora* is recorded throughout most of the important fruit growing regions, and is present in the PNW-USA (Kaur 2021; WSU Tree Fruit 2021a), and several eastern states and Canada (CABI 2022).

*Grapholita packardi* is widely distributed in northeastern USA and in the PNW-USA (CABI 2022; Wiman & Stoven 2022) and is present in Washington (Wise, Vander Poppen & Isaacs 2012). *Grapholita molesta* has a wide host range including apple, pear, apricot, plum, peach and persimmon (Gilligan, Baixeras & Brown 2018). *Grapholita molesta* is an important pest of stone fruit in Europe, eastern Australia and North America (Murrell & Lo 1998). It can also be a pest of apple orchards, especially where these are adjacent to stone fruit orchards (Neven et al. 2018).

The major hosts of *G. prunivora* are in the rose family including most cultivated pome and stone fruit (CABI 2022; Krawczyk & Johnson 1996), but crabapple, hawthorn and wild roses are reported as main hosts (Wiman & Stoven 2022).

*Grapholita packardi* is recorded to feed on fruit crops in the families Rosaceae and Ericaceae (Gilligan & Epstein 2014c). *Grapholita packardi* is mainly a pest of blueberry and cherry, although it can also attack apples and other fruit (Gilligan & Epstein 2014a; Michigan State University 2020).

*Grapholita molesta* has four life stages: egg, larva, pupa and adult. Adults are dark greyish-brown, 6 mm in length and with an average wingspan of 13 mm. Eggs, which are laid on leaves, fruit, shoots and twigs, are translucent white, slightly convex and approximately 0.7 mm in diameter. Newly hatched larvae are 1.5 mm in length and the last instar larvae are up to 12 mm in length. Young larvae bore into growing shoots, while later instar larvae attack fruit before seeking overwintering sites. *Grapholita molesta* overwinters as mature larvae in silk webbing in ground cover or in tree crevices. Pupation occurs in spring and adults appear near the time of host bloom. Visual indications of damage from larval feeding include dead and wilting shoots and fruit injury. Damaged fruit are more prone to secondary fungal infection and may drop from

the tree prematurely. Depending on climatic conditions, *G. molesta* may complete 3 to 7 generations per year (Gilligan & Epstein 2014a).

*Grapholita prunivora* has four life stages: egg, larva, pupa and adult (Gilligan & Epstein 2014a). Adult females lay eggs singly on young fruit or on the upper surface of the leaves. After hatching, *G. prunivora* larvae generally bore into fruit through the calyx end and feed internally within the fruit for about three weeks (Wiman & Stoven 2022). Larvae hollow out superficial galleries usually at a depth of less than 6 mm under the skin. These areas remain intact at first, but then wrinkle and turn brown. Excrement of the pest accumulates in the calyx end of the fruit, and also may be found near the peduncle on the fruit. Mature larvae exit the fruit and spin cocoons to pupate or overwinter at the base of host plants or under bark scales (Plantwise 2020; Wiman, Stoven & Bush 2019).

*Grapholita prunivora* has 2 generations per year, with the first generation of adults beginning to emerge in spring and the second generation appearing from late summer. Both generations of adult females lay eggs on the fruit (Gilligan & Epstein 2014a; Wiman, Stoven & Bush 2019). Apple fruit attacked by first generation larvae usually drop from the tree prematurely (Plantwise 2020; Wiman, Stoven & Bush 2019). The *G. prunivora* adult is a small moth with a wingspan of 8 to 11 mm (Pfeiffer 2013). Fully-grown larvae are approximately 7.5 to 9.5 mm in length (Gilligan & Epstein 2014a). Golden-brown coloured pupae are 4.5 to 6.0 mm in length (Krawczyk & Johnson 1996).

The life-cycle of *G. packardi* is very similar to that of *G. prunivora*, with four life stages and 2 to 3 generations per year (Gilligan, Baixeras & Brown 2018; Gilligan & Epstein 2014a; Pfeiffer 2013; Wise, Vander Poppen & Isaacs 2012). However, (Gilligan, Baixeras & Brown 2018; Pfeiffer 2013; Wise, Vander Poppen & Isaacs 2012) reported that this pest has a single generation on blueberries. Adult females lay eggs singly on terminal shoot leaves. The overwintering stage is the mature larva, which overwinters on the host plant in a cocoon and pupation occurs the following spring (Gilligan & Epstein 2014a). Like *G. prunivora*, *G. packardi* causes damage to fruit and shoots, with larvae entering the fruit through the calyx (Gilligan, Baixeras & Brown 2018; Pfeiffer 2013; Wise, Vander Poppen & Isaacs 2012). Similar to *G. prunivora*, *G. packardi* is also a small moth of 5 to 6 mm in length (Wise, Vander Poppen & Isaacs 2012). Larvae are pink-coloured and approximately 8 mm in length (Gilligan, Baixeras & Brown 2018; Wise, Vander Poppen & Isaacs 2012).

The risk scenario of biosecurity concern is that eggs or larvae of *Grapholita* moths may be imported on apple fruit from the PNW-USA.

*Grapholita molesta* has been assessed previously in various existing import policies, for example, for fresh apple fruit from the People's Republic of China (Biosecurity Australia 2010a), fresh apple fruit from New Zealand (Biosecurity Australia 2006a), stone fruit from California, Idaho, Oregon and Washington (Biosecurity Australia 2010b), and stone fruit from New Zealand into Western Australia (Biosecurity Australia 2006b). *Grapholita prunivora* and *G. packardi* have been assessed previously in the existing import policy for stone fruit from California, Idaho, Oregon and Washington (Biosecurity Australia 2010b).

The unrestricted risk estimate (URE) for *G. molesta* was assessed as Very low, which achieves the ALOP for Australia and therefore specific risk management measures are not required, for apples from New Zealand and apples from China. The URE for *G. molesta* was assessed as Low,

which does not achieve the ALOP for Australia and therefore specific risk management measures are required, for stone fruit from New Zealand and stone fruit from California, Idaho, Oregon and Washington. The URE for *G. prunivora* and *G. packardi* was assessed as Low, which does not achieve the ALOP for Australia and therefore specific risk management measures are required, for stone fruit from California, Idaho, Oregon and Washington.

The department has assessed the likelihood of importation of *G. molesta* as Very low for apples from New Zealand and apples from China, and as Moderate for stone fruit from New Zealand and stone fruit from California, Idaho, Oregon and Washington. The department has assessed the likelihood of importation of *G. prunivora* and *G. packardi* as Low for stone fruit from California, Idaho, Oregon and Washington. Differences in pest prevalence, climate and horticultural practices between export areas, and host status between commodities make it necessary to assess the likelihood of importation of Grapholita moths associated with the PNW-USA apple pathway.

The department has assessed the likelihood of distribution of *G. molesta* as Moderate for apples from New Zealand and China and for stone fruit from New Zealand and California, Idaho, Oregon and Washington. The department has also assessed the likelihood of distribution of *G. prunivora* and *G. packardi* as Moderate for stone fruit from California, Idaho, Oregon and Washington. Apples from the PNW-USA are expected to be distributed in Australia, as a result of their processing, sale or disposal, in a similar way to apples from New Zealand and China and to stone fruit from New Zealand and California, Idaho, Oregon and Washington. Grapholita moths have wide host ranges including a range of rosaceous species (Gilligan, Baixeras & Brown 2018; Kaur 2021; Wise, Vander Poppen & Isaacs 2012). Thus, suitable host plants for Grapholita moths are likely to be available all year round in Australia. There are suitable climatic conditions for the development of Grapholita moths in most parts of Australia. The life stages likely to be present on the pathway are eggs on the fruit or larvae within the fruit. Larvae may emerge from fruit, or eggs may hatch into larvae. Dispersal by larvae will be restricted to short-distance crawling, but adult moths developing from larvae would be capable of flying to find new hosts. Therefore, the same rating of Moderate for the likelihood of distribution of *G. molesta*, *G. prunivora* and *G. packardi* from the existing policies is adopted for these 3 Grapholita moths for the PNW-USA apple pathway.

The likelihoods of establishment and spread of Grapholita moths in Australia from the PNW-USA apple pathway are assessed as being similar to those in the previous assessments for these moths which were rated as High and High, respectively. These likelihoods relate specifically to events that occur in Australia and are principally independent of the import pathway. The consequences of the entry, establishment and spread of Grapholita moths in Australia are also independent of the import pathway and are assessed as being similar to previous assessments of Moderate. Therefore, the ratings of the likelihoods of establishment and spread, and the rating for the overall consequences of Grapholita moths on previous import pathways have been adopted for the PNW-USA apple pathway.

In addition, the department has also reviewed the latest literature—for example, Adams, Bush and Stoven (2021); EFSA PHS Panel et al. (2018); Gilligan, Baixeras and Brown (2018); Graillot et al. (2016); Hollingsworth (2019); Krawczyk (2016); Neven et al. (2018); Pfeiffer (2013); Salinas-Castro et al. (2018); Yang et al. (2016) and Zhang et al. (2017). No new information has

been identified that would significantly change the risk ratings for distribution, establishment, spread or consequences as set out for *Grapholita* moths in the existing policies.

#### 4.12.1 Likelihood of entry

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

##### Likelihood of importation

The likelihood that *G. molesta*, *G. prunivora* and/or *G. packardi* will arrive in Australia with the importation of apples from the PNW-USA is assessed as Very Low.

The following information provides supporting evidence for this assessment.

*Grapholita* moths are present in the PNW-USA and apple is a host.

- The three *Grapholita* species are widely distributed in the PNW-USA (Wiman, Stoven & Bush 2019) and apple is a host (Gilligan, Baixeras & Brown 2018; Krawczyk & Johnson 1996; Myers, Hull & Krawczyk 2007; Najar-Rodriguez, Bellutti & Dorn 2013; Wiman & Stoven 2022; Wise, Vander Poppen & Isaacs 2012).
- *Grapholita molesta* has a wide host range including apple, pear, apricot, plum, peach and persimmon (Gilligan, Baixeras & Brown 2018), but stone fruit such as peach are preferred (Myers, Hull & Krawczyk 2007; Najar-Rodriguez, Bellutti & Dorn 2013).
- Several studies have explored the host suitability of apple and stone fruit hosts for *G. molesta* (Myers, Hull & Krawczyk 2007; Najar-Rodriguez, Bellutti & Dorn 2013) (Sarker & Lim 2019). Myers, Hull & Krawczyk (2007) and Najar-Rodriguez, Bellutti & Dorn (2013) showed that mature apple fruit is an inferior host to mature peach fruit for *G. molesta*, largely due to larvae developing significantly slower in apple versus peach fruit. However, adult moths that emerged from apples had significantly greater longevities than those emerging from peach (Myers, Hull & Krawczyk 2007), while Najar-Rodriguez (2013) showed that adult longevity, fecundity and body mass were not significantly different when larva were reared on apple or peach. Sarker and Lim (2019) showed that, while *G. molesta* larvae developed more slowly in immature apple fruit than immature peach and plum fruit, the collective consideration of all performance indicators suggested that immature apple and plum fruit were more suitable hosts than immature peach fruit. Host suitability for *G. molesta* therefore appears to be dependent on the level of fruit maturity (Sarker & Lim 2019; Sarker, Woo & Lim 2021). Collectively, the results of studies on the host status of apple for *G. molesta* indicate that both immature and mature apple fruit are suitable hosts.
- Hosts of *G. prunivora* include most cultivated pome and stone fruit (CABI 2022; Krawczyk & Johnson 1996), although crabapple, hawthorn and wild roses are reported as main hosts (Wiman & Stoven 2021b).
- *Grapholita packardi* is recorded to feed on fruit crops in the families Rosaceae and Ericaceae (Gilligan & Epstein 2014c). *Grapholita packardi* is mainly a pest of blueberry and cherry, although it can also attack apples and other fruit (Gilligan, Baixeras & Brown 2018; Kaur 2021; Wise, Vander Poppen & Isaacs 2012).

*Grapholita* moths are not recognised as pests of commercially produced apples in the PNW-USA.

- *Grapholita molesta* is an important pest of stone fruit, especially peaches and nectarines, in the PNW-USA (Neven et al. 2018; Wiman & Stoven 2022). *Grapholita molesta* is not recognised as a pest of commercially produced apples in the PNW-USA but it may be found in neglected backyard apple trees (Wiman & Stoven 2022). *Grapholita molesta* has become a

more important pest of apples in eastern USA since the late 1990s (Myers, Hull & Krawczyk 2007).

- Central parts of Washington State, where most apples in the PNW-USA are grown, and eastern parts of the state, have been shown through modelling to have relatively low habitat and climatic suitability for *G. molesta*, in contrast to western parts of the state, consistent with the pest's current distribution (Neven et al. 2018).
- Apart from low habitat and climatic suitability of parts of the PNW-USA, Neven et al. (2018) proposed other reasons for why *G. molesta* is not a pest of commercial apples in the PNW-USA. These include apple orchards generally not adjoining stone fruit orchards and therefore being less prone to attack from moths flying in from stone fruit orchards, the low prevalence of alternate hosts in apple production areas, and insecticide spray programs.
- Outside of the PNW-USA in Michigan, Grapholita moths have been shown to be more common in abandoned apple orchards than commercial apple orchards (Krawczyk & Johnson 1996). *Grapholita prunivora* was the focus of the study of Krawczyk & Johnson (1996) who reported no commercially produced apple fruit to be damaged by this species even though *G. prunivora* adults were trapped in orchards. However, in abandoned orchards, *G. molesta* and *C. pomonella* were the main moth pests emerging from fruit, whereas *G. prunivora* and *G. packardi* were reared in much lower numbers. *Grapholita packardi* was the only species not reared from abandoned orchard apple fruit on all sampling occasions.
- There is very little additional information or evidence for *G. prunivora* and *G. packardi* in apples in the PNW-USA or wider north America. Most information relating to the two species in apples and other fruit is quite old and the absence of contemporary records indicates that they are either rare and/or effectively controlled in commercial orchards.

Grapholita moths may not be detected during harvest or post-harvest processes.

- Larvae of the three *Grapholita* species feed internally in fruit and signs of damage are often apparent, which would mean infested fruit would likely be detected during harvest or post-harvest processes in the packing house.
- Larvae of *G. molesta* (Stearns & Neiswander 1930 in Sarker and Lim (2022)), *G. prunivora* (Kaur 2021) and *G. packardi* (Pfeiffer 2013; Wise, Vander Poppen & Isaacs 2012) may enter fruit through the calyx or stalk end. As a result, signs of internal feeding may not be easily apparent leading to some infested fruit not being detected during harvest or post-harvest processes.

Grapholita moths may survive cold temperatures during storage in the PNW-USA and transport to Australia

- Harvested apples are normally cold stored at 0°C to 2°C (Good Fruit Grower 2014; Iowa State University Extension and Outreach 2008; Kupferman 1996; University of Maine 2020). Fruit will be transported to Australia at similar cold temperatures, with sea freight the likely preferred method of transport, which takes about 5 weeks.
- Immature stages of Grapholita moths may survive such cold temperatures as studies have shown they can survive in apple fruit for extended periods at low temperatures.
- Hansen (2002) reported complete mortality of *G. molesta* in apples at 3.3°C for eggs and early instar larvae after 8 weeks, and for late instar larvae after 10 weeks; and at 0.7°C ± 0.4°C for eggs and early instar larvae after 4 weeks, and for late instar larvae after 6 weeks.
- For *G. prunivora*, 99% mortality of late-stage eggs, first instar larvae and fourth instar larvae was achieved in apple stored at 2°C after 52 days, 46 days and 236 days, respectively (Neven 2004).

For the reasons outlined above, the likelihood of importation of *Grapholita* moths on imported apples sourced from PNW-USA is rated as Very Low.

#### **Likelihood of distribution**

The likelihood that *Grapholita* moths will be distributed within Australia in a viable state as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host is considered to be similar to those in the previous assessments for these moths (Biosecurity Australia 2006a, 2010b, a). Therefore, the same rating of Moderate for the likelihood of distribution previously assessed for these moths is adopted for *Grapholita* moths on the apples from PNW-USA pathway.

#### **Overall likelihood of entry**

The overall likelihood of entry for *Grapholita* moths is determined as Very Low by combining the assessed likelihood of importation of Very Low with the adopted likelihood of distribution of Moderate, using the matrix of rules in Table 2.2.

#### **4.12.2 Likelihoods of establishment and spread**

The likelihoods of establishment and spread of *Grapholita* moths in Australia from the PNW-USA apple pathway have been assessed as similar to those in the previous assessments for these moths, which were rated as High and High, respectively (Biosecurity Australia 2006a, 2010b, a). These likelihoods relate specifically to events that occur in Australia and are principally independent of the import pathway.

#### **4.12.3 Overall likelihood of entry, establishment and spread**

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that *Grapholita* moths will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible part of a host, establish in Australia, and subsequently spread within Australia is assessed as Very Low.

#### **4.12.4 Consequences**

The potential consequences of the entry, establishment and spread of *Grapholita* moths in Australia are similar to those in the previous assessments for these moths, which were assessed as Moderate (Biosecurity Australia 2006a, 2010b, a). The overall consequences for *Grapholita* moths on the apples from PNW-USA pathway are also assessed as Moderate.

#### **4.12.5 Unrestricted risk estimate**

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

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<b>Unrestricted risk estimate for <i>G. molesta</i>, <i>G. prunivora</i> and <i>G. packardii</i></b>	
Overall likelihood of entry, establishment and spread	Very Low
Consequences	Moderate
Unrestricted risk	Very Low

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The unrestricted risk estimate for *G. molesta*, *G. prunivora* and *G. packardi* on the PNW-USA apple pathway is assessed as Very Low, which achieves the ALOP for Australia. Therefore, no specific risk management measures are required for *G. prunivora* and *G. packardi* on the PNW-USA apple pathway.

### 4.13 Apple fruit moth

#### ***Argyresthia conjugella* (EP)**

*Argyresthia conjugella* Zeller (apple fruit moth) belongs to the family Yponomeutidae. *Argyresthia conjugella* is mainly distributed in the temperate climatic zones of Europe (Russell 2009), North America, Japan, the Middle East, Central Asia, Siberia and the Far East (Ovsyannikova & Grichanov 2008). *Argyresthia conjugella* is a major pest of apple in Nordic countries such as Norway (EPPO 1999; Kobro et al. 2003). *Argyresthia conjugella* has been present as an exotic pest in Washington, including in apple production areas, since 1985 (LaGasa 2008).

*Argyresthia conjugella* is recorded as feeding on seeds of two rosaceous species, apple and rowan (*Sorbus aucuparia*), with rowan being the preferred host (CABI 2022; Kobro et al. 2003; Pasini 2015). It also invades apple as an alternative host, particularly in low rowan-berry production years (Knudsen et al. 2008; Kobro et al. 2003; Pasini 2015), however other fruits such as pears and plum are not reported as hosts (CABI 2022; Pasini 2015). In the United States, the economic consequences caused by its feeding are not well documented. However, *A. conjugella* is probably a minor pest for apple in the PNW-USA, as it has not been listed as a pest of apple in these states (Wiman & Stoven 2022).

*Argyresthia conjugella* has four life stages: egg, larva, pupa and adult. The adult, with a wingspan of 10 to 12 mm, has whitish markings and dark purplish-brown forewings. Adults emerge from overwintering sites in the soil and, after mating, females oviposit about 20 to 30 eggs on rowan green berries or on immature apple fruit (Kobro et al. 2003; Pasini 2015). The oval, flat and whitish eggs, with dimensions of 0.5 x 0.3 mm, hatch in about 10 to 14 days. Emerging larvae immediately bore into the fruit and make tunnels in the apple flesh in search of the seeds (Alford 2007; Furenhed 2006). This can be seen on the fruit as sunken discoloured spots with the holes filled with frass, which can result in secondary infections that lead to fruit rot (Carter 1984). The mature larvae, dull-bodied and measuring up to 7 mm in length, generally exit the fruit by piercing the fruit skin and making numerous visible holes (Alford 2007). Pupation then occurs amongst dead leaves on the ground or under bark (Alford 2007; Carter 1984). Although rare, sometimes the larva pupates in the cavity within the seeds (Furenhed 2006). The brown pupa is 5 mm in length (Alford 2007). Depending on the climate, *A. conjugella* overwinters as a larva or pupa, for a period of 6 to 8 months (Pasini 2015). *Argyresthia conjugella* undergoes one generation per year (Elameen, Eiken & Knudsen 2016; UC IPM 2019).

The risk scenario of biosecurity concern is that larval and pupal stages of *A. conjugella* may be present within mature apple fruit from the PNW-USA.

A congeneric species, *Argyresthia assimilis* has been assessed in the policy for fresh apple fruit from the People's Republic of China (Biosecurity Australia 2010a). In the China apple policy, the unrestricted risk estimate for *A. assimilis* was assessed as Very Low, which achieves the ALOP for Australia.

*Argyresthia assimilis* and *A. conjugella* share a number of biological similarities including univoltine lifecycle, narrow host range and fruit seed feeding behaviour.

Therefore, it is considered that *A. conjugella* and *A. assimilis* pose similar biosecurity risks and will require similar risk management measures. Given the similarities between the two species,

the assessment for *A. assimilis* for the fresh apple fruit from China pathway is considered in the assessment of *A. conjugella* on the PNW-USA apple pathway.

The department has assessed the likelihood of importation of *A. assimilis* on fresh apple fruit from China as Low (Biosecurity Australia 2010a). However, differences in pest prevalence, climate and horticultural practices between the export areas make it necessary to re-assess the likelihood of importation of *A. conjugella* associated with the PNW-USA apple pathway.

Previous assessment of *A. assimilis* on the fresh apple fruit from China pathway rated the likelihood of distribution as Moderate. Fresh apple fruit from the PNW-USA are expected to be distributed in Australia, as a result of processing, sale or disposal, in a similar way to apples from China. Apples can be imported all year round, therefore, there would be no seasonal differences between both import pathways to contribute to variation in the risk rating for likelihood of distribution. Due to the narrow host range (rowan and apple) of this pest – adults lay eggs on host fruit, and larvae only feed on fruit, particularly immature fruit – *A. conjugella* may have some difficulty finding a host in Australia.

Flowering and fruit setting of rowan are cyclic (Pasini 2015) and fruit are not always available. Apples are grown commercially and in household gardens in many parts of Australia, with developing and mature apples available for about half the year. Therefore, the rating of Moderate for the likelihood of distribution for *A. assimilis* on the apples from China pathway is also adopted for *A. conjugella* on the PNW-USA apple pathway.

The likelihoods of establishment and spread of *A. conjugella* in Australia from the PNW-USA apple pathway are considered to be similar to those for *A. assimilis* on apples from China, namely, High and Moderate, respectively. Those likelihoods relate specifically to events that occur in Australia and are essentially independent of the import pathway. The consequences of entry, establishment and spread for *A. conjugella* are also independent of the import pathway and considered to be similar between pest risk assessments, and therefore rated as Low. Therefore, the ratings for the likelihoods of establishment and spread, and the rating for overall consequences for *A. assimilis* on the China apple pathway have been adopted for *A. conjugella* on the PNW-USA apple pathway.

In addition, the department has reviewed the latest literature — for example, Elameen, Eiken and Knudsen (2016) and Pasini (2015). No new information has been identified that would significantly change the risk ratings for distribution, establishment, spread and consequences, as set out for its congeneric species, *A. assimilis*, in the existing policy.

#### **4.13.1 Likelihood of entry**

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

##### **Likelihood of importation**

The likelihood that *A. conjugella* will arrive in Australia with the importation of apples from the PNW-USA is assessed as Low.

The following information provides supporting evidence for this assessment.

*Argyresthia conjugella* is present in apple production areas in the PNW-USA.

- *Argyresthia conjugella* has been present in Washington since 1985 (LaGasa 2008). This species is reported to be found in eastern and western North America, including in apple production areas in the PNW-USA (WSDA 2019).
- *Argyresthia conjugella* feeds primarily on seeds of rowan (*Sorbus aucuparia*) (Alford 2007; Pasini 2015). It can also attack apple, particularly in low rowan-berry production years (Knudsen et al. 2008; Kobro et al. 2003; Pasini 2015), and cause fruit damage (Pasini 2015).
- *Argyresthia conjugella* is considered to be a minor pest for apple in the PNW-USA on the basis that it has not been listed as a pest of commercially produced apples in the PNW-USA (Wiman & Stoven 2022).

*Argyresthia conjugella* may be associated with apple fruit at harvest.

- *Argyresthia conjugella* can successfully develop in apple fruit (Ovsyannikova and Grichanov (2008) even though older studies indicate that apple is a poor larval host for this pest, as reported in Furenhed (2006).
- Adults of *A. conjugella* emerge from overwintering sites in the soil and, after mating, females oviposit about 20 to 30 eggs on unripe apple fruit. Eggs hatch after about two weeks (Pasini 2015) and would not be expected to be present on fruit at the time of harvest.
- Larvae of *A. conjugella* bore tunnels in apple fruit in search of the seeds (Furenhed 2006). Larval development lasts 40 to 50 days (Ovsyannikova & Grichanov 2008), with most larvae exiting the fruit to pupate before harvest. However, some larvae could remain within infested fruit at the time of harvest.
- Pupation generally occurs outside the fruit, but larvae can pupate in the seed cavity (Pasini 2015). Some pupae could be present in infested fruit at the time of harvest.

Some *A. conjugella* may not be detected during harvest or post-harvest processes.

- Tunnels made by *A. conjugella* larvae may cause secondary infections that lead to fruit rot. The outside of infested apple fruit show sunken, discoloured patches on the skin (Carter 1984). Visible rotten fruit will be removed during harvest or packing house processes.
- The mature larvae measure up to 7 mm in length and generally exit the fruit by piercing the fruit skin and making numerous visible holes (Carter 1984; Ovsyannikova & Grichanov 2008). Packing house procedures may not detect larvae still feeding inside the fruit, or pupae in the cavity within the apple core, because the point where larvae enter the fruit is small and often concealed in the calyx (Ovsyannikova & Grichanov 2008).

*Argyresthia conjugella* could survive cold temperatures during storage in the PNW-USA and transport to Australia.

- Harvested apples are normally cold stored at 0°C to 2°C (Good Fruit Grower 2014; Iowa State University Extension and Outreach 2008; Kupferman 1996; University of Maine 2020). Fruit will be transported to Australia at similar cold temperatures, with sea freight the likely preferred method of transport, which takes about five weeks.
- Mature larvae and pupae of *A. conjugella* are likely to survive such cold temperatures as they overwinter for extended periods in sub-zero temperatures (Pasini 2015).

*Argyresthia conjugella* is known to be associated with apple fruit, and larvae bore into apples in search of seeds. Most larvae generally exit from infested fruit to pupate before harvest, but some larvae may remain in fruit and pupation can sometimes occur inside infested apple fruit. Larval feeding in fruit often results in visible secondary infections. Apple is not the preferred host of

*A. conjugella*, and this species is considered to be a minor pest of apples in the PNW-USA. For the reasons outlined, the likelihood of importation of *A. conjugella* on apples from PNW-USA is assessed as Low.

#### **Likelihood of distribution**

The likelihood that *A. conjugella* will be distributed within Australia in a viable state as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host is considered to be similar to *A. assimilis* on fresh apple fruit from China. Therefore, the same rating of Moderate for the likelihood of distribution previously assessed for *A. assimilis* on the fresh apple fruit from China pathway is adopted for *A. conjugella* on the apples from PNW-USA pathway.

#### **Overall likelihood of entry**

The overall likelihood of entry is determined as Low by combining the adopted likelihood of importation of Low with the adopted likelihood of distribution of Moderate, using the matrix of rules in Table 2.2.

#### **4.13.2 Likelihoods of establishment and spread**

The likelihoods of establishment and spread of *A. conjugella* in Australia from the PNW-USA apple pathway have been assessed as similar to those of the previous assessments, which were rated as High and Moderate respectively, for *A. assimilis* on the fresh apple fruit from China pathway (Biosecurity Australia 2010a). These likelihoods relate specifically to events that occur in Australia and are principally independent of the import pathway.

#### **4.13.3 Overall likelihood of entry, establishment and spread**

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that *A. conjugella* will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as Low.

#### **4.13.4 Consequences**

The potential consequences of the entry, establishment and spread of *A. conjugella* in Australia are similar to those in the previous assessment for *A. assimilis* on the fresh apple fruit from China pathway, which were assessed as Low (Biosecurity Australia 2010a). The overall consequences for *A. conjugella* on the apples from PNW-USA pathway are also assessed as Low.

#### **4.13.5 Unrestricted risk estimate**

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

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**Unrestricted risk estimate for *A. conjugella***

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Overall likelihood of entry, establishment and spread	Low
Consequences	Low
Unrestricted risk	Very Low

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The unrestricted risk estimate for *A. conjugella* on the PNW-USA apple pathway is assessed as Very Low, which achieves the ALOP for Australia. Therefore, no specific risk management measures are required for *A. conjugella* on the PNW-USA apple pathway.

## 4.14 Thrips

### *Frankliniella occidentalis* (GP, NT, RA) and *Frankliniella tritici* (GP)

Two thrips species were identified on the fresh apple fruit from the PNW-USA apple pathway that are quarantine pests and/or regulated articles for Australia: *Frankliniella occidentalis* and *F. tritici* (Table 4.5).

*Frankliniella occidentalis* is not present in the Northern Territory and is a regional quarantine pest for that territory. *Frankliniella occidentalis* is also identified as a regulated article for Australia, because it is capable of harbouring and spreading (vectoring) emerging orthotospoviruses that are quarantine pests for Australia, as detailed in the thrips Group PRA (DAWR 2017). For simplicity, thrips identified as regulated articles are referred to as regulated thrips.

*Frankliniella tritici* is not present in Australia and is a quarantine pest for Australia.

The indicative likelihood of entry for all quarantine and/or regulated thrips is assessed in the thrips Group PRA as Moderate (DAWR 2017). *Frankliniella occidentalis* and *F. tritici* are reported to be present in Idaho, Oregon and Washington (APHIS 2007; CABI 2018) and are associated with fresh apple fruit (APHIS 2007; CABI 2022). Standard packing house processes and transportation are not expected to eliminate these thrips from the pathway. After assessment of relevant pathway-specific factors (Sections 2.2.6 and 2.2.7) for fresh apple fruit from the PNW-USA, the likelihood of entry of Moderate, was verified as appropriate for these thrips (Table 4.5).

**Table 4.5 Quarantine thrips species for fresh apple fruit from the PNW-USA**

Pest	In thrips Group PRA	Quarantine pest	Regulated thrips	On apple pathway	Likelihood of entry
<i>Frankliniella tritici</i>	Yes	Yes	No	Yes	Moderate
<i>Frankliniella occidentalis</i>	Yes	Yes (NT)	Yes	Yes	Moderate

**NT:** Pest of biosecurity concern for the Northern Territory.

A summary of the risk assessment for quarantine thrips is presented in Table 4.6 for convenience.

**Table 4.6 Risk estimates for quarantine thrips**

Risk component	Rating for quarantine thrips
Likelihood of entry (importation x distribution)	Moderate (High x Moderate)
Likelihood of establishment	High
Likelihood of spread	High
Overall likelihood of entry, establishment and spread	Moderate
Consequences	Low
<b>Unrestricted risk</b>	<b>Low</b>

As assessed in the thrips Group PRA, the indicative unrestricted risk estimate for thrips is Low (Table 4.6), which does not achieve the ALOP for Australia.

This indicative unrestricted risk estimate is considered to be applicable for the quarantine thrips species present on the fresh apple fruit from PNW-USA pathway. Therefore, specific risk management measures are required for quarantine thrips on the PNW-USA apple pathway.

As *F. occidentalis* can vector orthospoviruses that are quarantine pests for Australia, a summary of the risk assessment for quarantine orthospoviruses transmitted by thrips is presented in Table 4.7 for convenience.

**Table 4.7 Risk estimates for emerging quarantine orthospoviruses vectored by regulated thrips**

<b>Risk component</b>	<b>Rating for emerging quarantine orthospoviruses (a)</b>
Likelihood of entry (importation x distribution)	Low (Moderate x Moderate)
Likelihood of establishment	Moderate
Likelihood of spread	High
Overall likelihood of entry, establishment and spread	Low
Consequences	Moderate
<b>Unrestricted risk</b>	<b>Low</b>

(a): Risk estimates for orthospoviruses adopted from the thrips Group PRA (DAWR 2017a).

As assessed in the thrips Group PRA, the Unrestricted Risk Estimate for emerging quarantine orthospoviruses transmitted by regulated thrips is Low (Table 4.7), which does not achieve the ALOP for Australia.

This Unrestricted Risk Estimate is considered to be applicable for the emerging orthospoviruses known to be vectored by *F. occidentalis* present on the PNW-USA apple pathway. Therefore, specific risk management measures are required for this regulated thrips to mitigate the risks posed by emerging quarantine orthospoviruses.

This risk assessment, which is based on the thrips Group PRA, applies to all phytophagous quarantine thrips and regulated thrips on the PNW-USA apple pathway, irrespective of the species identification in this document. This is explained in Section 2.2.7.

## 4.15 Fire blight

### *Erwinia amylovora* (EP)

Fire blight is a bacterial disease of apple, pear and other rosaceous hosts caused by *Erwinia amylovora* (Beer 1990; Dupont 2019c; Ordax et al. 2010a; Teviotdale 2011), which is a member of the order Enterobacterales. *Erwinia amylovora* is considered to have originated on wild hosts such as hawthorn (*Crataegus* spp.) in northeastern USA and then to have spread to apple and pear following their importation for cultivation (Van der Zwet & Keil 1979). Pears (*Pyrus* spp.) are very susceptible to fire blight (Teviotdale 2011); apples (*Malus* spp.) are less susceptible (Johnson 2014). In addition to hawthorn, pear and apple, other less common hosts of this pathogen include *Cydonia* spp. (quince), *Eriobotrya japonica* (loquat), *Cotoneaster* spp. (cotoneaster) and *Pyracantha* spp. (firethorn) (Teviotdale). These hosts all belong to the sub-family Maloideae of the family Rosaceae.

*Erwinia amylovora* is present in all parts of the PNW-USA (Bonn & Van der Zwet 2000; Dupont 2019c; Smith 1999). The pathogen overwinters almost exclusively in the previous season's cankers, which are concentrated sites of infection in woody tissues of the host (Beer & Norelli 1977; Dupont 2019c). The primary inoculum is produced mostly as bacterial ooze on the surface of cankers (Acimovic et al. 2019) when the humidity is high, and enters a new host through natural openings (for example, stomata or floral nectaries) (Dupont 2019c) or wounds such as those caused by pruning or hail (Teviotdale). Insects, wind, rain and pruning tools are all important means by which primary inoculum of *E. amylovora* can be spread (Teviotdale).

*Erwinia amylovora* can infect flowers, young leaves, stems and immature fruits. Fire blight infections are initiated as blossom blight (Slack et al. 2019) and infections commonly occur during bloom and for about three weeks following petal fall as bacterial cells are washed down the style into the floral cup by water (Dupont 2019c). During the course of infection, floral parts become water-soaked and greyish-green in appearance, and later shrivel and turn brown or black (Agrios 2008; Dupont 2019c). Epiphytic colonisation of the stigmatic surfaces of flowers by *E. amylovora* may result in bacteria persisting in low numbers on the dry flower parts subsumed into the calyx-end of fruit, where they are known to persist at low levels and decline over time (Hale, McRae & Thomson 1987; Sholberg, Gaunce & Owen 1988). Bees are the primary agents for secondary spread of inoculum from infected flowers to newly opened ones (Grove et al. 2003; Thomson 2000). Mediterranean fruit fly has been suggested as a potential vector of *E. amylovora* (Ordax et al. 2015), but the evidence is derived only from laboratory experiments; while the likelihood of occurrence under field conditions is currently undetermined, it is considered unlikely to be substantial.

Fruits formed by infected flowers generally do not mature, and differ in appearance depending on the stage at which they became infected. Such fruit usually shrivel and discolour, and remain attached to trees through winter, but do not show signs of bacterial ooze. Fruit infected as a result of progressive infection of branches are less shrivelled and discoloured, while those infected following injury by hail or insects often develop lesions and may exude ooze (Beer 1990).

Leaves are rarely infected, but can be prone to infection after hail damage (Beer 1990). Studies of *E. amylovora* found that multiplication of the bacterium could not be demonstrated on intact leaf surfaces, and that the bacteria died within a few hours when exposed to solar radiation or,

as a consequence of exopolysaccharide disruption, at humidity levels over 75% (Maas Geesteranus & de Vries 1984).

Apples from PNW-USA are usually harvested from August to early November and stored at 0°C to 2°C prior to being exported (Good Fruit Grower 2014; Iowa State University Extension and Outreach 2008; Kupferman 1996; University of Maine 2020; WSU Tree Fruit 2021c). Kupferman (1996) stated that storage time may vary from one day to more than 11 months, depending on the quality of the fruit and the marketing program. This would allow apple fruit from the PNW-USA to be shipped to Australia all year round, with sea freight that takes about five weeks likely to be the preferred method of transport.

The risk scenario of biosecurity concern is that *E. amylovora* associated with fruit may enter Australia and result in the establishment and spread of this pathogen in Australia.

*Erwinia amylovora* was most recently assessed in the existing import policy for fresh apple fruit from New Zealand (Biosecurity Australia 2011b). In that policy, the unrestricted risk estimate for *E. amylovora* was assessed as Very Low, which achieved the ALOP for Australia, when certain commercial production practices such as in-field controls, fruit maturity testing at harvest, and packing house sanitation were routinely applied. Therefore, no specific risk management measures are required for *E. amylovora* on the New Zealand apple pathway. Similar commercial production practices are routinely applied as part of the PNW-USA apple production system (see Chapter 3), and the assessment of likelihood of importation explicitly relies on their continued implementation.

The department assessed the likelihood of importation of *E. amylovora* on fresh apple fruit from New Zealand as Moderate (Biosecurity Australia 2011b). Differences in pest prevalences and transport times between exporting areas make it necessary to assess the likelihood of importation of *E. amylovora* on the PNW-USA apple pathway (see below).

The likelihood of distribution of *E. amylovora* on the apples from New Zealand pathway was assessed as Extremely Low (Biosecurity Australia 2011b). Apples from the PNW-USA are expected to be distributed in Australia (as a result of processing, sale or disposal) in a similar way to apples from New Zealand. Apples from New Zealand are harvested from February to May (AgFirst 2022), and in the PNW-USA, apples are harvested from August until early November (Washington Apple Commission 2019). As apples from both New Zealand and the PNW-USA may be imported throughout the year, there would be no seasonal differences between the import pathways to contribute to variation in the risk rating for likelihood of distribution.

Hosts of *E. amylovora* are widely available in various parts of Australia. However, due to the lack of suitable dispersal mechanisms, the vulnerability of the bacterium to desiccation (Maas Geesteranus & de Vries 1984) and/or saprophytic competition, it is considered unlikely that *E. amylovora*, if present in imported fruit, would be transferred to a susceptible part of a host in Australia in a viable state. Therefore, the same rating of Extremely Low for the likelihood of distribution of *E. amylovora* is adopted for the PNW-USA apple pathway.

The likelihoods of establishment and spread of *E. amylovora* in Australia from the PNW-USA apple pathway are also considered to be similar to those of the previous assessments of High for the apples from New Zealand pathway. These likelihoods relate specifically to events that occur in Australia and are principally independent of the import pathway. The consequences of entry,

establishment and spread for *E. amylovora* in Australia are also independent of the import pathway, and have been assessed as being similar between pest risk assessments, and rated as High. The existing ratings for the likelihoods of establishment and spread and for the overall consequences of High have been adopted for the PNW-USA apple pathway.

In addition, the department has reviewed the latest literature — for example, Dupont (2019c); IPPC (2016b); Johnson (2014); Pattemore et al. (2014); PNW Handbooks (2020a); QIA (2015); Rosenberger, Jentsch and Rugh (2020) and Tancos et al. (2017). No new information has been identified that would significantly change the risk ratings for distribution, establishment, spread or consequences as set out for *E. amylovora* in the existing policy.

#### 4.15.1 Likelihood of entry

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

##### Likelihood of importation

The likelihood that *E. amylovora* will arrive in Australia with the importation of apples from the PNW-USA is assessed as Moderate.

The following information provides supporting evidence for this assessment.

*Erwinia amylovora* is associated with apples in the PNW-USA.

- *Erwinia amylovora* is present in the PNW-USA (Bonn & Van der Zwet 2000; Dupont 2019c; Smith 1999).
- In Washington there have been minor outbreaks annually since 1991, and serious damage to foliage in about 5 to 10% of orchards was reported in 1993, 1997, 1998, 2005, 2009, 2012, 2015, 2016, 2017 and 2018 (Dupont 2019c).
- In 2017 and 2018, infections were severe due to multiple wetting events as well as high temperatures during bloom (DuPont 2019a).
- Surveys in Washington of 10% of apple and pear acreage showed that 88% of pear areas and 17% of apple areas were impacted by fire blight in 2018 (DuPont 2019a).
- Some apple varieties nominated for export by the USA, such as Fuji, Gala and Granny Smith, are very susceptible to *E. amylovora* (Douglas 2006). This assessment considers all apple varieties (including rootstocks) are susceptible to *E. amylovora*.

In-field monitoring and controls in place for *E. amylovora* in commercial orchards are likely to reduce inoculum to low levels.

- The elements of *E. amylovora* management in the PNW-USA include keeping field inoculum levels low through monitoring, winter pruning, use of predictive modelling and application of chemical or biological controls.
- Pacific Northwest states in the USA use the CougarBlight model (Smith 1999; Smith 2006) for disease event prediction, and for determining the timing of commencement of control measures in susceptible production areas.
- The CougarBlight prediction model estimates the risk of blossom blight, and predicts the disease event in spring (DuPont 2020a), using a temperature risk value and predicted blossom wetting events.

- The model is available in the WSU Decision Aid System (DAS) (Dupont 2019c, 2020a), with risk determined on the basis of the temperature of the previous four days (Dupont 2019c, 2020a) and the number of hours of free moisture as a film of a droplet (0.25 mm or greater) at temperatures above 21°C over the previous four days (Pusey & Curry 2004).
- The CougarBlight Model was developed over 20 years ago, but was updated in 2010, and more recently in 2019 to lower the threshold for calculation of hourly temperature risk values from 15.6°C to 10°C, to ensure it remains current (DuPont 2020a).
- Following event prediction using models, in-field controls applied within the 12 to 24 hour window before a wetting event produce best results (DuPont 2019d). Spraying with antibiotics and/or release of biological control agents (for example Blossom Protect) are commenced, along with the use of copper and lime sprays.
- Most infections in the PNW-USA occur during periods that the models indicate as being of high or extreme danger (Smith 1999). Many growers applying sprays on the basis of predictions by the CougarBlight model have achieved enhanced control of the disease (Smith 2006).
- Bacteria overwintering in cankers in living tissues are actively managed during winter by pruning, in order to remove potential primary inoculum for the following season (Dupont 2018).

There is no evidence that supports susceptibility of intact mature fruit to infection by *E. amylovora* under natural conditions.

- Infection of developing fruit can occur in the PNW-USA during bloom and in the three-week period following petal fall (Bonn & Van der Zwet 2000; Dupont 2019c; Smith 1999).
- If a developing fruit is endophytically infected it does not reach maturity, and may either drop prematurely or shrivel, discolour and remain attached to the tree (Beer 1990).
- Immature fruit will not be harvested for export.
- *Erwinia amylovora* is not internally associated with mature symptomless apple fruit (Roberts 2002), and is only rarely externally associated with mature symptomless apple fruit, even when harvested from blighted trees and orchards (Roberts, Reymond & McLaughlin 1989). Deckers (2010) reported that endophytic infections have not been documented in mature symptomless apple fruit. It has been suggested that the bacteria cannot readily multiply in mature fruit due to the absence of its preferred starch source (Deckers 2010; Paulin 2010; WTO 2010). A complex polysaccharide (starch) carbohydrate named amyllum is found in young, immature fruit and is progressively converted to sugars during fruit maturation (Deckers 2010).
- Maturity testing and sourcing only of mature symptomless fruit for export are current practices in place in PNW-USA; these practices are comparable to those required for apples from New Zealand in the existing policy (Biosecurity Australia 2006a, 2011b). Only fruit that meet maturity requirements will be eligible for export from the PNW-USA.

*Erwinia amylovora* has poor survival epiphytically (externally) on apple fruit surfaces.

- *Erwinia amylovora* was detected on freshly harvested, blemish-free and apparently healthy mature apple fruit from severely infected orchards (Douglas 2006; Sholberg, Gaunce & Owen 1988). However, epiphytic colonies of *E. amylovora* were not detected on calyces or surfaces of fruit of 6 susceptible apple cultivars from blighted orchards in West Virginia, USA (Van der Zwet, Brown & Wells 1991).
- On the surface of fruit, or other plant surfaces, *E. amylovora* is exposed to an adverse environment that results in a very high decline in bacterial numbers. For example, Sholberg,

Gaunce and Owen (1988) found declines in bacterial numbers on fruit surfaces under humid conditions or cold storage at 2°C for five months, and vulnerability of the bacterium to desiccation or 6 hours of exposure to solar radiation was observed by Maas Geesteranus and de Vries (1984).

- Manceau (1990) concluded that *E. amylovora* had poor epiphytic fitness under the conditions observed in France. The epiphytic fitness of *E. amylovora* present on apple leaves after rain events in summer in the USA was also reported to be low (Norelli & Brandi 2006). Thomson (1999) concluded that only transient populations of *E. amylovora* were present on leaves following rain storms.
- Temple et al. (2007) conducted experiments using *E. amylovora* from cultures and air-dried ooze from diseased fruits. In one experiment, immature pear or apple fruits on trees were artificially covered by an inoculum suspension with 10<sup>7</sup> cfu/ml. Resultant epiphytic populations of *E. amylovora* declined by an order of magnitude every three to four days in the first two weeks following inoculation. From an initial population of 1.6 x 10<sup>7</sup> cfu, by day 56 only one of 450 pear fruit tested positive, and harboured only 4 cfu (Temple et al. 2007). No *E. amylovora* could be detected on apple fruit after 35 days (Temple et al. 2007). This study demonstrated the poor survival and rapid decline of *E. amylovora* bacteria, even from very high levels, on the surface of fruit.
- The likelihood of viable epiphytic bacteria occurring on the mature fruit surface other than the calyx at the time of apple picking is considered to be very low (Roberts, Raymond & McLaughlin 1989) and the likelihood of transfer of bacteria to clean fruit during processing and transport even lower.

*Erwinia amylovora* may be associated with the fruit pathway as the bacterium can be detected in the fruit calyx at low levels, particularly in fruit from severely infected orchards.

- *Erwinia amylovora* predominantly colonises flowers (Thomson 1986, 2000), and low bacterial numbers have also been recorded (Roberts 2002) on dried remnant flower parts subsumed into the calyx sinus of mature fruit (Hale, McRae & Thomson 1987; Sholberg, Gaunce & Owen 1988; Temple et al. 2007).
- In a severely infected orchard in New Zealand, the proportion of fruit carrying *E. amylovora* was assessed over a 100-day period from the immature fruitlet stage to harvest (Hale, McRae & Thomson 1987). Initially, *E. amylovora* was found in 53% of fruitlet calyces, but by harvest it was isolated from only 3.5% of mature fruit and from less than 1% of calyces of mature fruit (Hale, McRae & Thomson 1987). *Erwinia amylovora* was not isolated from mature fruit from orchards with no visible infections (Hale, McRae & Thomson 1987). In a second study, *E. amylovora* was isolated from 2% of fruit immediately after harvest from orchards with average levels of fire blight symptoms (Hale & Taylor 1999).
- *Erwinia amylovora* was not isolated by direct plating of washings of the calyx-end or main portion of 1,400 fruit harvested from trees in lightly infested orchards, that is, orchards with only one or two infected trees (Hale, McRae & Thomson 1987). In a further assessment, *E. amylovora* was not detected at harvest, either in the calyces or on the surfaces of 173 mature fruit sampled from within 5 cm of experimental field inoculation sites approximately four months after inoculation (Hale, Taylor & Clark 1996).
- In Ontario, *E. amylovora* was not isolated from tissues of the stem-end and calyx-end of 60 mature fruit harvested from severely infested apple trees (Dueck 1974).
- Roberts and Sawyer (2008) reviewed the literature concerning the presence of *E. amylovora* on apple fruit in Canada, USA and New Zealand; they concluded that *E. amylovora* was detected in 1.3% of apple fruit from orchards with fire blight symptoms.

- In the USA, mature apples and pears developed from blossoms inoculated with *E. amylovora* showed very low levels of bacteria in the calyces. An average of 7 cfu of *E. amylovora* was recorded from the detectably infected 3.3% of the pear fruit sampled over a two-year experimental period. In apples, no *E. amylovora* could be detected at harvest (Temple et al. 2007).

*Erwinia amylovora* present in the fruit calyx may survive packing house procedures, but will decrease over time during cold storage and transport.

During standard procedures in packing houses in the PNW-USA, fruit are washed/soaked in a chlorinated dump tank (with chlorine concentration and pH being regularly monitored), transported in a water stream, then high-pressure washed, brushed and rinsed in the packing line, excess water is removed from fruit by rollers and brushes, and wax is applied (Washington State University 2018b). Washing procedures are considered to remove the majority of any *E. amylovora* present on the surface of apple fruit (Ayers, Ayers & Goodman 1979). Chlorine solutions have been shown to be effective at controlling a range of pathogens (Brown 2002; Kupferman 1984; Suslow 2004).

- Cell wall exopolysaccharides that protect *E. amylovora*, and are known to promote survival, are also likely to be removed by washing, as they are water soluble (Ordax et al. 2010a; Roberts & Reymond 1989). However, bacteria protected in the calyx are unlikely to be removed in the dump tank, at least in closed calyx varieties, as these areas are inaccessible. Bacteria may also survive low-temperature waxing, as the thermal death point of *E. amylovora* ranges from 45°C to 50°C (Van der Zwet & Keil 1979).
- When mature fruit were inoculated by swabbing calyces of apples with high levels of *E. amylovora* (an average of 10<sup>7</sup> cfu per mL), a level of infestation many orders of magnitude higher than found in naturally infested calyces, the initial population steadily decreased to an undetectable level over a 6-month period in cold storage (Sholberg, Gaunce & Owen 1988).
- Hale and Taylor (1999) inoculated mature fruit at the calyx-end with preparations of *E. amylovora* ranging from 10 to 10<sup>7</sup> cfu per fruit, then kept them in cold storage (2°C ± 0.5°C) either for 25 days, or for 25 days followed by incubation at room temperature (about 20°C) for a further 14 days. After cold storage alone, *E. amylovora* was detected by Polymerase Chain Reaction (PCR) in 90% of fruit inoculated with 10<sup>7</sup> cfu and 20% of fruit inoculated with 10<sup>4</sup> cfu, but was detected in less than 8% of fruit inoculated with 10, 10<sup>2</sup> or 10<sup>3</sup> cfu. After cold storage for 25 days and incubation at room temperature for 14 days, *E. amylovora* was detected in 35% of fruit inoculated with 10<sup>7</sup> cfu and in 3% of fruit inoculated with 10<sup>5</sup> cfu, but no detections were made in fruit inoculated with 10, 10<sup>2</sup>, 10<sup>3</sup> or 10<sup>4</sup> cfu.
- Taylor et al. (2003) inoculated the calyces of the closed-calyx variety Braeburn. These authors showed that bacterial populations in the calyx decreased from 10<sup>6</sup> cfu to 10<sup>2</sup> cfu over a 20-day period and from 10<sup>4</sup> to non-culturable levels after 14 days. Populations of *E. amylovora* in calyces inoculated with 10<sup>2</sup> cfu decreased to non-culturable levels after 8 days in storage. The PCR tests, which would detect the DNA of both live and dead bacteria, detected *E. amylovora* in calyces infested with 10<sup>6</sup> cfu and 10<sup>4</sup> cfu, but not in those with 10<sup>2</sup> cfu after the 20-day cold-storage period.
- For mature fruit inoculated with a suspension of 10<sup>7</sup> cfu, less than 100 cfu per fruit could be detected after four weeks, and no bacteria could be detected after eight weeks in cold storage using a sensitive detection method that could detect as little as 2 cfu (Temple et al. 2007).
- The studies outlined above suggest that any viable *E. amylovora* present in the calyx at harvest will decrease to undetectable levels with time in storage. The time required for this to occur will be variable, depending on the conditions and starting population, but is likely

to encompass a period from about one week to a maximum of 6 months. Experiments using apples inoculated at levels that represent naturally occurring levels typically have undetectable levels after a relatively short period of time.

*Erwinia amylovora* can multiply and persist on mature apples under experimental conditions. These experiments have been criticised because of their highly artificial nature (Deckers 2010; WTO 2005, 2010), but are reported here for completeness.

- When mature apples were artificially inoculated with *E. amylovora*, the bacterium dispersed into the fruit pulp with a concomitant increase in the bacterial population at room temperature, two weeks after inoculation, and then stabilised without producing any fire blight symptoms. The pathogen population did not change during subsequent storage over a period of five weeks (Jock, Langlotz & Geider 2005).
- Azegami et al. (2004) experimentally demonstrated systemic movement from the fruit stem into fruit. Inocula of *E. amylovora* were deposited at various concentrations on cut surfaces of pedicels of fruit, wounds on the shoulders and calyces of fruit, fruit-bearing twigs with attached fruit, and cut fruit flesh (mesocarp). When *E. amylovora* was deposited in fruit stem, the pathogen could invade mature and immature apple fruit, spread vertically and horizontally and colonise along vascular bundles, increasing its population, and reaching the calyx end and the flesh just under the exocarp within three to four days after inoculation. When deposited on cut fruit flesh, irrespective of fruit maturity, the bacterial population increased and survived for 2-4 weeks or more at 25°C. These experiments were conducted under high inoculum pressure and such invasions may not occur under field conditions.
- Tsukamoto (2005) examined the infection frequency of mature apple fruit inoculated with drops containing 10<sup>4</sup> and 10<sup>5</sup> cfu of *E. amylovora* on freshly cut pedicels and maintained at 25°C. The results showed that *E. amylovora* infected mature fruit inapparently, and that it remained viable after 6 months of storage at 5°C in most of the inoculated fruit.
- Azegami et al. (2006) examined the invasion of apple fruit after approximately 10<sup>5</sup> cfu *E. amylovora* was deposited in artificial wounds on fruit-bearing twigs of potted plants raised outdoors, but placed in a greenhouse environment before inoculation. *Erwinia amylovora* was isolated from 3% to 5% of symptomless fruit whose fruit-bearing twigs had been inoculated, indicating that the pathogen can move through the abscission layer and invade the fruit during fruit maturation. It was concluded that the possibility of *E. amylovora* invading apple fruit through fruit-bearing twigs in late summer to yield mature symptomless fruit could not be excluded.

*Erwinia amylovora* is unlikely to survive under adverse conditions despite capacity to enter a viable but non-culturable state.

- Some bacteria are able to enter a viable but non-culturable (VBNC) state; while in this state they will not grow under normal culturing conditions. The ability of *E. amylovora* to enter a VBNC state in response to environmental stresses such as nutrient starvation, or the presence of potential toxicants such as chlorine or copper, has been reported under laboratory conditions (Biosca et al. 2006; Ordax et al. 2006a, b).
- *Erwinia amylovora* is able to survive and remain infective for 6 months in sterile irrigation water (Biosca et al. 2006), and the culturability and pathogenicity of *E. amylovora* in a copper-induced VBNC state can be restored by inoculation into mineral medium under sterile conditions (Ordax et al. 2006a, b).
- A proportion of *E. amylovora* bacteria have been reported to enter the VBNC state when exposed to chlorinated tap water (Santander et al. 2009). When the VBNC bacteria were inoculated into a nutrient broth they regained culturability and then produced symptoms when inoculated into immature pear (Santander et al. 2009).

- Under laboratory conditions, it has been confirmed that *E. amylovora* can enter a VBNC state in sterilised apple calyces in response to copper exposure (Ordax et al. 2009), and regain culturability after periods of 7 to 28 days under favourable conditions (Ordax et al. 2009). Only *E. amylovora* that had been in the VBNC state for 6 days or less produced symptoms when inoculated onto immature pear and loquat fruits (Ordax et al. 2009).
- On the basis of laboratory studies, it should be considered whether application of copper-based treatments during dormant growth periods and at flowering to reduce *E. amylovora* populations could induce the bacterium to enter into a VBNC state. However, Ordax (2006a) and Ordax (2006b) have shown a reduction in total bacterial populations, including bacteria considered to be in the VBNC state, after exposure to copper. Given the low numbers of bacteria likely to remain on apples if copper is applied, these results suggest VBNC bacteria are unlikely to be present at fruit maturity.
- There is no evidence that *E. amylovora* enters a VBNC state in apples under field conditions; when VBNC detection was specifically attempted, no *E. amylovora* VBNC or culturable cells could be detected on symptomless apples harvested from infected trees (Ordax et al. 2010b). Even were it to be assumed that *E. amylovora* could enter the VBNC state in an apple calyx in the orchard, there is still no evidence of revival and subsequent infection under natural conditions (Deckers 2010).

*Erwinia amylovora* is unlikely to survive under adverse conditions using mechanisms such as exopolysaccharides and biofilms.

- Exopolysaccharides (EPS) play a role in protecting bacterial cells against desiccation in the biofilms, assisting adhesion to solid surfaces, and promoting cellular recognition (Allison 1998; Harrison et al. 2005; Stoodley et al. 2002). Exopolysaccharides such as amylovoran and levan produced by *E. amylovora* can also provide the bacterium with a carbon source (Ordax et al. 2010a). It has been shown that EPS contribute to the formation of biofilms which protect the bacterium from desiccation and play an important role in the pathogenesis and disease development of *E. amylovora* in plants (Geider 2009).
- Biofilm formation is widespread among enterobacterial species (Charkowski, Yap & Jabn 2005) and is a mechanism for bacterial protection in unfavourable conditions at a liquid–solid interface (Hall-Stoodley, Costerton & Stoodley 2004). Biofilms may also form on the surfaces of containers used for harvesting, transporting, and displaying foods at retail level (Consterton et al. 1987).
- It is unlikely that *E. amylovora* from such biofilms could attach to fruit, and it is likely that any bacteria that may superficially attach would be removed during washing and brushing procedures.

The information presented indicates that *E. amylovora* is present in all parts of the PNW-USA and is associated with apple trees. However, in PNW-USA orchards, *E. amylovora* is actively managed by reduction of inoculum sources, including by winter pruning of canker-infected branches. In spring, potential blossom infection is managed by application of blossom protection sprays, guided by the temperature-based predictive models for disease events.

There is no evidence to support the occurrence of active infection of mature fruit under natural conditions. For *E. amylovora* to be imported into Australia on apple fruit from the PNW-USA, fruit surfaces or parts, such as the calyx, would need to be contaminated with the bacteria. There is evidence that *E. amylovora* bacteria are unlikely to survive as epiphytic populations, and that commercial industry practices such as packing house sanitation will further reduce any such occurrence. Epiphytic pathways are therefore not considered to be of significance. Colonisation of *E. amylovora* in the calyx of mature fruit has been documented. For calyx colonisation to

occur, seasonal climatic conditions need to be conducive for production of *E. amylovora* inoculum to a level at which it can colonise the floral parts that are subsumed into the calyx during fruit development. Calyx colonisation is documented as involving only small populations of bacteria and their numbers will decrease over time. It has also been documented that the calyx is an unsupportive environment for *E. amylovora*, potentially because of the lack of required nutrients and moisture. Extended times under cold storage and transport to Australia are anticipated to further reduce the numbers of viable bacteria in fruit calyces. However, some bacterial cells may survive for a sufficient length of time to allow importation of some contaminated apples.

In summary, considering a significant volume of trade, the evidence shows that *E. amylovora* has potential to be associated with apple fruit from the PNW-USA. However, the proportion of fruit carrying bacteria is likely to be small, and the bacterial numbers are likely to be low, both of which will be affected by climate effects from year to year.

For the reasons outlined above, the likelihood estimate for importation of *E. amylovora* on the PNW-USA apple pathway is assessed as Moderate.

#### **Likelihood of distribution**

The likelihood that *E. amylovora* will be distributed within Australia in a viable state as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host is considered to be similar to *E. amylovora* on apples from New Zealand. Therefore, the same rating of Extremely Low for the likelihood of distribution previously assessed for *E. amylovora* on the apples from New Zealand pathway is adopted for *E. amylovora* on the apples from PNW-USA pathway.

#### **Overall likelihood of entry**

The overall likelihood of entry is determined as Extremely Low by combining the assessed likelihood of importation of Moderate with the adopted likelihood of distribution of Extremely Low, using the matrix of rules in Table 2.2.

#### **4.15.2 Likelihoods of establishment and spread**

The likelihoods of establishment and spread for *E. amylovora* are independent of the import pathway and are considered similar to those previously assessed for the apples from New Zealand pathway.

Based on the previous assessment for apples from New Zealand (Biosecurity Australia 2011b), the likelihoods of establishment and spread for *E. amylovora* are both assessed as High.

#### **4.15.3 Overall likelihood of entry, establishment and spread**

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that *E. amylovora* will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as Extremely Low.

#### 4.15.4 Consequences

The potential consequences of the entry, establishment and spread of *E. amylovora* in Australia are similar to those in the previous assessment for *E. amylovora* on the apples from New Zealand pathway, which were assessed as High (Biosecurity Australia 2011b). The overall consequences for *E. amylovora* on the apples from PNW-USA pathway are also assessed as High.

#### 4.15.5 Unrestricted risk estimate

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

<b>Unrestricted risk estimate for <i>E. amylovora</i></b>	
Overall likelihood of entry, establishment and spread	Extremely low
Consequences	High
Unrestricted risk	Very Low

When routinely applied industry commercial practices such as in-field controls, fruit maturity testing and packing house sanitation are taken into consideration, the unrestricted risk estimate for *E. amylovora* on the apples from PNW-USA pathway has been assessed as Very Low, which achieves the ALOP for Australia. Therefore, no additional practices or specific risk management measures are required for *E. amylovora* on the PNW-USA apple pathway.

## 4.16 Coprinus rot

### *Coprinopsis psychromorbida*

Coprinus rot is a post-harvest fungal disease caused by the basidiomycete pathogen *Coprinopsis psychromorbida*, which belongs to the family Psathyrellaceae (Jones & Aldwinckle 1990). The disease occurs on apple and pear fruit including those stored for extended periods (Spotts, Traquair & Peters 1981). *Coprinopsis psychromorbida* is also reported in forage legumes, grasses and winter cereal crops (Gaudet & Sholberg 1990; Redhead & Traquair 1981; Spotts 1990b; Traquair 1987) where it causes 'snow mold' disease.

Coprinus rot has been reported in northern North America (Farr & Rossman 2022). It is present in Alaska, as well as in western Canada, including Alberta and British Columbia (Sholberg & Gaudet 1992; Smith 1981; Traquair 1987; Willett et al. 1989) and in Oregon (Pscheidt & Ocamb 2021d) in the PNW-USA. There are no reports of this pathogen in Washington or Idaho.

*Coprinopsis psychromorbida* infections in orchards are initiated by air-borne basidiospores released from basidiocarps produced by the fungus on orchard litter (Almaguer-Vargas & Ayala-Garay 2014; Sholberg & Gaudet 1992; Spotts 1990b; Sutton et al. 2014) while fruit is on the tree (Spotts 1990b; Willett et al. 1989). Penetration of fruit occurs through lenticels (Gaudet, Kokko & Sholberg 1990). Infection of apple fruit by *C. psychromorbida* causes sunken lesions, 0.5 to 25 mm in diameter, with dark brown borders and lighter centres. The decayed tissue is firm and dry (Spotts 1990b). In the advanced stages of the disease, extensive white raised mycelia often cover the fruit, and may even spread to associated packaging (Spotts, Traquair & Peters 1981). Growth of mycelia from fruit to fruit causes spread of infection between fruit in cold storage (Gaudet, Kokko & Sholberg 1990). *Coprinopsis psychromorbida* is capable of causing fruit decay at 2°C or lower (Gaudet, Kokko & Sholberg 1990), and due to low temperature tolerance of this pathogen (Meheriuk & McPhee 1984; Spotts, Traquair & Peters 1981), apples and pears can develop symptoms of Coprinus rot when they are held at temperatures of -1.0°C to 2.0°C (Gaudet, Kokko & Sholberg 1990). In the PNW-USA where it is recorded, *C. psychromorbida* has been reported as a rare problem, and is more common on pears than apples (Pscheidt & Ocamb 2021d).

In fruit inoculation experiments in Canada, *C. psychromorbida* was able to cause post-harvest rot after 6 to 7 months in commercial cold storage (Sholberg & Gaudet 1992). A study by Sholberg & Gaudet (1992) showed that *C. psychromorbida* caused decay in 2.2% of the assessed apples under cold storage.

The risk scenario of biosecurity concern for *C. psychromorbida* is that symptomless infected apple fruit from PNW-USA may enter Australia and result in the establishment and spread of the pathogen.

#### 4.16.1 Likelihood of entry

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

##### Likelihood of importation

The likelihood that *C. psychromorbida* will arrive in Australia with the importation of apples from the PNW-USA is assessed as Low.

The following information provides supporting evidence for this assessment.

*Coprinopsis psychromorbida* may be associated with apple fruit in the PNW-USA.

- *Coprinopsis psychromorbida* has been identified in Oregon in the PNW-USA as a post-harvest rot disease of pear (Spotts 1990b; Willett et al. 1989).
- It has been reported to be sporadically found on apples stored for long periods in the PNW-USA (Spotts 1990b).
- *Coprinopsis psychromorbida* can infect most of the apple cultivars grown in the PNW-USA. Susceptible apple cultivars include McIntosh, Golden Delicious and Red Delicious. The cultivars Spartan, Newtown, Jonathan and Jonagold are less susceptible (Gaudet & Sholberg 1990; Meheriuk & McPhee 1984; Spotts 1990b; Sutton et al. 2014).
- However, *C. psychromorbida* is not a significant pathogen for apples in the PNW-USA. The pathogen is only listed as a disease of pears in PNW diseases handbook (Pscheidt & Ocamb 2021c). Washington State University Extension (2020) does not list this pathogen and (Pscheidt & Ocamb 2021d) does not mention this pest as a significant pathogen on apples in Oregon.
- Post-harvest rot surveys of stored apples in the PNW-USA did not detect this pathogen (Amiri & Ali 2016; Kim & Xiao 2008; Xiao 2007).
- There are no reports of this pathogen in Washington and Idaho and field surveys conducted in Washington during 2016-2018 did not find this pathogen (Pscheidt & Ocamb 2021d).

Asymptomatic fruit infected with *C. psychromorbida* are likely to remain undetected during harvest and post-harvest processes.

- Infection of apple fruit by *C. psychromorbida* occurs in the orchard before harvest (Aldwinckle 1990c; Spotts 1990b; Willett et al. 1989). Symptoms may not have developed at the time of harvest, and there is a possibility that symptomless infected fruit may be harvested.
- *Coprinopsis psychromorbida* symptoms occur most frequently in apple fruit that have been stored for extended periods (Spotts 1990b).
- Infected apples can remain asymptomatic for 6 to 7 months in commercial storage (Sholberg & Gaudet 1992).
- Packing house processes such as washing and application of sanitisers (e.g. chlorine), are likely to remove, inactivate or kill most of the *C. psychromorbida* spores that may be present on the surface of apple fruit (Brown 2002; Kupferman 1984; Suslow 2004). However, these processes are unlikely to affect *C. psychromorbida* that may be present inside the fruit.

*Coprinopsis psychromorbida* may survive cold temperatures during storage in the PNW-USA and transport to Australia. However, apples that have been cold stored before packing and express symptoms of Coprinus rot are likely to be removed from export.

- Harvested apples are normally cold stored at 0°C to 2°C (Good Fruit Grower 2014; Iowa State University Extension and Outreach 2008; Kupferman 1996; University of Maine 2020).
- The fungus is adapted to low temperatures and is known to be able to grow rapidly at temperatures that restrict the growth of most other pathogens (González 2008; Traquair 1987).
- *Coprinopsis psychromorbida* is capable of causing fruit decay at 2°C (Gaudet, Kokko & Sholberg 1990), and has been observed on apples and pears held under controlled

atmosphere conditions at temperatures of  $-1.1^{\circ}\text{C}$  to  $2^{\circ}\text{C}$  (Meheriuk & McPhee 1984; Spotts, Traquair & Peters 1981).

- The longer the period that apples from the PNW-USA are in cold storage before export to Australia, the more likely it is that infected fruit will express symptoms. Symptomatic fruits are likely to be detected and discarded before export.
- Sea freight, which takes about five weeks, is likely to be the preferred method of transport of apples from the PNW-USA and apples would be maintained at very low temperatures (WSU Tree Fruit 2021c).
- *Coprinopsis psychromorbida* in infected fruit that are packed for export will likely survive cold temperatures during transport to Australia.

*Coprinopsis psychromorbida* is widely distributed throughout the PNW-USA, but at a low incidence in apple production areas. The pathogen has not been detected in recent apple post-harvest rot surveys in the PNW-USA. Packing house measures are likely to remove or kill mycelial fragments and any spores on the surfaces of fruit. Infections of fruit usually remain asymptomatic at harvest but become apparent after an extended period in cold storage. In the PNW-USA, harvested apples are usually cold-stored, with storage time varying from 1 day to more than 11 months. Infected fruit showing symptoms are likely to be discarded and not be packed for export. If symptomless infected fruit were packed for export, the pest would be likely to survive cold temperatures during transport to Australia. For the reasons outlined, the likelihood of importation of *C. psychromorbida* on apples from PNW-USA is assessed as Low.

#### Likelihood of distribution

The likelihood that *C. psychromorbida* will be distributed in Australia in a viable state, as a result of importation, processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host, is assessed as Very Low.

The following information provides supporting evidence for this assessment.

*Coprinopsis psychromorbida* may continue spreading in consignments during storage and transport at cold temperatures.

- In Australia, imported apples will be stored and transported under cold temperatures (Good Fruit Grower 2014; Iowa State University Extension and Outreach 2008; Kupferman 1996; University of Maine 2020).
- *Coprinopsis psychromorbida* is capable of causing fruit decay at  $2^{\circ}\text{C}$  or lower (Gaudet, Kokko & Sholberg 1990). Apples can show Coprinus rot symptoms when they are held at temperatures of  $-1.1^{\circ}\text{C}$  to  $2.0^{\circ}\text{C}$  (Meheriuk & McPhee 1984; Spotts, Traquair & Peters 1981).
- The ability of *C. psychromorbida* to grow in cold storage (Gaudet, Kokko & Sholberg 1990; Meheriuk & McPhee 1984; Spotts, Traquair & Peters 1981) presents the possibility of the fungus colonising additional fruit within distribution centres while apples are in storage awaiting distribution.
- Low temperatures during transport of fruit in Australia will also be suitable for survival of the pathogen as the fungus is capable of growing in low temperatures (Traquair 1987).

Apple fruit imported from the PNW-USA will be distributed throughout Australia for retail sale. Infected fruit showing symptoms of *C. psychromorbida* infection are likely to be removed from distribution, but some asymptomatic fruit, and fruit with mild symptoms, may be distributed and sold.

- Imported apple fruit will likely be distributed throughout Australia via the wholesale and retail trade for sale for human consumption. The major population centres are likely to receive most of the imported fruit.
- Packed apple fruit may not be processed or handled until they arrive at the retail points. Any fruit showing symptoms of *C. psychromorbida* infection at this point are likely to be removed from further distribution and discarded into managed waste systems. Commercial waste of imported apple fruit may also be generated prior to or during retail sale and discarded in the same way. Potential exposure to suitable host plants from waste discarded into managed waste systems is likely to be negligible.
- However, some apple fruit infected with *C. psychromorbida* may not show symptoms and therefore may be sold to consumers.

Some apple waste infected with *C. psychromorbida* may be discarded into the environment near a suitable host.

- Apple fruit from the PNW-USA are intended for human consumption and most fruit, other than the core of the fruit, will be consumed. Most fruit waste, including the core and rotten fruit, is likely to be discarded into managed waste systems. Potential exposure to suitable host plants from waste discarded in this way is likely to be negligible.
- However, individual consumers may discard apple fruit waste in domestic compost or in a variety of urban, rural and natural environments. Some of this waste could be discarded near suitable host plants, including household or wild host plants.
- *Coprinopsis psychromorbida* can infect a wide variety of hosts, including pome fruits, grasses, forage legumes and cereal crops (Farr & Rossman 2021; Redhead & Traquair 1981).
- Many hosts of *C. psychromorbida* are common and abundant in Australia, both as cultivated plants and/or in the natural environment.

Successful transfer to a suitable host from discarded, infected fruit waste is unlikely due to the limited dispersal range of *C. psychromorbida* by growth of mycelia.

- Asexual morphs of the fungus such as mycelia are only capable of spreading through direct contact (Gaudet, Kokko & Sholberg 1990).
- If infected fruit waste was discarded into the environment near a suitable host, infection of the host could only occur through growth of mycelia. The range of dispersal via mycelial growth would be very limited.
- Mycelial growth is limited by warm temperatures with an optimal temperature of 15°C (Gaudet & Sholberg 1990). During summer, hot and dry conditions are likely to limit the growth of the fungus from discarded fruit waste.
- *Coprinopsis psychromorbida* is able to form sclerotia on pears (Gaudet & Kokko 1985; Spotts 1990b; Spotts, Traquair & Peters 1981), which may serve as propagules for survival in adverse conditions such as hot and dry summers (Traquair 1987). However, formation of sclerotia on apples has not been recorded.
- If formed on discarded apple fruit waste, sclerotia can only spread if the mycelia (formed when sclerotia germinate) come into direct contact with host material.

- Under favourable damp and cool conditions, competition with specialist saprophytes may limit *C. psychromorbida* mycelial growth.

*Coprinopsis psychromorbida* may be distributed through movement of contaminated packing materials, but such materials are likely to be discarded into managed waste systems from where exposure to potential host plants is likely to be negligible.

- The fungus can be distributed via movement of storage trays and other packing materials. In storage, infected fruit produce extensive white raised mycelia which frequently cover fruit surfaces, fruit wraps and trays (Spotts 1990b). However, packaging materials contaminated by the fungus are likely to be discarded through managed waste systems and are unlikely to enter the environment.

*Coprinopsis psychromorbida* has a wide host range, and there is some potential for fruit waste to be discarded near these hosts. However, the only known dispersal mechanism for this fungus from discarded fruit waste is by mycelia. This form of dispersal would significantly limit the ability of the fungus to move from infected waste to a new host in Australia. The climate in most regions of Australia is likely to limit the growth of mycelia due to warm and/or dry conditions. For the reasons outlined, the likelihood estimate for distribution of *C. psychromorbida* on apples from PNW-USA is assessed as Very Low.

#### Overall likelihood of entry

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

The likelihood that *C. psychromorbida* will enter Australia as a result of trade in the commodity and be distributed in a viable state to a suitable host is assessed as Very Low.

#### 4.16.2 Likelihood of establishment

The likelihood that *C. psychromorbida* will establish, based on a comparison of factors in the source and destination areas that affect pest survival and reproduction, is assessed as Moderate.

The following information provides supporting evidence for this assessment.

*Coprinopsis psychromorbida* has widespread and abundant host plants across Australia.

- *Coprinopsis psychromorbida* has a wide host range, including apples, pears, cereals, grasses and legumes (Gaudet & Sholberg 1990). Most of these hosts are widely present and abundant in Australia.
- *Coprinopsis psychromorbida* has the ability to survive on both live and dead tissues (such as litter and ground cover) of its hosts (Spotts 1990b).
- *Coprinopsis psychromorbida* has been isolated from orchard litter, substrates and horse manure (Redhead & Traquair 1981; Sholberg & Gaudet 1992).

Suitable environments for *C. psychromorbida* may be available in Australia.

- Coprinus rot grows well in temperate climatic conditions. Its optimal temperature for growth is 15°C but it can develop at 20°C (Gaudet & Sholberg 1990). Under experimental conditions, no growth of *C. psychromorbida* cultures was observed above 25°C (Spotts, Traquair & Peters 1981).
- *Coprinopsis psychromorbida* occurs in western Canada (including Alberta and British Columbia) and the USA (including Alaska and the PNW-USA) (Farr & Rossmann 2009; Smith

1981; Traquair 1980, 1987; Willett et al. 1989). Parts of temperate southeastern and southwestern Australia have climates similar to PNW-USA (Peel, Finlayson & McMahon 2007), suggesting that these parts of Australia are likely to be suitable for survival of *C. psychromorbida*.

- The restricted geographic range of *C. psychromorbida* to climates with cold winters suggests it is less likely to establish in many regions of Australia.
- *Coprinopsis psychromorbida* is able to form sclerotia on pears (Gaudet & Kokko 1985; Spotts 1990b; Spotts, Traquair & Peters 1981). Traquair (1987) noted that sclerotia are likely to be significant survival propagules and sources of infection. Formation of sclerotia by *C. psychromorbida* may aid survival over hot and dry summer conditions (Spotts 1990b).

The lack of active dissemination of *C. psychromorbida* may potentially limit its establishment.

- The mycelia are capable of being distributed to host plants in Australia through contact. Once in contact with new hosts such as legumes, grasses and cereal crops in Australia, they can colonise these host tissues and form basidiocarps (Spotts 1990b). Basidiospores from the basidiocarps can infect a variety of hosts.
- In PNW-USA, infections of apple fruit leading to development of storage rot are initiated by basidiospores released from fruiting bodies (basidiocarps) from other hosts such as cereal, grass and legumes on the ground in autumn (Gaudet & Sholberg 1990; Spotts 1990b).
- Basidiocarps of *C. psychromorbida* are not formed on apple fruit and do not directly cause apple fruit storage rot (Gaudet & Sholberg 1990; Spotts 1990b).
- Basidiocarps require moist conditions or rain for development and release and basidiospores released from basidiocarps are air-borne. Both basidiocarps and the basidiospores are short-lived, and are sensitive to desiccation, which may limit the successful establishment.

Host plants of *C. psychromorbida* are continuously present and abundant in most regions of Australia. The fungal mycelium is able to survive and overwinter for several months and colonise both live and decaying plant materials of hosts with which it is in contact. However, fungal growth is likely to be limited by high temperatures typical in most regions in Australia. In addition, the life cycle of *C. psychromorbida* may reduce potential for successful establishment under Australian conditions. For the reasons outlined, the likelihood of *C. psychromorbida* establishing in Australia from imported apples from PNW-USA is assessed as Moderate.

#### 4.16.3 Likelihood of spread

The likelihood that *C. psychromorbida* will spread within Australia, based on a comparison of factors in the source and destination areas that affect the expansion of the geographic distribution of the pest, is assessed as Moderate.

The following information provides supporting evidence for this assessment.

Suitable environments for the spread of *C. psychromorbida* may exist in Australia.

- The optimal temperature for growth of *C. psychromorbida* is 15°C, but it has also been reported to develop at 20°C (Gaudet & Sholberg 1990). Under experimental conditions, no growth of *C. psychromorbida* cultures was observed to occur at temperatures over 25°C (Spotts, Traquair & Peters 1981).

- *Coprinopsis psychromorbida* is only present in its native range in northern North America (Farr & Rossman 2020; Smith 1981; Traquair 1980, 1987; Willett et al. 1989), suggesting a limited ability to effectively adapt and spread to different climatic regions.
- The colder temperate areas of southeastern and southwestern Australia have a similar climate to parts of northern North America where *C. psychromorbida* is established (Farr & Rossman 2020; Smith 1981; Traquair 1980, 1987; Willett et al. 1989).
- Hot and dry summer conditions in most parts of Australia are not favourable for spread of the fungus. It is also unlikely the disease will spread naturally to tropical or subtropical areas, or between southeastern and southwestern Australia due to the barriers posed by arid regions of central Australia.
- *Coprinopsis psychromorbida* is able to form sclerotia on pears (Gaudet & Kokko 1985; Spotts 1990b; Spotts, Traquair & Peters 1981), which may serve as survival propagules at higher temperatures. However, following germination of sclerotia, spread by mycelia can only occur through direct contact.

There are numerous hosts available in Australia.

- Hosts and host-derived substrates for *C. psychromorbida* include apple, pear, cereals, grasses, legumes, orchard litter and horse manure (Gaudet & Sholberg 1990; Redhead & Traquair 1981; Sholberg & Gaudet 1992). These hosts and substrates are present in Australia in commercial orchard districts, and suburban and rural areas.

Different modes of propagation of *C. psychromorbida* may aid spread of the pathogen.

- The asexual morph of the fungus occurs as mycelia on a wide range of hosts including pome fruit, grasses and lucerne, but asexual morphs are only capable of spreading through contact (Gaudet & Sholberg 1990).
- *Coprinopsis psychromorbida* produces basidiocarps containing sexual basidiospores, which are involved in dissemination of the pathogen (Gaudet & Sholberg 1990; Redhead & Traquair 1981; Traquair 1980).
- In orchards in the PNW-USA, the source of inoculum for fruit infection is probably basidiospores produced on litter (Sutton et al. 2014; Spotts 1990b).
- *Coprinopsis psychromorbida* is able to form sclerotia (Gaudet & Kokko 1985; Spotts 1990b; Spotts, Traquair & Peters 1981), which may serve as survival propagules and assist survival on litter under hot and dry conditions, however further spread from vegetative mycelia from the sclerotia can only occur by direct contact.
- Domestic trade of apple fruit may aid the spread of *C. psychromorbida*. However, spread of fungus by this method would be limited to the asexual stage associated with fruit. This reduces the likelihood of *C. psychromorbida* being functionally spread to new areas through human-mediated transport. However, spread by movement of host materials carrying fungal mycelia is possible.

There are numerous hosts available in Australia and *Coprinopsis psychromorbida* has the ability to spread from infected hosts to new hosts. However, known dispersal mechanisms are limited to rain-splashed basidiocarps, air-borne basidiospores or mycelial growth. Favourable climatic conditions are limited to cooler parts of southeastern and southwestern Australia and natural spread of the pathogen between these parts through arid regions of central Australia is likely to be limited. Spread by domestic movement of infected host materials is possible. For the reasons outlined, the likelihood of spread of *C. psychromorbida* within Australia on the PNW-USA apple pathway is assessed as Moderate.

#### 4.16.4 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, establishment and spread using the matrix of rules for combining qualitative likelihoods shown in Table 2.2.

The overall likelihood that *C. psychromorbida* will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible host, establish in the area and subsequently spread within Australia, is assessed as Very Low.

#### 4.16.5 Consequences

The potential consequences of the establishment of *C. psychromorbida* in Australia have been estimated according to the methods described in Table 2.3.

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

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
<b>Direct</b>	
Plant life or health	<p>D – Minor significance at the regional level:</p> <p>Coprinus rot is a post-harvest disease of apple and pear in Oregon (Pscheidt &amp; Ocamb 2021d; Spotts 1990b). Coprinus rot is listed as a disease of pears in the PNW diseases handbook (Pscheidt &amp; Ocamb 2021d). However, it is not mentioned as a pome fruit pathogen of significance (Wenneker &amp; Thomma 2020).</p> <p><i>Coprinopsis psychromorbida</i> causes sunken fruit lesions, 0.5 to 25 mm in diameter, with dark brown borders and lighter centres. In the advanced stages of the disease, extensive white, raised mycelia often cover fruit, fruit wraps and storage trays (Spotts 1990b). Infected fruit is unmarketable.</p> <p>There are few reports of pome fruit damage by <i>C. psychromorbida</i> but Golden Delicious, McIntosh, Spartan, Newton and Red Delicious apples can all be affected (Meheriuk &amp; McPhee 1984). Coprinus rot of apples in cold storage has been reported as a problem only in the Okanagan Valley of British Columbia. Losses (estimated at \$US 115,000) of stored d'Anjou pears due to <i>C. psychromorbida</i> occurred in Oregon in 1979 (Spotts, Traquair &amp; Peters 1981). After 7 months in controlled-atmosphere storage, around 180 tonnes of Spartan apples were lost due to decay by <i>C. psychromorbida</i> in 1986 (Sholberg &amp; Gaudet 1992).</p> <p><i>Coprinopsis psychromorbida</i> also causes snow mold on cereals, grasses and legumes (Spotts 1990b). The potential damage <i>C. psychromorbida</i> may cause in Australia is likely to be limited by the generally unfavourable climate.</p>
Other aspects of the environment	<p>A – Indiscernible at the local level:</p> <p>There are no known direct consequences of these species on other aspects of the environment.</p>
<b>Indirect</b>	
Eradication, control etc.	<p>D – Significant at the district level:</p> <p>Recommended measures for the control of <i>C. psychromorbida</i> 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 1990b; Spotts, Traquair &amp; Peters 1981).</p> <p>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.</p>

Criterion	Estimate and rationale
Domestic trade	D – Significant at the district level: The introduction of <i>C. psychromorbida</i> into commercial production areas could have a significant effect as interstate trade restrictions may be imposed to limit the spread of this pest on a range of commodities including apple, pear and winter cereals, grasses and legumes (Spotts 1990b).
International trade	D – Minor significance at the regional level: The presence of <i>C. psychromorbida</i> in commercial production areas of a range of commodities, including apple and pear, would have a minor significance at the regional level due to potential limitations of accessing international markets where this pest is absent. For example, New Zealand lists <i>C. psychromorbida</i> as one of the regulated pests for pears from Oregon, USA (MAF Biosecurity New Zealand 1999).
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.

#### 4.16.6 Unrestricted risk estimate

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

<b>Unrestricted risk estimate for <i>Coprinopsis psychromorbida</i></b>	
Overall likelihood of entry, establishment and spread	Very Low
Consequences	Low
Unrestricted risk	Negligible

As indicated, the unrestricted risk estimate for *C. psychromorbida* on apples from the PNW-USA pathway is assessed as Negligible, which achieves the ALOP for Australia. Therefore, no specific risk management measures are required for this pest on the PNW-USA apple pathway.

## 4.17 Phacidiopycnis rot

### *Discula pyri*

*Discula pyri* (synonym: *Phacidiopycnis piri*), an ascomycete fungal pathogen belonging to the family Rhytismataceae, causes a post-harvest rot disease named Phacidiopycnis rot in apple and pear fruit in the PNW-USA (Ali et al. 2018; Kim & Xiao 2006; PNW Handbooks 2020b; Xiao et al. 2005; Xiao & Boal 2002). *Discula pyri* causes one of the major emerging post-harvest fruit rots in d'Anjou pears in Washington and Oregon (Kim & Xiao 2006; Pscheidt & Ocamb 2021e; Xiao & Boal 2005a; Xiao & Boal 2004b). It also causes post-harvest rot on apples, however, it is more common on pears (Ali et al. 2018; Kim & Xiao 2006; Pscheidt & Ocamb 2021e). DiCosmo et al. (1984) reported quince as a host.

In contrast, *Phacidiopycnis washingtonensis* that causes speck rot (Section 4.21) is a disease of apples in Washington (Ali et al. 2018; Amiri & Ali 2016; DiCosmo, Nag Raj & Kendrick 1984). Although *D. pyri* and *Phacidiopycnis washingtonensis* were formerly placed in the same genus, their biology is sufficiently different to warrant separate risk assessments for these pathogens.

*Discula pyri* has been found in all major pear-producing areas of Washington, however, its importance is not characterised and can vary from one year to another (Pscheidt & Ocamb 2021e). On apple fruit, where infection is rare (Kim & Xiao 2008), early symptoms appear as spongy and brown decayed areas which turn black as the infection progresses (Kim & Xiao 2006). *Discula pyri* causes stem-end rot, calyx-end rot and wound-associated rot in stored pears (Xiao & Boal 2005a). Post-harvest infections by *D. pyri* were observed to take three to four months to develop at 0°C and for the fungus to reach fruit flesh and cause fruit rot (Xiao & Boal 2002). Fruit rot was observed under laboratory conditions when pears were wounded (Xiao & Boal 2005a). Laboratory experiments indicated that fruit-to-fruit spread by mycelia of the fungus could also occur during storage (Xiao & Boal 2002). In a survey in 2017, *D. pyri* was found to be the cause of 3.9% and 6.7% of total pear decay in Washington and Oregon, respectively (Ali et al. 2018). There is no record of *D. pyri* in Idaho.

*Discula pyri* also causes canker and dieback of twigs and fruit spurs of apple and pear trees (DiCosmo, Nag Raj & Kendrick 1984; Sholberg, Stokes & O'Gorman 2010). Under humid conditions, the fungus forms white mycelia that colonise host tissues.

At advanced stages of infection, the fungus forms asexual reproductive structures known as pycnidia and conidia (pycnidiospores) on the decayed area of the fruit (Xiao 2006; Xiao & Boal 2004b). Pycnidia, and less frequently apothecia (fruiting body of the sexual morph of the fungus), which can survive adverse conditions, are also formed on dead or dying bark tissues (Xiao & Boal 2005a). Conidia are dispersed by water (Ali et al. 2018; DiCosmo, Nag Raj & Kendrick 1984; Sholberg, Stokes & O'Gorman 2010), and rain may initiate infection.

The risk scenario of biosecurity concern for *D. pyri* is that symptomless infected fruit carrying viable pycnidia or conidia may be exported from PNW-USA and result in the establishment of this pathogen in Australia.

#### 4.17.1 Likelihood of entry

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

### Likelihood of importation

The likelihood that *D. pyri* will arrive in Australia with the importation of apples from the PNW is assessed as Low.

The following information provides supporting evidence for this assessment.

*Discula pyri* is unlikely to be associated with apples exported from the PNW-USA.

- *Discula pyri* is widespread in Washington and Oregon in PNW-USA (Xiao & Boal 2005a) but mainly affects pear (Ali et al. 2018; Amiri & Ali 2016; Pscheidt & Ocamb 2021e). It causes a post-harvest disease known as Phacidiopycnis rot primarily in stored pears (Ali et al. 2018; Xiao & Boal 2005a). Conidia from pear cankers may provide a source of inoculum for apple infections.
- *Discula pyri* is only occasionally found on apples (Xiao & Boal 2005a; Xiao et al. 2005), and considered a minor pathogen (Kim & Xiao 2006, 2008).
- In a survey in 2017, *D. pyri* was found to be the cause of 3.9% and 6.7% of total pear decay in Washington and Oregon, respectively (Ali et al. 2018). Since 2002, fruit surveys have not detected *D. pyri* to any significant level on apple (Amiri & Ali 2016; Kim & Xiao 2006; Xiao 2007). These surveys either did not detect *D. pyri* at all, or only detected it as a minor post-harvest pathogen of apple.

*Discula pyri* causes infections that are initially asymptomatic but symptoms develop during storage. Infected apples that show symptoms during packing processes will likely be detected and removed from the export pathway prior to export.

- Infections of the stem- and calyx-ends of fruit by *D. pyri* usually take place in the orchard, and symptoms develop during storage (Ali et al. 2018; Xiao & Boal 2004b).
- Symptoms of infections with *D. pyri* are first observed after approximately three months in storage and increase with time (Washington State University 2005; Xiao & Boal 2004b).
- Symptoms of *D. pyri* originating from wound infections become visible after approximately two months (Washington State University 2005; Xiao & Boal 2004b).
- On apple fruit, symptoms appear as spongy and brown decayed areas in the early stage, which turn black as the infection progresses (Kim & Xiao 2006).
- In PNW-USA, apples are usually stored after being harvested. Storage time may vary from 1 day to more than 11 months (Kupferman 1996).
- Infected apples showing symptoms at the time of packing are likely to be detected and removed from the export pathway.
- Consignments with infected fruit showing symptoms are likely to be detected at the export phytosanitary inspection after cold storage and will be removed from export.
- Infected fruit not showing symptoms during packing processes or pre-export phytosanitary inspection, such as those packed and exported shortly after harvest, could be exported.

*Discula pyri* is tolerant of low temperatures and can spread in storage, making it likely to survive cold temperatures during storage and transport.

- *Discula pyri* can survive and grow over a wide temperature range of  $-3^{\circ}\text{C}$  to  $25^{\circ}\text{C}$ , with optimum growth occurring at  $15^{\circ}\text{C}$  to  $20^{\circ}\text{C}$  (Xiao & Sitton 2004).
- Conidia of *D. pyri* can germinate at  $0^{\circ}\text{C}$  to  $30^{\circ}\text{C}$  with an optimal temperature for germination of  $20^{\circ}\text{C}$  to  $25^{\circ}\text{C}$  (Liu & Xiao 2005).

- Apples are cold-stored and transported at temperatures from 0°C to 2°C (Good Fruit Grower 2014; Iowa State University Extension and Outreach 2008; Kupferman 1996; University of Maine 2020).
- Sea freight, which takes about five weeks, is likely to be the preferred method of transport of apples from the PNW-USA to Australia and fruit will be maintained at very low temperatures (WSU Tree Fruit 2021c).

*Discula pyri* is primarily a pest of stored pears in Oregon and Washington. While this fungus can cause minor post-harvest decay on apples in the PNW-USA, it has only been detected at low levels in recent surveys of post-harvest rots of apples in Washington. *Discula pyri* is likely to survive cold temperatures during storage and transport. Considering the rare association of the fungus with apple fruit in the PNW-USA, and development of visible symptoms of infection in storage, which provide opportunity for detection during post-storage handling, the likelihood of importation of *D. pyri* on apples from PNW-USA is rated as Low.

### Likelihood of distribution

The likelihood that *D. pyri* will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host, is assessed as Low.

The following information provides supporting evidence for this assessment.

Upon arrival, some infected apples from PNW-USA may still be asymptomatic or exhibit mild symptoms and could be distributed in Australia.

- It is expected that apple fruit from PNW-USA will be widely distributed for wholesale or retail sale for human consumption. Fruit infected with *D. pyri* may be distributed during these procedures.
- The pathogen is likely to survive low temperature conditions during distribution and storage of fruit in Australia.
- Packed apple fruit may not be processed or handled until they arrive at the retail points. Any fruit showing symptoms of *D. pyri* infection at this point are likely to be removed from further distribution and discarded into managed waste systems. Commercial waste of imported apple fruit may also be generated prior to or during retail sale and discarded in the same way. Potential exposure to suitable host plants from waste discarded into managed waste systems is likely to be negligible.
- However, some apple fruit infected with *D. pyri* that were packed and exported shortly after harvest may still be asymptomatic or exhibit only mild symptoms and therefore may be sold to consumers.

Some apple waste infected with *D. pyri* may be discarded into the environment. The limited host range of *D. pyri* reduces the likelihood of apple waste being discarded in close proximity to a suitable host.

- Apple fruit from the PNW-USA are intended for human consumption and most fruit, other than the core of the fruit, will be consumed. Most fruit waste, including the core and rotten fruit, is likely to be discarded by consumers into managed waste systems. Potential exposure to suitable host plants from waste discarded in this way is likely to be negligible.

- However, individual consumers may discard apple fruit waste in domestic compost or in a variety of urban, rural and natural environments. Some of this waste could be discarded near suitable host plants.
- Pycnidia and conidia may be produced on decayed areas of the fruit (Xiao 2006; Xiao & Boal 2004b).
- Conidia of *D. pyri* are dispersed by water (Ali et al. 2018; DiCosmo, Nag Raj & Kendrick 1984; Sholberg, Stokes & O'Gorman 2010), and rain-splash may enable initiation of subsequent infections.
- However, *D. pyri* has a limited host range. The primary hosts are *Pyrus* species. While known to also infect apple (*Malus* spp.) and quince (*Cydonia vulgaris* with the synonym as *C. oblonga*) (DiCosmo, Nag Raj & Kendrick 1984), such infections are rare.

The fungus is able to persist and grow at the low temperatures used for commercial cold storage and distribution of apples in Australia. There is potential for distribution of *D. pyri* in association with infected apples from the PNW-USA. Some infected fruit carrying viable pycnidia or conidia (pycnidiospores) developed at advanced stages of infection could be discarded in the environment. Pycnidia can survive adverse conditions. Conidia from pycnidia are dispersed by water and rain may initiate infection. However, *D. pyri* has a limited host range, which reduces the likelihood of fruit waste being discarded in close proximity to a suitable host.

For the reasons outlined, the likelihood estimate for distribution of *D. pyri* on apples from PNW-USA is rated as Low.

#### Overall likelihood of entry

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

The likelihood that *D. pyri* will enter Australia as a result of trade in apples from the PNW-USA and be distributed in a viable state to a suitable host is assessed as Very Low.

#### 4.17.2 Likelihood of establishment

The likelihood that *D. pyri* will establish, based on the comparison of factors that affect pest survival and reproduction in the source and destination areas, is assessed as Moderate.

The following information provides supporting evidence for this assessment.

Hosts of *D. pyri* are present in Australia.

- *Discula pyri* has a limited range of hosts in the family Rosaceae, including apple (*Malus* spp.), pear (*Pyrus* spp.) and quince (*Cydonia vulgaris* with the synonym as *C. oblonga*) (DiCosmo, Nag Raj & Kendrick 1984; Farr & Rossman 2009).
- These hosts are widely distributed in Australia in commercial orchard districts, as well as suburban and rural areas.

Climatic conditions are likely to be suitable for the establishment of *D. pyri*.

- *Discula pyri* can grow over a wide temperature range of  $-3^{\circ}\text{C}$  to  $25^{\circ}\text{C}$  (Xiao & Sitton 2004), and, if introduced to an area in close proximity to a suitable host, could establish a viable population in Australia.

- *Discula pyri* occurs in Austria, Canada (British Columbia), Germany, India, the United Kingdom and the USA (Oregon and Washington State) (DiCosmo, Nag Raj & Kendrick 1984; Farr & Rossman 2009; Xiao & Boal 2005a). These areas have similar climates to parts of temperate southeastern and southwestern Australia, suggesting that these parts of Australia are likely to be suitable for the establishment of this fungus.
- *Discula pyri* is unlikely to establish during the hot and dry Australian summer conditions. However, most apple and pear growing regions within Australia have suitable conditions, such as suitable temperatures and moisture durations for successful conidial germination and mycelial growth, for establishment of the pathogen during most of the year.
- *Discula pyri* can survive as mycelia in diseased twigs all year round (Xiao & Boal 2004a).
- The overwintering and survival properties of pycnidia and conidia of *D. pyri* on dead and living tissues of apple and compost could allow the pathogen to overwinter and re-emerge when favourable conditions again become available in autumn and spring. However, conidial dispersal by rain is a passive mechanism that carries the inoculum only over short distances.
- Human-assisted movement of infected fruit, compost or host material could facilitate spread of the fungus to new regions.

Hosts such as apples and pears are widely present across Australia. Once established on susceptible hosts, the fungus could readily grow and infect further hosts. Suitable temperatures and moisture durations for successful conidial germination and mycelial growth exist in many regions of Australia and could support establishment of the disease during most of the year. The ability of *D. pyri* to survive on both live and dead tissues of its hosts, and over a wide range of temperatures, could assist *D. pyri* to establish in Australia. One of the limitations moderating the potential for establishment of the pathogen would be climatic conditions during the hot, dry Australian summer.

For the reasons outlined, the likelihood of *D. pyri* establishing in Australia from imported apples from the PNW-USA is rated as Moderate.

#### 4.17.3 Likelihood of spread

The likelihood that *D. pyri* will spread in Australia, based on a comparison of factors that affect the expansion of the geographic distribution of the pathogen in the source and destination areas, is assessed as Moderate.

The following information provides supporting evidence for this assessment.

It is likely that *D. pyri* would be able to encounter additional hosts in Australia once established.

- *Discula pyri* has a limited range of hosts in the family Rosaceae, including apple (*Malus* spp.), pear (*Pyrus* spp.) and quince (*Cydonia vulgaris* with the synonym as *C. oblonga*) (DiCosmo, Nag Raj & Kendrick 1984; Farr & Rossman 2009).
- These hosts are widely distributed in Australia in commercial orchard districts, as well as suburban and rural areas.

Suitable climates for the spread of *D. pyri* exist in Australia.

- *Discula pyri* can survive and grow at a wide temperature range of  $-3^{\circ}\text{C}$  to  $25^{\circ}\text{C}$  (Xiao & Sitton 2004).

- *Discula pyri* occurs in Austria, Canada (British Columbia), Germany, India, the United Kingdom and the USA (Oregon and Washington State) (DiCosmo, Nag Raj & Kendrick 1984; Farr & Rossman 2009; Xiao & Boal 2005a). These areas have similar climates to parts of temperate southeastern and southwestern Australia, where host plants are present.
- Arid regions between western and eastern parts of Australia may present natural barriers to the spread of the fungus.

Natural dispersal by conidia (spores) is likely to spread the pathogen.

- Conidia of *D. pyri* are dispersed by water (Ali et al. 2018; DiCosmo, Nag Raj & Kendrick 1984; Sholberg, Stokes & O'Gorman 2010), and rain-splash may enable initiation of subsequent infections. However, conidial dispersal by rain is a passive mechanism that carries the inoculum only over short distances.
- Natural hosts of *D. pyri* such as apples, pears and quince are widely distributed across Australia.
- The overwintering and survival properties of pycnidia and conidia of *D. pyri* on host plants and fruit could allow the pathogen to overwinter and re-emerge when conditions become favourable again in autumn and spring. *Discula pyri* is likely to spread within Australia by human-assisted transport.
- Conidia of *D. pyri* are found in pycnidia on fruit or twigs (Xiao 2006; Xiao & Boal 2004b). The distribution of infected fruit, compost or host material via commercial or domestic trade may aid the spread of this pathogen.
- Early symptoms of *D. pyri* are similar to those of grey mould (Xiao 2006), caused by *Botrytis cinerea*, a pathogen which is present in Australia. This may make early identification of *D. pyri* difficult in Australia.
- Human-assisted movement of infected fruit or host material could facilitate spread of the fungus to new regions.

Natural hosts of *D. pyri* such as apples, pears and quince are widely distributed across Australia, and could support spread from already established infections. Many parts of temperate southeastern and southwestern Australia have suitable conditions for spread of the fungus for much of the year. Spread may be further assisted by human-mediated activities, such as domestic movement of fruit and nursery stock. The likelihood of spread of *D. pyri* is moderated by the limited host range of this fungus and climatic conditions during the hot, dry Australian summer.

For the reasons outlined, the likelihood of spread of *D. pyri* within Australia is rated as Moderate.

#### **4.17.4 Overall likelihood of entry, establishment and spread**

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, establishment and spread using the matrix of rules for combining qualitative likelihoods shown in Table 2.2.

The likelihood that *D. pyri* will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to suitable hosts, establish in an area and subsequently spread within Australia is assessed as Very Low.

#### 4.17.5 Consequences

The potential consequences of the establishment of *D. pyri* in Australia have been estimated using the decision rules described in Table 2.3.

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

Reasoning for these ratings is provided below.

Criterion	Estimate and rationale
<b>Direct</b>	
Plant life or health	E - Significant at regional level: <i>Discula pyri</i> is one of the major post-harvest fruit rots of d'Anjou pears in Washington (Xiao & Boal 2004b) and to a lesser extent of apple (Kim & Xiao 2006; Xiao et al. 2005). The apple industry in Australia is worth over \$500 million annually while the pear industry is worth over \$100 million annually (Australian Bureau of Statistics 2018). It is not known if <i>D. pyri</i> 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 this pathogen on other aspects of the environment.
<b>Indirect</b>	
Eradication, control etc.	E - Significant at regional level: Recommended measures for the control of <i>D. pyri</i> include removal of cankers and twigs with dieback symptoms. 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. 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 <i>D. pyri</i> 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 <i>D. pyri</i> 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, <i>D. pyri</i> has been recorded from Austria, Canada, Germany, India, the United Kingdom and the USA (DiCosmo, Nag Raj & Kendrick 1984; Farr & Rossman 2009; Xiao & Boal 2005a). Israel and Korea have listed <i>D. pyri</i> as a quarantine pest. A number of pear consignments from the USA have been rejected entry to Israel due to the presence of this pathogen (Willett & Powers 2006).
Non-commercial and environmental	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.

#### 4.17.6 Unrestricted risk estimate

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

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**Unrestricted risk estimate for *Discula pyri***

Overall likelihood of entry, establishment and spread	Very Low
Consequences	Moderate
Unrestricted risk	Very Low

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As indicated, the unrestricted risk for *D. pyri* on the apples from PNW-USA pathway has been assessed as Very Low, which achieves the ALOP for Australia. Therefore, no specific risk management measures are required for this pest on the PNW-USA apple pathway.

## 4.18 Gymnosporangium rusts

### ***Gymnosporangium clavipes*, *Gymnosporangium juniperi-virginianae* and *Gymnosporangium libocedri***

*Gymnosporangium clavipes*, *G. juniperi-virginianae* and *G. libocedri* are fungal pathogens causing rusts, namely quince rust, Cedar apple rust and Pacific Coast pear rust, respectively. Fungi in the genus *Gymnosporangium* belong to the family Pucciniaceae. These three species have been grouped together based on their similar biologies, from which they are predicted to pose similar biosecurity risks. In this assessment, the term Gymnosporangium rusts is used to refer to these three species, and scientific names are used when the information relates to a specific species.

The distribution of all three species is restricted to North America (Aldwinckle 1990b; PNW Handbooks 2010; Sinclair & Lyon 2005). While *Gymnosporangium clavipes* and *G. juniperi-virginianae* are uncommon in the PNW-USA (Sinclair & Lyon 2005), *Malus* spp. are known hosts (Sinclair & Lyon 2005). *Gymnosporangium libocedri* has been reported to cause severe infections of pear and quince fruit (Pscheidt & Ocamb 2022b; Sutton et al. 2014) and it can also infect apple fruit in the PNW-USA in Washington and Oregon (Aldwinckle 1990b; PNW Handbooks 2019a; Sinclair & Lyon 2005; Sutton et al. 2014). Gymnosporangium rusts are heteroecious rusts requiring two types of hosts for completing their life cycles. As a result, most *Gymnosporangium* species require two years to complete their life cycle (Sinclair & Lyon 2005). Gymnosporangium rusts require *Juniperus* spp. (junipers) or *Calocedrus decurrens* (incense cedar) as alternate (or telial) hosts during the sexual reproduction phase in forming sexual spores (telial spores and basidiospores produced in telia) for infecting primary rosaceous host species, such as apples, pears, hawthorns and quinces. Rosaceous species are the aecial hosts in which the asexual (aecial) stage is completed to develop aecia and aeciospores (Aldwinckle 1990b; Farr & Rossman 2018; Sinclair & Lyon 2005).

These three *Gymnosporangium* species have similar life cycles and cause similar symptoms in their hosts. Telia are produced from galls on bark or leaves of the juniper/cedar hosts during spring, and in turn 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 and fruit. Infections from basidiospores give rise to two types of asexual spores, pycniospores formed in pycnia on the upper surfaces of apple leaves, which eventually reach the lower surfaces of the leaves (or fruit) to form the second type of asexual spores named aeciospores produced in aecia. These aeciospores are released during dry weather in late summer and are wind-dispersed to infect the alternate juniper/cedar host (Aldwinckle 1990a; Sinclair & Lyon 2005). After germinating on the juniper/cedar host, an overwintering mycelium is produced. Galls of *G. libocedri* are perennial, whereas those of *G. juniperi-virginianae* produce teliospores during spring only, and fresh infections are needed every year for the life cycle to be maintained (Aldwinckle 1990a; Sinclair & Lyon 2005).

The risk scenario of biosecurity concern for Gymnosporangium rusts is that symptomless infected apple fruit carrying aecia and/or aeciospores and basidiospores might enter Australia, infect alternate hosts, and initiate establishment of this pathogen in Australia.

A congeneric species *Gymnosporangium yamadae* (Japanese apple rust) has been assessed in the existing policy for fresh apple fruit from the People's Republic of China (Biosecurity Australia 2010a). In that policy the unrestricted risk estimate for *G. yamadae* was assessed as Low, which

does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for *G. yamadae* on the fresh apple fruit from China pathway. *Gymnosporangium clavipes*, *G. juniperi-virginianae* and *G. libocedri* have very similar biologies and life cycles to other *Gymnosporangium* species, including *G. yamadae* (Aldwinckle 1990a; Sinclair & Lyon 2005). Therefore, it is considered that these *Gymnosporangium* species are likely to pose similar biosecurity risks to *G. yamadae*.

The department has assessed the likelihood of importation of *G. yamadae* on fresh apple fruit from China as Moderate (Biosecurity Australia 2010a). However, the differences in pest prevalence, climate and horticultural practices between export areas make it necessary to assess the likelihood of importation of *Gymnosporangium* rusts associated with the PNW-USA apple pathway.

The department has assessed the likelihood of distribution of *G. yamadae* on fresh apple fruit from China as Moderate (Biosecurity Australia 2010a). Fresh apple fruit from the PNW-USA are expected to be distributed in Australia, as a result of the processing, sale or disposal, in a similar way to apples from China. Apples can be imported all year round, therefore, there would be no seasonal differences between both import pathways to contribute to variation in the risk rating for likelihood of distribution. In order for the pathogen's life cycle to be completed, aeciospores from an infected apple fruit would need to reach an alternate host. The potential for distribution of infected fruit throughout Australia, the disposal of fruit waste in the environment, and the ability of wind and water droplets to transfer rust spores from fruit waste to a host, are moderated by the limited availability of alternate hosts in Australia. Therefore, the same rating of Moderate as assessed for the likelihood of distribution for *G. yamadae* on the China apple pathway is adopted for these *Gymnosporangium* rusts on the PNW-USA apple pathway.

The likelihoods of establishment and spread of *Gymnosporangium* rusts on the PNW-USA apple pathway have also been assessed as corresponding to those of previous assessments for *G. yamadae*, being Moderate and High, respectively. Those likelihoods relate specifically to events that occur in Australia and are essentially independent of the import pathway. The consequences of entry, establishment and spread of these *Gymnosporangium* rusts are also independent of the import pathway, and have been assessed as similar to the existing assessment of Moderate for *G. yamadae*. Therefore, the existing ratings for the likelihoods of establishment and spread, and the rating for overall consequences for *G. yamadae* on the China apple pathway have been adopted for these *Gymnosporangium* rusts on the PNW-USA apple pathway.

The department has also reviewed the latest literature — for example Hudelson (2019); Lâce (2017); PNW Handbooks (2019d); Tao et al. (2017) and Zhao et al. (2016). No new information has been identified that would significantly change the risk ratings for distribution, establishment, spread and consequences as assessed for these *Gymnosporangium* rusts and the congeneric species *G. yamadae* in the existing policy.

#### **4.18.1 Likelihood of entry**

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

### Likelihood of importation

The likelihood that *Gymnosporangium* rusts will arrive in Australia with the importation of apples from the PNW-USA is assessed as Low.

The following information provides supporting evidence for this assessment.

*Gymnosporangium* rusts are present in apple production areas in the PNW-USA.

- *Gymnosporangium juniperi-virginianae* is uncommon in western USA, although it has been reported in California and Washington (Sinclair & Lyon 2005). Species of *Malus* and less commonly *Crataegus*, are the primary (aecial) hosts (Sinclair & Lyon 2005).
- *Gymnosporangium libocedri* is present in Washington and Oregon (PNW Handbooks 2019d) and reported as a pest of pears in Willamette valley in Oregon (Pscheidt & Ocamb 2022b). *Gymnosporangium libocedri* causes a serious disease of pears in the western United States leading to malformation and premature drop of fruit (Sutton et al. 2014).
- In the PNW-USA, *G. clavipes* is considered a minor pathogen of apples (Sinclair & Lyon 2005), and has been reported on *Crataegus douglasii* (black hawthorn) and *Juniperus communis* (common juniper) in Washington (Farr & Rossman 2017).

*Gymnosporangium* rusts may be associated with apple fruit at low levels in the PNW-USA.

- Young, succulent tissues of apple tree, including developing fruit, can become infected by basidiospores from a juniper/cedar host if a film of water is present for a sufficiently long period (Aldwinckle 1990a; Sinclair & Lyon 2005). Basidiospores from juniper infections are forcibly discharged into the air immediately after formation and can be carried more than one kilometre on air currents (Sutton et al. 2014).
- *Gymnosporangium juniperi-virginianae* basidiospores can infect green stems, leaves and young fruits of apple trees, causing superficial swollen lesions. Apple fruit are susceptible from the tight-cluster stage to just after petal fall stage. One to two weeks after infection, orange-brown pycnia containing pycniospores appear on the infected fruit (Aldwinckle 1990a; Sinclair & Lyon 2005).
- *Gymnosporangium libocedri* is mainly a pest of pears (Sutton et al. 2014) but it can also attack apple and other rosaceous species (Aldwinckle 1990b).
- *Gymnosporangium clavipes* primarily infects apple fruit. Apple fruit are susceptible for only two weeks when fruit are young, and chlorotic spot symptoms become visible 7 to 10 days after infection. Large dark-green lesions appear at the calyx end, extending to the core, and causing distortion of the fruit (Aldwinckle 1990c).
- Symptoms of *Gymnosporangium* rusts on apple fruit vary depending on the cultivar. Symptoms can be reduced or absent on rust tolerant cultivars (Aldwinckle 1990a, b, c; Pearson, Aldwinckle & Seem 1977; Sinclair & Lyon 2005; Sutton et al. 2014). Red Delicious and Liberty cultivars are reputed to be resistant to *G. juniperi-virginianae*, but Golden Delicious and Jonathan varieties are susceptible.

Some *Gymnosporangium* rust-infected fruit may only exhibit initiation of rust symptoms during harvest and post-harvest processes.

- Infected fruit exhibiting visual symptoms of *Gymnosporangium* rusts are likely to be removed during harvest and post-harvest processes.
- Asymptomatic *Gymnosporangium* rust-infected fruit, and fruit with small lesions, may be harvested and packed for export to Australia.

Gymnosporangium rusts may survive cold temperatures during storage and transport.

- Harvested apples are normally cold-stored at 0°C to 2°C (Good Fruit Grower 2014; Iowa State University Extension and Outreach 2008; Kupferman 1996; University of Maine 2020).
- Sea freight, which takes about five weeks, is likely to be the preferred method of transport of apples from the PNW-USA to Australia and fruit will be maintained at very low temperatures (WSU Tree Fruit 2021c).
- *Gymnosporangium* rusts in infected apple fruit may survive cold temperatures, given that the pathogens survive in the infected branches and galls on alternate hosts (Aldwinckle 1990a, b, c; Hudelson 2019; Sinclair & Lyon 2005) in the PNW-USA in sub-zero winter temperatures.

All three *Gymnosporangium* rusts are present, to varying extents, in the PNW-USA apple production areas. Young apple fruit may become infected in spring, and symptoms typically develop one to two weeks after infection. Infected fruit exhibiting visual symptoms of the *Gymnosporangium* rusts are likely to be removed during harvest and post-harvest processes. However, symptoms may be reduced or inapparent on some cultivars, and these fruits may be harvested and packed for export to Australia. *Gymnosporangium* rusts in infected apple fruit may survive cold storage, given that the pathogens survive in infected branches and galls on alternate hosts in the PNW-USA in sub-zero winter temperatures. For the reasons outlined, the likelihood estimate for importation of *Gymnosporangium* rusts on the PNW-USA apple pathway is assessed as Low.

#### **Likelihood of distribution**

The likelihood that *Gymnosporangium* rusts will be distributed within Australia in a viable state as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host is considered to be similar to *G. yamadae* on apples from China. Therefore, the same rating of Moderate for the likelihood of distribution previously assessed for *G. yamadae* on the apples from China pathway is adopted for *Gymnosporangium* rusts on the apples from PNW-USA pathway.

#### **Overall likelihood of entry**

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

The overall likelihood of entry is determined as Low by combining the assessed likelihood of importation of Low with the adopted likelihood of distribution of Moderate, as assessed in the existing policy for fresh apple fruit from China.

#### **4.18.2 Likelihoods of establishment and spread**

The likelihoods of establishment and spread for *Gymnosporangium* rusts are independent of the import pathway and are considered similar to those previously assessed for *G. yamadae* on the apples from China pathway.

Based on the previous assessment for *G. yamadae* on apples from China (Biosecurity Australia 2010a) and due to the presence of similar telial hosts (*Juniper* spp.) of *G. yamadae* assessed in the China apple policy within Australia, the likelihoods of establishment and spread for *Gymnosporangium* rusts are assessed as Moderate and High, respectively.

#### 4.18.3 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that *Gymnosporangium* rusts will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as Low.

#### 4.18.4 Consequences

The potential consequences of the entry, establishment and spread of *Gymnosporangium* rusts in Australia are similar to those in the previous assessment for *G. yamadae* on the apples from China pathway, which were assessed as Moderate (Biosecurity Australia 2010a). The overall consequences for *Gymnosporangium* rusts on apples from the PNW-USA pathway are also assessed as Moderate.

#### 4.18.5 Unrestricted risk estimate

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

Unrestricted risk estimate for <i>Gymnosporangium</i> rusts	
Overall likelihood of entry, establishment and spread	Low
Consequences	Moderate
Unrestricted risk	Low

The unrestricted risk estimate for *Gymnosporangium* rusts on the apples from PNW-USA pathway has been assessed as Low, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for *Gymnosporangium* rusts on the PNW-USA apple pathway.

## 4.19 Bull's eye rot

### ***Neofabraea malicorticis* (EP)**

*Neofabraea malicorticis* is a fungal pathogen belonging to the Dermateaceae family that causes 'bull's eye rot' in apple and pear fruit in the PNW-USA (Pscheidt & Ocamb 2022b). *Neofabraea malicorticis* is an important pathogen in apple and pear orchards in the PNW-USA (Amiri & Ali 2016; Garipey et al. 2005; Grove 1990a; Spotts 1990a; Sutton et al. 2014; Xiao 2007), and also occurs on a number of other rosaceous hosts (Grove 1990a).

*Neofabraea malicorticis* is widely distributed in North America (Aguilar 2017) and Europe (Pešicová et al. 2017). In the PNW-USA, *N. malicorticis* is very common in humid areas west of the Cascade Range (Dugan, Grove & Rogers 1993; Grove 1990a; Kienholz 1939). It is also widely reported in Oregon (Garipey et al. 2005).

The tree canker caused on apple trees by *N. malicorticis* is known as anthracnose canker (Dugan, Grove & Rogers 1993). While the canker may reduce growth and bearing capacity (PNW Handbooks 2019b) it rarely kills branches or trees (Grove 1990a; Sutton et al. 2014). The canker serves as a source of conidial inoculum for the infection of fruit and the pathogen is described as an aggressive pathogen (Sutton et al. 2014).

Conidia are dispersed by rain or sprinkler irrigation, and can infect lenticels or wounds at any time between petal fall and harvest (Spotts 1990a), with the infection process more likely to commence closer to harvest (Henriquez, Sugar & Spotts 2008). Symptoms on fruit usually do not appear in the field, but show after 3 to 7 months of storage (Garipey et al. 2005; Spotts 1990a; Sutton et al. 2014). Symptoms of bull's eye rot present as brown, depressed, round spots, reflecting the presence of acervuli, fruiting bodies containing conidia, which develop in concentric rings causing formation of a 'bull's eye' pattern (Spotts 1990a; Sutton et al. 2014). Cold storage does not eliminate the fungi, but can delay the onset of symptoms (Edney 1956).

The risk scenario of biosecurity concern for bull's eye rots is that symptomless infected fruit may enter Australia and result in the establishment and spread of this pathogen in Australia.

*Neofabraea malicorticis* has been assessed previously under its synonym *Cryptosporiopsis curvispora*, in the existing import policy for fresh apple fruit from the People's Republic of China (Biosecurity Australia 2010a). In that policy, the unrestricted risk estimate for *N. malicorticis* was assessed as Very Low, which achieves the ALOP for Australia. Therefore, no specific risk management measures are required for *N. malicorticis* for the fresh apple from China pathway.

The department has assessed the likelihood of importation of *N. malicorticis* on fresh apple fruit from China as Moderate (Biosecurity Australia 2010a). However, the differences in pest prevalence, climate and horticulture practices between export areas make it necessary to assess the likelihood of importation of *N. malicorticis* associated with the PNW-USA apple pathway.

The department has assessed the likelihood of distribution of *N. malicorticis* on fresh apple fruit from China as High (Biosecurity Australia 2010a). Fresh apple fruit from the PNW-USA are expected to be distributed in Australia, as a result of processing, sale or disposal, in a similar way to apples from China. Apples can be imported all year round, therefore, there would be no seasonal differences between both import pathways to contribute to variation in the risk rating for likelihood of distribution. *Neofabraea malicorticis* has a wide range of plant hosts (de Jong et

al. 2001; Sutton et al. 2014), and infections are able to remain symptomless for up to 3 to 7 months while actively growing in cold storage (Garipey et al. 2005; Grove, Dugan & Boal 1992; Spotts 1990a; Sutton et al. 2014). Fruit that develop rot symptoms could be discarded in compost or in the natural environment where the rot is likely to encounter a host. *Neofabraea malicorticis* thrives in decaying vegetable litter and can produce spores, which are a viable form of inoculum, from this source (Aguilar 2017; Grove, Dugan & Boal 1992). Infections in apples are not always superficial, and can include cells deep inside the lenticels of the apple (Spotts 1990a). Any fungicide treatments applied during pre-harvest or packing house processes will only be partially effective at stopping bull's eye rot. Therefore, the same rating of High assessed for *N. malicorticis* on apples from China is adopted for *N. malicorticis* on the PNW-USA apple pathway.

The likelihoods of establishment and spread of *N. malicorticis* in Australia from the PNW-USA apple pathway are also considered to be similar to those of the previous assessment for apples from the People's Republic of China, and are rated as Moderate and Moderate, respectively. Those likelihoods relate specifically to events that occur in Australia and are principally independent of the import pathway. The consequences of entry, establishment and spread for *N. malicorticis* are also independent of the import pathway, and have been assessed as similar to the existing assessment of Low for the apples from China. Therefore, the existing ratings for the likelihoods of establishment and spread, and the rating for overall consequences for *N. malicorticis* on the China apple pathway have been adopted for *N. malicorticis* on the PNW-USA apple pathway.

The department has also reviewed the latest literature — for example, Aguilar, Mazzola and Xiao (2018); Cameldi et al. (2016); Garton et al. (2016); Kingsnorth et al. (2017) and WSU (2018, 2020). No new information has been identified that would significantly change the risk ratings for distribution, establishment, spread or consequences, as set out for *N. malicorticis* in the existing policy for apples from China.

#### 4.19.1 Likelihood of entry

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

##### Likelihood of importation

The likelihood that *N. malicorticis* will arrive in Australia with the importation of apples from the PNW-USA is assessed as High.

The following information provides supporting evidence for this assessment.

In the PNW-USA, *N. malicorticis* is widely prevalent in apple production areas

- *Neofabraea malicorticis* is prevalent on apples in the PNW-USA (Amiri & Ali 2016; Xiao 2007).
- In Washington, *N. malicorticis* is very common in the moist areas west of the Cascade Ranges (Dugan, Grove & Rogers 1993; Garipey et al. 2005; Grove 1990a; Kienholz 1939; PNW Handbooks 2019b; Sutton et al. 2014). A survey of post-harvest rots in apple production areas of Washington state during 2003 and 2005 found *Neofabraea* spp. to be prevalent (Kim & Xiao 2008).
- *Neofabraea malicorticis* is also widely reported in Oregon (Garipey et al. 2005).

- Most of the widely-grown apple cultivars in the PNW-USA are susceptible (PNW Handbooks 2019b), including Golden Delicious, Red Delicious and Fuji (Grove 1990a; MAL 2007; PNW Handbooks 2019b).

Asymptomatic fruit infected with *N. malicorticis* will not be detected or removed during harvesting and packing processes and may be packed for export. The pathogen is likely to survive cold temperatures during storage and transport.

- Cankers on apple trees produce conidia, which serve as inoculum for apple fruit infection. Fruit infection can occur any time between petal fall and harvest (Spotts 1990a), with the infection process more likely to commence closer to harvest (Henriquez, Sugar & Spotts 2008; Pscheidt & Ocamb 2021d).
- Infections on fruit commonly remain asymptomatic at harvest, but become apparent after 3 to 7 months of storage (Garipey et al. 2005; Pierson, Ceponis & McColloch 1971; Spotts 1990a; Sutton et al. 2014).
- Most apple fruit are cold stored prior to being exported. The period of cold storage may range from 1 day to 11 months (Kupferman 1996). Infected apple fruit that are packed after extended period of storage are likely to show symptoms and will not be packed for export.
- However, infected apple fruit may be asymptomatic at the time they are processed and packed for export.
- *Neofabraea malicorticis* could survive cold temperatures during storage and transport.
- Cold temperatures, such as those during cold storage of apples, delay the onset of symptoms of bull's eye rot (Edney 1956; Pierson, Ceponis & McColloch 1971; Spotts 1990a).
- Sea freight, which takes about 5 weeks, is likely to be the preferred method of transport of apples from the PNW-USA to Australia and fruit will be maintained at very low temperatures. Harvested apples are normally cold-stored and transported at 0°C to 2°C (WSU Tree Fruit 2021c).

In the PNW-USA, *N. malicorticis* is highly prevalent in Washington and Oregon. Most of the commonly grown apple cultivars are susceptible to infection. Fruit infection can occur any time between petal fall and harvest, with the infection process more likely to commence closer to harvest. Infections of fruit usually remain asymptomatic until 3 to 7 months after entering storage. Symptomless infected fruit may be harvested and packed for export. *Neofabraea malicorticis* could survive cold temperatures during storage in the PNW-USA and transport to Australia. For the reasons outlined, the estimated likelihood of importation of *N. malicorticis* on the PNW-USA apple pathway is assessed as High.

#### **Likelihood of distribution**

The likelihood that *N. malicorticis* will be distributed within Australia in a viable state as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host is considered to be similar to *N. malicorticis* on apples from China. Therefore, the same rating of High for the likelihood of distribution previously assessed for *N. malicorticis* on the apples from China pathway is adopted for *N. malicorticis* on the apples from PNW-USA pathway.

#### **Overall likelihood of entry**

The overall likelihood of entry is determined by combining the likelihood of importation with the likelihood of distribution using the matrix of rules shown in Table 2.3.

The overall likelihood of entry is determined as High by combining the assessed likelihood of importation of High with the adopted likelihood of distribution of High, as assessed in the existing policy for fresh apple fruit from China.

#### 4.19.2 Likelihoods of establishment and spread

The likelihoods of establishment and spread for *N. malicorticis* are independent of the import pathway and are considered similar to those previously assessed for *N. malicorticis* on the apples from China pathway.

Based on the previous assessment for *N. malicorticis* on apples from China (Biosecurity Australia 2010a), the likelihoods of establishment and spread for *N. malicorticis* are assessed as Moderate and Moderate, respectively.

#### 4.19.3 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that *N. malicorticis* will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as Low.

#### 4.19.4 Consequences

The potential consequences of the entry, establishment and spread of *N. malicorticis* in Australia are similar to those in the previous assessment for *N. malicorticis* on the apples from China pathway, which were assessed as Low (Biosecurity Australia 2010a). The overall consequences for *N. malicorticis* on apples from the PNW-USA pathway are also assessed as Low.

#### 4.19.5 Unrestricted risk estimate

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

<b>Unrestricted risk estimate for <i>N. malicorticis</i></b>	
Overall likelihood of entry, establishment and spread	Low
Consequences	Low
Unrestricted risk	Very Low

The unrestricted risk estimate for *N. malicorticis* on the apples from PNW-USA pathway has been assessed as Very Low, which achieves the ALOP for Australia. Therefore, no specific risk management measures are required for *N. malicorticis* on the PNW-USA apple pathway.

## 4.20 European canker

### ***Neonectria ditissima* (EP)**

*Neonectria ditissima* is an ascomycete fungus belonging to the family Nectriaceae, and causes the important disease European canker that affects apple, pear and many species of hardwood forest trees (Castlebury, Rossman & Hyten 2006; Gómez-Cortecero et al. 2016; Grove 1990b; PNW Handbooks 2019a; Swinburne 1975; Wenneker & Thomma 2020).

*Neonectria ditissima* is present in North America, South America, Asia, Africa, New Zealand and Europe (CABI 2019). In the PNW-USA, the disease is found primarily in high rainfall areas along the coast, such as Willamette Valley in western Oregon and western Washington (CABI 2019; Grove 1990b; Kim & Beresford 2012; PNW Handbooks 2019a; Pscheidt & Ocamb 2021a; Shaw 1973). *Neonectria ditissima* has rarely been reported in southern, central or eastern Oregon (Pscheidt & Ocamb 2021a). The disease has not been reported in eastern Washington, which is where the majority of apples are produced in the PNW-USA, or in Idaho (CABI 2022; Pscheidt & Ocamb 2021a). *Neonectria ditissima* has a wide host range, having been recorded on more than 60 tree and shrub species from 20 genera (Department of Agriculture 2018).

Infection of host plants by *N. ditissima* occurs during autumn rains, primarily through leaf scars, but the fungus may also enter a host through wounds such as pruning cuts, open calyces or through galls at the feeding sites of woolly aphids (Swinburne 1975). The canker caused by *N. ditissima* is perennial (Plante, Hamelin & Bernier 2002). White clusters of fungal stromae (sporodochia) appear on the canker during either the first spring after infection or in the following autumn and winter.

In apples and pears, the fruit may also be infected, leading to the development of rot (PNW Handbooks 2019a; Shaw 1973). Young fruit are most susceptible up to 4 weeks after pollination, with susceptibility declining until about 2 months after pollination when it increases again (Xu & Robinson 2010). Foliage is not affected (Butler 1949). Typically, infection of fruit occurs at the blossom end (Weber & Dralle 2013), through either an open calyx, lenticels, scab lesions or wounds caused by insects (McCartney 1967; PNW Handbooks 2019a; Swinburne 1964, 1975). The rot can sometimes develop at the stem-end (Bondoux & Bulit 1959; Swinburne 1964), or occasionally on the surface of the fruit when the skin is damaged (Bondoux & Bulit 1959). Infection usually remains asymptomatic and generally develops into a rot during storage (Bondoux & Bulit 1959; Wenneker & Thomma 2020). Inoculation studies showed that pre-harvest symptoms (eye-rot) may appear on fruit inoculated within four weeks after full bloom (Xu & Robinson 2010). Apple varieties vary greatly in their susceptibility to the disease, but no variety is immune (Gómez-Cortecero et al. 2016; McKay 1947; PNW Handbooks 2019a; Walter et al. 2016).

*Neonectria ditissima* produces two types of spores: conidia (asexual) and ascospores (sexual). Conidia are produced in spring and summer from stroma (sporodochium) containing masses of hyphae. Ascospores are produced by the sexual morph of the fungus in autumn and winter. Sexual bodies (perithecia) producing ascospores are round and red, and discharge spores during the second and subsequent winters and springs post-infection (PNW Handbooks 2019a). Conidia are dispersed by rain splash (Amponsah et al. 2017; PNW Handbooks 2019a), and ascospores are dispersed by wind (Swinburne 1975). Both types of spores are able to germinate

over a temperature range of 6° to 32°C, with reduced germination occurring below 6°C and optimum germination occurring between 20° to 25°C (Latorre et al. 2002).

The risk scenario of biosecurity concern for *Neonectria ditissima* is that asymptomatic infected apple fruit may be imported.

*Neonectria ditissima* was most recently assessed in the existing import policy for fresh apple fruit from New Zealand (Biosecurity Australia 2011b). In that policy, the unrestricted risk estimate for *N. ditissima* was assessed as Very Low, which achieved the ALOP for Australia, when certain industry commercial practices such as in-field controls and packing house sanitation were routinely applied. Similar in-field controls and packing house measures are applied on the PNW-USA apple pathway (see Section 3.4.3), and the assessment of likelihood of importation explicitly relies on their continued implementation.

The department has assessed the likelihood of importation of *N. ditissima* on fresh apple fruit from New Zealand as Very Low. Differences in pest prevalence, climate and transport times between New Zealand and the PNW-USA make it necessary to assess the likelihood of importation of *N. ditissima* on the PNW-USA apple pathway.

The likelihood of distribution of *N. ditissima* on fresh apple fruit from New Zealand was assessed as Very Low (Biosecurity Australia 2011b). Fresh apple fruit from the PNW-USA is expected to be distributed in Australia, as a result of processing, sale or disposal, in a similar way to apples from New Zealand. Apples in the PNW-USA are harvested from August until early November (Washington Apple Commission 2019) and apples in New Zealand are harvested from February to May (AgFirst 2022). As apples from both New Zealand and the PNW-USA may be imported throughout the year, there would be no seasonal differences between the import pathways to contribute to variation in the risk rating for likelihood of distribution.

Hosts of *N. ditissima*, including *Malus* spp. and *Pyrus* spp., are present across Australia. *Neonectria ditissima* infections of fruit can remain asymptomatic (PNW Handbooks 2019a; Wenneker & Thomma 2020), and are able to survive long periods (three to seven months) of cold storage (Snowdon 1990; Swinburne 1975) and transport. Disposal of damaged fruit and fruit waste (e.g. apple cores) would largely occur through managed waste systems. Potential exposure to suitable host plants from waste discarded into managed waste systems is likely to be negligible. A small proportion of fruit waste may be discarded as litter throughout Australia in urban, peri-urban and agricultural situations, as well as areas of natural vegetation within a reasonable distance of a suitable host. However, successful distribution of *N. ditissima*, if present, from fruit waste to a susceptible part of a host is not likely to occur as apple waste would quickly decay, minimising the likelihood of conidia development; there are no known specific vectors or mechanisms to transmit the pathogen from apple waste to a host. Therefore, the same rating of Very Low for the likelihood of distribution of *N. ditissima* on the fresh apple fruit from New Zealand pathway is adopted for the PNW-USA apple pathway.

The likelihoods of establishment and spread of *N. ditissima* in Australia from apples on the PNW-USA pathway have also been assessed as similar to the previous respective assessments of Moderate for apple fruit from New Zealand (Biosecurity Australia 2011b). These likelihoods relate specifically to events that occur in Australia and are principally independent of the import pathway. The consequences of entry, establishment and spread for *N. ditissima* are also independent of the import pathway and have been assessed as similar between pest risk

assessments as Low. Therefore, the existing ratings for likelihoods of establishment and spread of Moderate and the rating for the overall consequences of Low for *N. ditissima* have been adopted for the PNW-USA apple pathway.

The department has also reviewed the latest literature—for example, Amponsah et al (2017), Amponsah et al. (2015); Farr and Rossman (2019); Kim and Beresford (2012); PNW Handbooks (2019a); Walter et al. (2016) and Wenneker et al. (2017). No new information has been identified that would significantly change the risk ratings for distribution, establishment, spread and consequences as set out for *N. ditissima* in the existing policy.

#### 4.20.1 Likelihood of entry

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

##### Likelihood of importation

The likelihood that *N. ditissima* will arrive in Australia with the importation of apples from the PNW-USA is assessed as Very Low.

The following information provides supporting evidence for this assessment.

*Neonectria ditissima* is uncommon in apple production areas in the PNW-USA.

- *Neonectria ditissima* is present in the PNW-USA (APHIS 2007; Farr & Rossman 2019; Grove 1990b; PNW Handbooks 2019a).
- The disease is found primarily in coastal high rainfall areas of western Oregon (Willamette Valley) and western Washington, and rarely in southern, central or eastern parts of Oregon and not reported in eastern Washington (Pscheidt & Ocamb 2021a).
- *Neonectria ditissima* has not been reported in apple orchards in eastern Washington (Pscheidt & Ocamb 2021a), which produce over 95% of the apples within the PNW-USA (Grove 1990b; Kim & Beresford 2012; Shaw 1973).
- *Neonectria ditissima* has not been reported from the state of Idaho (CABI 2022; Pscheidt & Ocamb 2021a).

*Neonectria ditissima* is unlikely to be associated with apple fruit in the PNW-USA because climatic conditions have low suitability for fruit infection.

- Climatic modelling has predicted the major production areas of the PNW-USA have low suitability for fruit infection (Beresford & Kim 2011) due to the absence of prolonged periods of wetness in summer months.
- Amponsah et al (2017) confirmed through spore trapping studies in New Zealand that conidia and ascospores could be disseminated at any time of year when rainfall occurred.
- For fruit to become infected with *N. ditissima*, prolonged periods of wetness in summer months are required to enable the production, dissemination and germination of spores. All three events need to occur for fruit to become infected (Swinburne et al. 1975).
- Germination of *N. ditissima* conidia is dependent on availability of moisture and temperature, however, regardless of moisture, conidial germination is reduced below 6°C and infection does not occur below 5°C (Latorre et al. 2002).
- Xu & Robinson (2010) reported that the incidence of fruit rot was influenced more by fruit maturity at the time of inoculation than by duration of wetness. Mature fruit were more

resistant to infection by *N. ditissima* than immature fruit in which starch conversion had not progressed. However, wetness was essential for inoculated conidia to germinate.

Existing in-field controls will further reduce the likelihood of fruit infection.

- Industry in-field control practices are in place for *N. ditissima* where it occurs in the PNW-USA, as outlined in Table 3.1.
- Various disease management measures used to control summer fruit rots in USA orchards, including cultural practices and the use of fungicides (Xiao 2015), would greatly reduce the likelihood of *N. ditissima* infections being present.
- In-field control for *N. ditissima* involves cultural control by removing and destroying cankers on host plants during dry weather, and disinfecting pruning shears.
- In addition, in-field fungicide applications for canker control are conducted before autumn rains for fruit rot control, and during early and mid to late leaf fall for canker control on branches. Fungicide applications also protect leaf scars.
- Fungicide applications can reduce cankers by 65 to 90%, although they must be supplemented by canker removal and wound treatment (Cooke 1999).

Packing house procedures will greatly reduce the likelihood of infected fruit being exported.

- Chlorine solutions have been shown to be effective at controlling a range of pathogens (Brown 2002; Kupferman 1984; Suslow 2004).
- Both conidia and ascospores of *N. ditissima* from various inoculum sources can initiate infection on fruit (Latorre et al. 2002). Spores on the surface of fruit that survive post-harvest disinfectants and washing are unlikely to be a source for infection as they are sensitive to desiccation during cold storage, even with free moisture or wetness (Latorre et al. 2002). Dubin and English (1975) found that conidia that could contaminate the fruit surface or survive packing house processes of disinfecting and washing will not survive for more than a few days in cold storage even with wetness.
- For fruit internally colonised by *N. ditissima* mycelia at harvest (which is rare in commercially produced fruit), the pathogen is unlikely to be impacted by packing house procedures and is able to survive long periods (3 to 7 months) of cold storage and transport.
- Most apple fruit are cold stored prior to being exported. The period of cold storage may range from 1 day to 11 months (Kupferman 1996). Symptoms become apparent on infected fruit during cold storage and symptomatic fruit will likely be detected during packing house processes. Consignments detected with symptoms post-cold storage at the pre-export phytosanitary inspection will be rejected for export.
- Surveys of apple storage rots in the PNW-USA in commercial packing houses from about 180 grower lots in 2003, 2004 and 2005 did not detect *N. ditissima* (Kim & Xiao 2008).
- A more recent survey of Washington packing houses in 2016 of fruit picked in 2015 failed to detect this pathogen (Amiri & Ali 2016).

Any fruit infected with *N. ditissima* that remain asymptomatic during pre-export phytosanitary inspection will not be detected and may be exported. The pathogen is likely to survive but may be adversely affected by cold temperatures during transport to Australia.

- Asymptomatic infection by *N. ditissima* on apple fruit generally develops into a visible rot during storage (Bondoux & Bulit 1959; PNW Handbooks 2019a; Wenneker & Thomma 2020). In cooking varieties, fruit infections can express after three to seven months of storage (Snowdon 1990; Swinburne 1975) especially if infection occurs late in the growing season (Bondoux & Bulit 1959).

- Depending on the timing of infection and the period of cold storage prior to pre-export phytosanitary inspection, some infected fruit may remain symptomless during inspection and may be exported.
- Cold storage at 0°C to 2°C and low temperature transport are likely to adversely affect infection as conidial germination of *N. ditissima* is reduced below 6°C and infection does not occur below 5°C (Latorre et al. 2002).
- Sea freight, which takes about five weeks, is likely to be the preferred method of transport of apples from the PNW-USA to Australia. Some infected fruit may express visible symptoms when arriving in Australia and will likely be detected and rejected at the on-arrival inspection. However, some infected fruit may remain symptomless on arrival and will not be detected.

While *N. ditissima* has been recorded within some apple producing areas in the PNW-USA, climatic conditions limit the occurrence of this pathogen and disease incidence. The limited occurrence reduces the potential for a source of inoculum to be present in orchards that produce apples for export. Further, specific environmental conditions are required over an extended period of time to produce spores that could potentially infect fruit. These conditions are unlikely to occur in the exporting region.

Further, fruit are produced in orchards using targeted and general management measures to control *N. ditissima*. These management measures limit inoculum levels within an orchard and therefore reduce the opportunity for fruit infection, even when climatic conditions are favourable. The lack of reported fruit infections in packing houses in the PNW-USA in surveys supports the limited occurrence of fruit infection. Should some fruit infection occur, packing house procedures such as application of disinfectants will limit surface contamination from short-lived spores. Grading procedures and pre-export inspection, which generally occurs after a period of cold storage, will also remove apples with visible fruit rots. For the reasons outlined, the likelihood estimate for importation of *N. ditissima* on the PNW-USA apple pathway is assessed as Very Low.

#### **Likelihood of distribution**

The likelihood that *N. ditissima* will be distributed within Australia in a viable state as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to susceptible hosts is considered to be similar to *N. ditissima* on apples from New Zealand.

Therefore, the same rating of Very Low for the likelihood of distribution previously assessed for *N. ditissima* on the apples from New Zealand pathway is adopted for *N. ditissima* on the apples from PNW-USA pathway.

#### **Overall likelihood of entry**

The overall likelihood of entry is determined as Extremely Low by combining the assessed likelihood of importation of Very Low with the adopted likelihood of distribution of Very Low, using the matrix of rules in Table 2.2.

#### **4.20.2 Likelihoods of establishment and spread**

The likelihoods of establishment and spread for *N. ditissima* are independent of the import pathway and are considered similar to those previously assessed for apples from New Zealand.

Based on the previous assessment for apples from New Zealand (Biosecurity Australia 2011b), the likelihoods of establishment and spread for *N. ditissima* are assessed as Moderate and Moderate, respectively.

#### 4.20.3 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that *N. ditissima* will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as Extremely Low.

#### 4.20.4 Consequences

The potential consequences of the entry, establishment and spread of *N. ditissima* in Australia are similar to those in the previous assessment for *N. ditissima* on the apples from New Zealand pathway, which were assessed as Low (Biosecurity Australia 2011b). The overall consequences for *N. ditissima* on apples from the PNW-USA pathway are also assessed as Low.

#### 4.20.5 Unrestricted risk estimate

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

<b>Unrestricted risk estimate for <i>N. ditissima</i></b>	
Overall likelihood of entry, establishment and spread	Extremely low
Consequences	Low
Unrestricted risk	Negligible

When routinely applied industry commercial practices such as in-field controls and packing house sanitation are taken into consideration, the unrestricted risk estimate for *N. ditissima* on the apples from PNW-USA pathway has been assessed as Negligible, which achieves the ALOP for Australia. Therefore, no additional practices or specific risk management measures are required for *N. ditissima* on the PNW-USA apple pathway.

## 4.21 Speck rot

### *Phacidiopycnis washingtonensis*

*Phacidiopycnis washingtonensis* is an ascomycete fungal pathogen belonging to the family Rhytismataceae, that causes a post-harvest rot disease named 'speck rot' in apple and pear fruit in the PNW-USA (Ali et al. 2018; Amiri & Ali 2016; Kim & Xiao 2006; Pscheidt & Ocamb 2021c; Xiao 2011; Xiao & Kim 2013).

*Phacidiopycnis washingtonensis* is an emerging pome fruit pathogen in PNW-USA (Amiri & Ali 2016), which was discovered in Washington during a survey of post-harvest diseases in Red Delicious apples in the 2002 and 2003 storage seasons (Kim & Xiao 2006; Sikdar et al. 2014; Xiao et al. 2005; Xiao & Kim 2008). It is more common in apples than in pears in Washington (Amiri & Ali 2016). Since 2002, *P. washingtonensis* has been found in Oregon (Elliott et al. 2014), but it has not been recorded in Idaho.

Globally, *P. washingtonensis* is present in Germany (Weber 2011), Italy (Garibaldi et al. 2010; Sikdar et al. 2016), South America (Díaz et al. 2016) and India (Amiri & Ali 2016). Known hosts of *P. washingtonensis* are *Malus* spp. (apple and crabapple) and *Pyrus communis* (pear) (Kim & Xiao 2006; Xiao et al. 2005) in Washington, *Arbutus menziesii* (Pacific madrone) in Washington and Oregon (Elliott et al. 2014) and *Diospyros kaki* (persimmon) in Italy (Garibaldi et al. 2010). This disease is distinct from Phacidiopycnis rot caused by the fungus *Discula pyri*, which is primarily a pear rot and is considered under a separate assessment in this report in (Section 4.17).

*Phacidiopycnis washingtonensis* enters fruit through the stem-end, calyx-end or through wounds, causing stem-end rot, calyx-end rot and wound rot, respectively (Amiri & Ali 2016; Xiao & Kim 2008, 2013). The infection begins in the orchard but remains asymptomatic at harvest and fruit rot symptoms develop during storage or distribution (Sikdar et al. 2014; Wenneker & Thomma 2020; Xiao 2013a). In Washington, speck rot was observed after storage durations of up to 6 months at 0°C (Xiao et al. 2005). Symptoms first appear as brown to black specks around the lenticels of the fruit (Xiao 2013a) causing decayed areas which are spongy and appear water-soaked (Ali et al. 2018; Xiao 2013a). As the disease progresses, the decayed area turns brown and then black (Kim & Xiao 2008), and the margins of decayed areas commonly continue to show a water-soaked appearance. Under high relative humidities the fungus forms white mycelia. Pycnidia (fruiting bodies of the asexual morph) of the fungus often form on the decayed area at advanced stages of infection and provide inoculum by releasing conidia (Kim & Xiao 2006).

Speck rot decay caused by *P. washingtonensis* occurs only sporadically on apples (Pscheidt & Ocamb 2021c). *Phacidiopycnis washingtonensis* contributed to only 6.4% of apple rots in central Washington during a survey in 2017 (Ali et al. 2018), and 2.5% of apple rots from a survey in Washington in 2016 on fruit harvested in 2015 (Amiri & Ali 2016).

*Phacidiopycnis washingtonensis* is a weak canker pathogen on apple trees (Xiao 2013a) and is also associated with canker and twig dieback disease of crabapple (Xiao et al. 2005; Xiao 2013a). Canker-infected Manchurian crabapple trees used as pollinisers in apple orchards are the primary sources of inoculum (PNW Handbooks 2020b; Xiao et al. 2005). Crabapple fruits infected with *P. washingtonensis* become mummified and covered in black pycnidia, providing

inoculum by releasing conidia throughout the following season (PNW Handbooks 2020b; Sikdar, Willett & Mazzola 2018). Removal of cankers and mummified fruit helps reduce levels of fungal inoculum in the orchard. The fungal spores are spread by rain splash, sprinkler irrigation or over-tree cooling systems (PNW Handbooks 2020b; Xiao 2013a).

The risk scenario of biosecurity concern for *P. washingtonensis* is that symptomless infected fruit carrying viable spores may be imported and result in the establishment and spread of this pathogen in Australia.

#### 4.21.1 Likelihood of entry

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

##### Likelihood of Importation

The likelihood that *P. washingtonensis* will arrive in Australia with the importation of apples from the PNW-USA is assessed as High.

The following information provides supporting evidence for this assessment.

*Phacidiopycnis washingtonensis* is widely distributed in Washington and Oregon and is associated with apple fruit from the PNW-USA.

- *Phacidiopycnis washingtonensis* causes speck rot, which is a post-harvest disease of apple in Washington (Amiri & Ali 2016; Kim & Xiao 2006; Sikdar, Willett & Mazzola 2018; Xiao & Kim 2008). It is also present in Oregon (Elliott et al. 2014).
- Recent surveys have confirmed that speck rot is an emerging disease issue in PNW-USA (Amiri & Ali 2016).
- *Phacidiopycnis washingtonensis* contributed to 6.4% of apple rots in central Washington during a survey in 2017 (Ali et al. 2018), and 2.5% of apple rots from a survey in Washington in 2016 on fruit harvested in 2015 (Amiri & Ali 2016).
- A study of fruit in Washington packing houses from 2003 to 2005 found speck rot was detected in 6 of 26 grower lots (23%), accounting for 1% of the total decayed fruit in 2003, in 19 of 72 grower lots (26%), accounting for 4% of total decayed fruit in 2004, and in 14 of 81 grower lots (17%), accounting for 3% of the total decayed fruit in 2005 (Kim & Xiao 2006).

Crabapple trees in the PNW-USA provide a continuing source of inoculum for apple fruit infection.

- *Phacidiopycnis washingtonensis* is commonly associated with a canker and twig dieback disease of Manchurian crabapple trees used as pollinisers in apple orchards (Xiao et al. 2005; Xiao 2013a).
- Crabapple fruit infected with *P. washingtonensis* become mummified and covered in black pycnidia, which provide inoculum by releasing conidia throughout the following season (PNW Handbooks 2020b).

Infections of *P. washingtonensis* can remain asymptomatic during harvest, grading and packing processes.

- *Phacidiopycnis washingtonensis* is primarily a post-harvest disease, and infected fruit commonly remain asymptomatic during harvest and post-harvest processing (Sikdar et al.

2014; Wenneker & Thomma 2020). Decay is typically observed after 2 to 3 months in storage and incidence increases with time in storage (Kim & Xiao 2006).

- Infected fruit may start to develop symptoms from about 45 days (Sikdar, Willett & Mazzola 2018) to 6 months after cold storage (Xiao et al. 2005).
- Most apple fruit are cold-stored prior to being exported. The period of cold storage may range from 1 day to 11 months (Kupferman 1996). Infected apple fruit that are packed after an extended period of storage are likely to show symptoms and will not be packed for export.
- However, infected apple fruit packed shortly after harvest will not show symptoms and may be packed for export.

*Phacidiopycnis washingtonensis* is able to survive low temperatures during storage and transport.

- *Phacidiopycnis washingtonensis* can survive and grow over a temperature range of  $-3^{\circ}\text{C}$  to  $25^{\circ}\text{C}$ , with optimum growth from  $15^{\circ}\text{C}$  to  $20^{\circ}\text{C}$  (Xiao et al. 2005).
- *Phacidiopycnis washingtonensis* can therefore survive cold temperatures during storage and transportation of apples, which are typically at  $0^{\circ}\text{C}$  to  $2^{\circ}\text{C}$  (Good Fruit Grower 2014; Iowa State University Extension and Outreach 2008; Kupferman 1996; University of Maine 2020). Sea freight, which takes about five weeks, is likely to be the preferred method of transport of apples from the PNW-USA to Australia and fruit will be maintained at very low temperatures. Harvested apples are normally cold-stored and transported at  $0^{\circ}\text{C}$  to  $2^{\circ}\text{C}$  (WSU Tree Fruit 2021c).

*Phacidiopycnis washingtonensis* is widely distributed in the PNW-USA (Washington and Oregon), causing a post-harvest rot disease in apple fruit. Infection of fruit occurs in the orchard, but remains asymptomatic at harvest, and symptoms start to develop during storage between 45 days to 6 months after harvest. Infected apple fruit packed shortly after harvest are unlikely to be detected during packing processes and may be packed for export. The fungus can survive and grow at low temperatures used in cold storage and transportation and is likely to survive transport to Australia. The likelihood of importation of *P. washingtonensis* on the PNW-USA apple pathway is therefore assessed as High.

#### Likelihood of distribution

The likelihood that *P. washingtonensis* will be distributed in Australia in a viable state as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host, is assessed as Low.

The following information provides supporting evidence for this assessment.

Apples from the PNW-USA are expected to be distributed throughout Australia for retail sale. Infected fruit showing symptoms of *P. washingtonensis* infection are likely to be removed from distribution, but some asymptomatic fruit, and fruit with mild symptoms, may be distributed and sold.

- Infections of apple fruit remain asymptomatic for some time (Wenneker & Thomma 2020), and fruit rot symptoms may develop during storage or sale (Xiao 2013a).
- Imported apple fruit are intended for human consumption in Australia. It is expected that fruit will be distributed to urban and rural regions throughout Australia for wholesale or retail sale.

- Fruit with obvious signs of rot are likely to be discarded rather than distributed further. However, infected fruit that remain asymptomatic or exhibit only mild symptoms are likely to be distributed further. Disposal of infected fruit is likely to be via commercial or domestic rubbish routes into managed waste systems.

*Phacidiopycnis washingtonensis* is likely to remain viable at temperatures commonly used during storage and transportation of apples within Australia.

- *Phacidiopycnis washingtonensis* can survive and grow over a temperature range of  $-3^{\circ}\text{C}$  to  $25^{\circ}\text{C}$  (Xiao et al. 2005).
- In Australia, imported apples will likely be stored and transported under similar cold temperatures ( $0^{\circ}\text{C}$  to  $2^{\circ}\text{C}$ ). In retail stores, apples are likely to be stored at both ambient and cold temperatures. When the pathogen is exposed to ambient temperatures, its growth rate will be optimal. However, at temperatures above  $20^{\circ}\text{C}$ , growth of the fungus will be limited with mycelial growth arrested at  $30^{\circ}\text{C}$  (Xiao et al. 2005).
- Conidia may germinate under unfavourable conditions by budding, however, under adverse conditions the germ tubes may not lead to mycelial formation and multiplication of inoculum for subsequent infections.

Suitable hosts for *P. washingtonensis* are present in Australia and some infected apple waste may be discarded into the environment near hosts.

- Known hosts of *P. washingtonensis* are *Malus* spp. (apple and crabapple), *Pyrus communis* (pear), *Diospyros kaki* (persimmon) and *Arbutus menziesii* (Pacific madrone) (Elliott et al. 2014; Garibaldi et al. 2010; Sikdar et al. 2016; Xiao et al. 2005).
- These hosts, with the exception of *A. menziesii*, are widespread within Australia in commercial orchard districts, as well as in suburban and rural areas.
- Although most apple waste will be discarded into managed waste systems, some infected apple fruit may be discarded as litter in urban, rural or natural environments, including near suitable host plants.

*Phacidiopycnis washingtonensis* is likely to produce only limited amounts of inoculum during distribution processes.

- *Phacidiopycnis washingtonensis* can survive on decaying tissues and overwinter as pycnidia for a long period of time.
- Conidia of *P. washingtonensis* formed in pycnidia on discarded fruit/fruit cores are likely to further multiply to develop inoculum for fresh infections when conditions are favourable.
- *Phacidiopycnis washingtonensis* can grow over a wide temperature range with optimal growth occurring at  $15^{\circ}\text{C}$  to  $25^{\circ}\text{C}$  (Xiao et al. 2005), and this temperature range exists in parts of Australia during parts of the year. Many regions in Australia have hot and dry summer conditions with regular maximum temperatures above  $30^{\circ}\text{C}$  (Bureau of Meteorology 2018). Inoculum production of *P. washingtonensis* is likely to be restricted on fruit waste discarded during hot and dry conditions.
- Inoculum production by *P. washingtonensis* may also be restricted due to colonisation of discarded fruit or fruit cores by saprophytic fungi or bacteria and competitive interactions with them.

The dispersal of pycnidia and conidia of *P. washingtonensis* to a host is possible under favourable Australian conditions.

- Conidia of *P. washingtonensis* require moisture to be splash- or water-dispersed (Xiao 2013a) to a new host, which is a passive mechanism for conidial dispersal over short distances.
- Many regions of Australia have hot, dry summer conditions with regular temperature maxima above 30°C for several consecutive weeks or months (Bureau of Meteorology 2018). Dispersal of conidia of *P. washingtonensis* from fruit waste discarded during hot and dry conditions to a nearby host is likely to be restricted.
- Throughout the remainder of the year the climate in some Australian regions could support conidial dispersal.

*Phacidiopycnis washingtonensis* can be present as asymptomatic infections on fruit and survive low temperatures during storage and transportation in Australia. Some infected fruit waste may be discarded into the Australian environment. Hosts of *P. washingtonensis* are widely present in various parts of Australia. Inoculum production on fruit waste discarded during hot and dry conditions is likely to be restricted. Inoculum production may also be restricted due to colonisation of discarded fruit waste by saprophytic fungi or bacteria. Conidia dispersal is also likely to be restricted if infected fruit waste are discarded into the Australian environment during hot and dry conditions.

For the reasons outlined, the likelihood estimate for distribution of *P. washingtonensis* on apples from the PNW-USA is assessed as Low.

#### **Overall likelihood of entry**

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

The overall likelihood that *P. washingtonensis* will enter Australia as a result of trade in the commodity and be distributed in a viable state to a susceptible part of a host is assessed as Low.

#### **4.21.2 Likelihood of establishment**

The likelihood that *P. washingtonensis* will establish within Australia, based on a comparison of factors in the source and destination areas that affect pest survival and reproduction, is assessed as Moderate.

The following information provides supporting evidence for this assessment.

Known hosts of *P. washingtonensis* are present within Australia.

- Known hosts of *P. washingtonensis*, including *Malus* spp., *Pyrus communis* and *Diospyros kaki* (Elliott et al. 2014; Garibaldi et al. 2010; Sikdar et al. 2016; Xiao et al. 2005) are present and reasonably widely distributed within Australia.
- The commercial apple cultivars Fuji, Golden Delicious and Red Delicious are known to be susceptible to *P. washingtonensis* (Kim & Xiao 2006). These cultivars are grown in Australia.
- *Phacidiopycnis washingtonensis* has the ability to survive on both live and dead tissues of its hosts (Kim & Xiao 2006; Xiao et al. 2005).

Climatic conditions suitable for the establishment of *P. washingtonensis* are available in various parts within Australia during parts of the year.

- *Phacidiopycnis washingtonensis* can grow over a wide temperature range with optimal growth occurring at 15°C to 20°C (Xiao et al. 2005), indicating suitable conditions are likely to be present in many parts of Australia.
- Although most apple and pear growing regions within Australia would have optimal conditions for development of *P. washingtonensis* during autumn and spring, the fungus is unlikely to survive hot and dry summer conditions. Further, the fungus will require conducive conditions such as rain and moisture for conidial germination for fruit infection (PNW Handbooks 2020b) for possible establishment in these areas.
- The overwintering and survival properties of *P. washingtonensis* on dead and living host tissues indicate that there is a chance that the pathogen may be able to overwinter and re-grow when favourable conditions are available.

Hosts of *P. washingtonensis* (apples, pears, crabapples and persimmons) are widely present in various parts of Australia. Optimal climatic conditions exist in many regions of Australia and could support successful establishment of the fungus during most of the year it was distributed to susceptible hosts in a viable state. Successful establishment is likely to be limited during the hot, dry Australian summer. The ability of the pathogen to overwinter and survive for several months on both live and dead tissues of its hosts could allow the pathogen to establish and re-emerge when favourable conditions are available.

For the reasons outlined, the likelihood estimate for establishment of *P. washingtonensis* within Australia from imported apples from the PNW-USA is assessed as Moderate.

#### 4.21.3 Likelihood of spread

The likelihood that *P. washingtonensis* will spread within Australia, based on a comparison of factors in the source and destination areas that affect the expansion of the geographic distribution of the pest, is assessed as Moderate.

The following information provides supporting evidence for this assessment.

Widely distributed host plants in various parts of Australia could support the spread of *P. washingtonensis* within Australia.

- Known host species, including apples, crabapples, pears and persimmons, are present and widely distributed within Australia in commercial orchard districts, as well as in suburban and rural areas.
- *Phacidiopycnis washingtonensis* has the ability to maintain infections on hosts throughout the growing season, and is able to overwinter on both live and dead tissues of its hosts (Kim & Xiao 2006; Xiao et al. 2005).

Suitable environments for the spread of *P. washingtonensis* exist in Australia.

- *Phacidiopycnis washingtonensis* can survive and grow over a wide temperature range of – 3°C to 25°C (Xiao et al. 2005).
- Climates similar to those in the geographic range of *P. washingtonensis* in PNW-USA exist in parts of temperate southeastern and southwestern Australia, suggesting that these parts of Australia are likely to be suitable for spread of *P. washingtonensis*.

- Hot, dry climatic conditions in some parts of Australia during summer may not be conducive for the spread of the pathogen during this period.

Natural dispersal by spores may spread the pathogen over short distances.

- Pycnidia, which are the fruiting bodies of *P. washingtonensis*, contain millions of spores, from which infection of hosts can be initiated (PNW Handbooks 2020b; Washington State University Extension 2020; Xiao & Kim 2013).
- Natural dispersal of *P. washingtonensis* is through spores spread from one host to another by water splash or rain. Presence of moisture also creates conditions conducive for fruit infection (PNW Handbooks 2020b; Sikdar et al. 2016).

Long distance spread of *P. washingtonensis* may occur through human-assisted activities.

- Domestic trade of infected asymptomatic apple fruit and planting materials may aid the spread of *P. washingtonensis* within Australia.
- Disposal of infected fruit/fruit cores directly into the environment may also aid the spread of the pathogen.

Hosts of *P. washingtonensis* are available in various parts of Australia. The fungus is able to survive and grow over a wide temperature range and develop adequate levels of inoculum to maintain infection. Most temperate horticultural production regions within Australia experience suitable conditions for growth and spread of this fungus for most of the year. Spread of the pathogen may also be assisted by human-mediated activities. Survival of *P. washingtonensis* is expected to be reduced during the hot, dry Australian summer.

For the reasons outlined, the likelihood estimate for spread of *P. washingtonensis* within Australia from apples from the PNW-USA is assessed as Moderate.

#### 4.21.4 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that *P. washingtonensis* will enter Australia as a result of trade in apples from PNW-USA, be distributed in a viable state to susceptible hosts, establish in that area and subsequently spread within Australia is assessed as Low.

#### 4.21.5 Consequences

The consequences of the establishment of *P. washingtonensis* in Australia have been estimated according to the methods described in Table 2.3.

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

The reasoning for these ratings is provided below.

Criterion	Estimate and rationale
<b>Direct</b>	
Plant life or health	E - Significant at regional level: <i>Phacidiopycnis washingtonensis</i> is associated with both infected and decaying tissues of apple fruit (Xiao et al. 2005). The fungus

	<p>causes post-harvest rot on apples, crabapple and pears, and infects other parts of the crabapple tree in the states of Washington and Oregon (Xiao et al. 2005). It also has other hosts such as <i>Diospyros kaki</i> (persimmon) in the states of Washington and Oregon (Elliott et al. 2014) and in Italy (Garibaldi et al. 2010), and <i>Arbutus menziesii</i> (Pacific madrone) in western Washington and Oregon (Elliott et al. 2014).</p> <p>In Washington, <i>P. washingtonensis</i> occurred in up to 23, 26 and 27% of total apple lots surveyed, accounting for 1%, 4% and 3% of the total decay in 2003, 2004 and 2005, respectively (Kim &amp; Xiao 2006). In 2004 and 2005, Red Delicious fruit losses observed were as high as 24% in three grower lots in Washington (Kim &amp; Xiao 2006). In a recent survey in 2017, speck rot accounted for 6.4% of the apple decays in central Washington (Ali et al. 2018). It is not known if the assessed fungus would have any effects on Australian native plants.</p> <p>Orchard hygiene and chemical application practices already applied in Australia in apple production areas may mitigate the consequences of establishment of the pest.</p>
Other aspects of the environment	<p>A - Indiscernible at the local level:</p> <p>In 2009 and 2011, severe leaf necrosis, blotching and spot caused by <i>P. washingtonensis</i> was observed on Pacific madrone in western Washington and Oregon (Elliott et al. 2014). It is not known if other plant species could be hosts for the pathogen and there are no known direct consequences of this pathogen on other aspects of the environment.</p>
<b>Indirect</b>	
Eradication, control	<p>E - Significant at the regional level:</p> <p>Speck rot caused by <i>P. washingtonensis</i> can be controlled by orchard sanitation, removal of dead or diseased twigs and branches and removal of cankers of crabapple pollinisers, and application of pre-harvest fungicides (Ali et al. 2018).</p> <p>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.</p>
Domestic trade	<p>E - Significant at the regional level:</p> <p>The presence of <i>P. washingtonensis</i> in commercial apple and pear production areas could result in the implementation of interstate quarantine measures, causing loss of market and subsequent industry adjustment.</p>
International trade	<p>E - Significant at the regional level:</p> <p>Australia exports around 5,000 tonnes of apples per year and imports over 1,000 tonnes. The presence of <i>P. washingtonensis</i> 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 not present.</p>
Non-commercial and environmental	<p>B - Minor significance at the local level:</p> <p>Additional fungicide applications or other control activities may be required to control this pathogen on susceptible crops. Any additional fungicide usage may affect the environment.</p>

#### 4.21.6 Unrestricted risk estimate

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

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<b>Unrestricted risk estimate for <i>Phacidiopycnis washingtonensis</i></b>	
Overall likelihood of entry, establishment and spread	Low
Consequences	Moderate
Unrestricted risk	Low

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As indicated, the unrestricted risk for *P. washingtonensis* on apples from the PNW-USA pathway is assessed as Low, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for this pest on the PNW-USA apple pathway.

## 4.22 Apple Blotch

### ***Phyllosticta arbutifolia* (EP)**

*Phyllosticta arbutifolia* (synonym: *Phyllosticta solitaria*) is an ascomycete fungal pathogen belonging to the family Botryosphaeriaceae.

*Phyllosticta arbutifolia* is native to North America. It is present in Greece, USA, Brazil, India, China, Zimbabwe and South Africa (Farr & Rossman 2020). Apple blotch caused by *P. arbutifolia* was a major apple disease in the eastern United States in the early 1900s, but is now considered a minor apple disease in these areas (Sutton et al. 2014; Yoder 1990). *Phyllosticta arbutifolia* has been recorded in Washington (Farr & Rossman 2018), but there are no records of the pathogen in Oregon or Idaho. The pathogen is considered rare in the PNW-USA as state-wide surveys of apple diseases in Washington (Amiri & Ali 2016; Kim & Xiao 2008; Xiao & Kim 2008) did not detect this pathogen. This is possibly due to planting of resistant apple cultivars (Yoder 1990).

Known hosts of *P. arbutifolia* include *Pyrus* spp., *Malus* spp. and *Crataegus* spp. (hawthorn) (Farr & Rossman 2020). Apple blotch can cause damage to fruit, leaves, buds and stems of its host plants (Gardner 1923; McClintock 1930; Yoder 1990).

*Phyllosticta arbutifolia* overwinters as dormant mycelia in stem cankers or infected dormant buds, and as pycnosclerotia in cankers (Yoder 1990). Overwintered cankers are the likely main source of primary inoculum in spring. Primary infection occurs about two to three weeks after petal fall. Rain splash-dispersed conidia infect the current year's growth, and new infections appear in August; lesions also occur on leaves and fruit. Conidia (pycnidiospores) are produced in pycnidia (asexual spore-forming structures) each spring from cankers, leaves and fruit (Gardner 1923; Yoder 1990). Primary lesions on fruit and foliage are subsequently important inoculum sources for summer infections. Spores can germinate at temperatures between 5°C and 39°C (Gardner 1923). The sexual morph of the fungus (ascigerous stage producing ascocarps) has not been found but possibly occurs in spring within the overwintering mature pycnidia (pycnosclerotia), along with the asexual conidia (Yoder 1990). Apple blotch incidence and severity increase following heavy rains and extended wet periods, which promote the dissemination and germination of conidia (Yoder 1990).

In warm and wet weather, infection can occur throughout the growing season (Pierson, Ceponis & McColloch 1971). *Phyllosticta arbutifolia* can survive low temperature storage (Wikee et al. 2011) such as at 1°C to 2°C for at least 9 months on apple seedlings (CABI & EPPO 1997a).

The risk scenario of biosecurity concern for *P. arbutifolia* is that infected fruit with viable inoculum may enter Australia and result in the establishment and spread of this pest.

*Phyllosticta arbutifolia* has been assessed previously in the existing import policy for fresh apple fruit from China (Biosecurity Australia 2010a). In that policy the unrestricted risk estimate for *P. arbutifolia* was assessed as Low, thus not achieving the ALOP for Australia. Therefore, specific risk management measures are required for *P. arbutifolia* on the apples from China pathway.

The department assessed the likelihood of importation of *P. arbutifolia* on fresh apple fruit from China as Moderate (Biosecurity Australia 2010a). However, the differences in pest prevalence, climate and horticultural practices between export areas in different countries make it

necessary to re-assess the likelihood of importation of *P. arbutifolia* potentially associated with the PNW-USA apple pathway.

The previous assessment of *P. arbutifolia* on fresh apple fruit from China (Biosecurity Australia 2010a) rated the likelihood of distribution as Moderate. Fresh apple fruit from the PNW-USA are expected to be distributed in Australia, as a result of processing, sale or disposal, in a similar way to apples from China. Apples can be imported all year round, therefore, there would be no seasonal differences between both import pathways to contribute to variation in the risk rating for likelihood of distribution. Therefore, the same rating of Moderate for the likelihood of distribution for *P. arbutifolia* on the China apple pathway is adopted for the PNW-USA apple pathway.

The likelihoods of establishment and spread of *P. arbutifolia* in Australia from the PNW-USA apple pathway have also been assessed as similar to the previous assessments of Moderate and Moderate, respectively, for apple fruit from China. These likelihoods relate specifically to events that occur in Australia and are principally independent of the import pathway. The consequences of entry, establishment and spread for *P. arbutifolia* are also independent of the import pathway and have been assessed as similar to the existing assessment of Moderate for the apples from China pathway. Therefore, the existing ratings for the likelihoods of establishment and spread, and the rating for overall consequences for *P. arbutifolia* on the China apple pathway have been adopted for *P. arbutifolia* on the PNW-USA apple pathway.

The department has also reviewed the latest literature—for example, Bell et al. (2015); EFSA PLH Panel et al. (2018); Farr and Rossman (2020); Pscheidt and Ocamb (2021c) and Wikee et al. (2011). No new information has been identified that would significantly change the risk ratings for distribution, establishment, spread and consequences as set out for *P. arbutifolia* in the existing policy.

#### **4.22.1 Likelihood of entry**

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

##### **Likelihood of importation**

The likelihood that *P. arbutifolia* will arrive in Australia with the importation of apples from the PNW-USA is assessed as Low.

The following information provides supporting evidence for this assessment.

*Phyllosticta arbutifolia* is present in the PNW-USA at a low incidence.

- Apple blotch caused by *P. arbutifolia* was a major apple disease in the eastern United States in the early to mid-1900s, but has been rare in most commercial apple orchards since the 1990s, possibly due to the planting of resistant apple cultivars (Yoder 1990).
- The pathogen has been recorded in Washington (Farr & Rossman 2018), but there are no records of the pathogen in Oregon or Idaho.
- Apple blotch caused by *P. arbutifolia* is now considered a minor apple disease in the USA (Sutton et al. 2014; Yoder 1990).

- The pathogen is considered rare in the PNW-USA as surveys of apple diseases in Washington did not detect this pathogen (Amiri & Ali 2016; Kim & Xiao 2008; Xiao & Kim 2008).

Fruit infected by *P. arbutifolia* may be detected during harvest or post-harvest processing.

- Infections on fruit usually occur early in the season and symptoms appear by mid-summer (Pierson, Ceponis & McColloch 1971; Yoder 1990).
- Lesions on infected fruit gradually enlarge and develop fringed but distinct margins and lesions often crack as the fruit enlarges (Yoder 1990).
- Infected fruit with obvious symptoms are likely to be rejected during the harvesting and packing processes.
- Symptoms are, however, reduced on resistant cultivars such as Red and Golden Delicious and Jonathan (Yoder 1990). Infected fruit without obvious symptoms may be harvested and packed for export.

*Phyllosticta arbutifolia* may survive cold temperatures during storage and transport.

- Harvested apples are normally cold-stored at 0°C to 2°C (Good Fruit Grower 2014; Iowa State University Extension and Outreach 2008; Kupferman 1996; University of Maine 2020).
- Sea freight, which takes about five weeks, is likely to be the preferred method of transport of apples from the PNW-USA to Australia and fruit will be maintained at very low temperatures.
- *Phyllosticta arbutifolia* naturally overwinters in stem cankers or infected dormant buds in the PNW-USA in sub-zero temperatures.
- *Phyllosticta arbutifolia* can survive for long periods at the low temperatures used in cold storage and transportation (Wikee et al. 2011). It has been reported to survive at 1°C to 2°C for at least 9 months on apple seedlings (CABI & EPPO 1997a).

*Phyllosticta arbutifolia* is present in the PNW-USA at low levels of incidence. Infection of fruit normally occurs early in the season and visible symptoms generally appear by mid-summer, well before harvest. Fruit infected by *P. arbutifolia* will often be detected during harvest or post-harvest processing. However, symptoms may not be obvious on infected fruit of resistant cultivars and may be packed for export. *Phyllosticta arbutifolia* is likely to survive cold temperatures during storage in the PNW-USA and transport to Australia. For the reasons outlined, the likelihood estimate for importation of *P. arbutifolia* on the PNW-USA apple pathway is assessed as Low.

#### **Likelihood of distribution**

The likelihood that *P. arbutifolia* will be distributed within Australia in a viable state, as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host is considered to be similar to *P. arbutifolia* on apples from China.

Therefore, the same rating of Moderate for the likelihood of distribution previously assessed for *P. arbutifolia* on the apples from China pathway is adopted for *P. arbutifolia* on the apples from PNW-USA pathway.

### Overall likelihood of entry

The overall likelihood of entry is determined as Low by combining the assessed likelihood of importation of Low with the adopted likelihood of distribution of Moderate, using the matrix of rules in Table 2.2.

#### 4.22.2 Likelihoods of establishment and spread

The likelihoods of establishment and spread for *P. arbutifolia* are independent of the import pathway and are considered similar to those previously assessed for the apples from China pathway.

Based on the previous assessment for apples from China (Biosecurity Australia 2010a), the likelihoods of establishment and spread for *P. arbutifolia* are assessed as Moderate and Moderate, respectively.

#### 4.22.3 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2

The overall likelihood that *P. arbutifolia* will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as Low.

#### 4.22.4 Consequences

The potential consequences of the entry, establishment and spread of *P. arbutifolia* in Australia are similar to those in the previous assessment for *P. arbutifolia* on the apples from China pathway, which were assessed as Low (Biosecurity Australia 2010a). The overall consequences for *P. arbutifolia* on the apples from PNW-USA pathway are also assessed as Moderate.

#### 4.22.5 Unrestricted risk estimate

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

<b>Unrestricted risk estimate for <i>Phyllosticta arbutifolia</i></b>	
Overall likelihood of entry, establishment and spread	Low
Consequences	Moderate
Unrestricted risk	Low

The unrestricted risk estimate for *P. arbutifolia* on apples from the PNW-USA has been assessed as Low, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for *P. arbutifolia* on the PNW-USA apple pathway.

## 4.23 Sphaeropsis rot

### *Sphaeropsis pyriputrescens*

*Sphaeropsis pyriputrescens*, an ascomycete fungal pathogen belonging to the family [Botryosphaeriaceae](#), causes a post-harvest rot disease named Sphaeropsis rot in apple (Kim, Curry & Xiao 2014; Kim & Xiao 2008; PNW Handbooks 2020b; Sikdar et al. 2016; Sikdar et al. 2014; Xiao & Rogers 2004; Xiao 2006; Xiao 2015; Xiao & Kim 2013) and pear fruit in the PNW-USA (WSU 2005). The genus *Sphaeropsis* was identified as the anamorph of the genus *Phaeobotryosphaeria* (Phillips et al. 2008). *Sphaeropsis pyriputrescens* is a pycnidia-forming asexual morph (anamorph); a sexual morph (teleomorphic stage) of the species has not been reported (Xiao & Rogers 2004).

*Sphaeropsis pyriputrescens* is native to North America and was first described in 2004 (Xiao & Rogers 2004). The species has only been recorded from the USA and Canada (Stokes, Sholberg & O'Gorman 2007; Xiao & Rogers 2004; Xiao, Rogers & Boal 2004), but is widely distributed in Washington where it attacks apples (Xiao & Kim 2008), crabapples (Xiao & Boal 2005b) and pears (WSU 2005; Xiao & Kim 2008). The disease was detected in apple fruit from all 7 counties of central Washington State surveyed over a three-year period from 2003 to 2005 (Xiao 2007). No instances of *S. pyriputrescens* have been reported from the states of Oregon or Idaho.

*Sphaeropsis pyriputrescens* can infect twigs, branches and fruit of apples and crabapples (Xiao, Kim & Boal 2014). On apple fruit the fungus primarily infects the stem and calyx and causes stem-end rot and calyx-end rot, respectively, and in both instances infected fruit develop decayed brown rot areas in post-harvest situations (WSU 2005). Fruit decay caused by Sphaeropsis rot has a distinct unpleasant odour, particularly when the decayed flesh of the fruit is cut (WSU 2005; Xiao 2013b; Xiao & Kim 2013).

*Sphaeropsis pyriputrescens* has become a significant problem in apple orchards where Manchurian crabapple pollinisers are planted. Manchurian crabapple is very susceptible to infection, and conidia (pycnidiospores) released from pycnidia are a significant source of inoculum for apple fruit (PNW Handbooks 2020b). *Sphaeropsis pyriputrescens* infections result in mummified crabapple fruitlets hanging from trees (Xiao 2013b), each with fruiting bodies containing millions of spores (PNW Handbooks 2020b; WSU 2005; Xiao & Kim 2013). A survey of apples in commercial fruit packing houses in Washington State in 2003, 2004 and 2005, found that Sphaeropsis rot accounted for 18.4% of the total post-harvest decay recorded on the cultivars Red Delicious, Fuji and Golden Delicious (Xiao 2007).

Infection of apple fruit by *S. pyriputrescens* occurs in the orchard (WSU 2005), but remains asymptomatic prior to and at harvest, with subsequent development of fruit rot symptoms post-harvest (Sikdar et al. 2016; Sikdar et al. 2014; Wenneker & Thomma 2020). Fruit rot symptoms are commonly first observed one to two months after harvest, and incidence of Sphaeropsis rot can increase as the storage period is extended (Xiao, Kim & Boal 2014). Fruit-to-fruit spread of the rot under cold storage conditions at 1°C to 2°C has been observed (Kim & Xiao 2008). *Sphaeropsis pyriputrescens* can survive and overwinter, often as pycnidia, on infected dead tissues of apple and crabapple trees (WSU 2005; Xiao, Kim & Boal 2014). The fungus spreads through conidial dispersal by water (rain/irrigation) (PNW Handbooks 2020b; Sikdar et al. 2016; Xiao 2013b).

The risk scenario of biosecurity concern for *S. pyriputrescens* is that symptomless infected apple fruit carrying viable conidia in pycnidia may enter Australia, resulting in the establishment and spread of this pest.

#### 4.23.1 Likelihood of entry

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

##### Likelihood of importation

The likelihood that *S. pyriputrescens* will arrive in Australia with the importation of apples from the PNW-USA is assessed as High.

The following information provides supporting evidence for this assessment.

*Sphaeropsis pyriputrescens* is widely distributed in the state of Washington and is associated with apple fruit.

- *Sphaeropsis pyriputrescens* is widely distributed in Washington (Kim & Xiao 2008; Xiao 2015; Xiao & Kim 2008), which is the major apple producing state in the PNW-USA. There have been no records of *S. pyriputrescens* reported in the states of Oregon and Idaho.
- Apple packing house surveys in Washington over a period of three years (2003-2005) showed *Sphaeropsis* infection on fruit from 73% of the grower lots sampled (Xiao 2007). *Sphaeropsis pyriputrescens* accounted for 16.9% of decayed apple fruit during the surveys.
- *Sphaeropsis pyriputrescens* may infect apple fruit during the growing season (Xiao, Kim & Boal 2014) and remain asymptomatic in the fruit (Wenneker & Thomma 2020; Xiao, Kim & Boal 2011).
- Fruit of some common varieties, such as Red Delicious and Fuji apple seem to be particularly susceptible to the disease (Kim & Xiao 2008; Xiao 2007).
- Examination of naturally infected and inoculated twigs over a three-year period (2003-2005) showed viable pycnidia throughout the sampling periods, suggesting that pycnidia can survive for a long period of time under orchard conditions in north-central Washington State (Xiao, Kim & Boal 2014).

Crabapple trees in PNW-USA provide a source of inoculum for apple fruit infection.

- Crabapple trees, and particularly the Manchurian crabapple (*Malus baccata*), used as pollinisers in apple orchards, are highly susceptible to infection with *S. pyriputrescens* (WSU 2005; Xiao 2013b).
- In 2006, over 90% of sampled crabapple trees were infected by *S. pyriputrescens* in a commercial Fuji apple orchard in Washington State (Xiao 2007).
- Crabapple trees infected with *S. pyriputrescens* also develop pycnidia on cankers and mummified fruitlets hanging on the trees (Xiao 2013b). Pycnidia on crabapples contain millions of conidia that serve as inoculum for infection of apple fruit (PNW Handbooks 2020b; Xiao 2013b; Xiao & Kim 2013).

*Sphaeropsis pyriputrescens* infections are generally asymptomatic on mature apple fruit and are likely to go undetected during harvest. Fruit are normally washed, brushed and waxed and cold-stored in bins prior to being packed for export. Infected fruit develops rot during storage.

- Infected fruit are likely to be asymptomatic at the time of harvest and packing.

- Infected apples are processed and packed shortly after harvest prior to being cold-stored.
- Harvested apples are normally cold-stored at 0°C to 2°C (Good Fruit Grower 2014; Iowa State University Extension and Outreach 2008; Kupferman 1996; University of Maine 2020; Washington Apple Commission 2020) up to 11 months prior to export (Kupferman 1996).
- Symptoms become apparent after 1 to 2 months of cold storage (Sikdar, Willett & Mazzola 2018) and disease incidence commonly increases as the storage period extends up to about 5 to 6 months (Xiao, Kim & Boal 2014).
- Infected fruit that are cold-stored for a period of time before being packed are more likely to express visible symptoms and be removed during regulatory inspection prior to export.
- However, some asymptomatic infected fruit may be packed for export to Australia.

*Sphaeropsis pyriputrescens* may survive cold temperatures during storage in the PNW-USA and transport to Australia.

- *Sphaeropsis pyriputrescens* may survive storage and transport to Australia as it survives at cold storage temperatures and spreads from fruit-to-fruit under cold storage conditions at 1°C to 2°C temperatures (Kim & Xiao 2008).
- Sea freight, which takes about five weeks, is likely to be the preferred method of transport of apples from the PNW-USA to Australia and the fruit will be maintained at low temperatures to maintain fruit quality (Iowa State University Extension and Outreach 2008; University of Maine 2020; WSU Tree Fruit 2021c).

*Sphaeropsis pyriputrescens* is widely distributed in Washington apple orchards where it causes a post-harvest rot disease in apple fruit. Infected fruit are asymptomatic at harvest but symptoms begin to express after 1 to 2 months of cold storage. For cold-stored fruit some, but not all, infected fruit would be removed during packing house processes prior to export. *Sphaeropsis pyriputrescens* is likely to survive and grow at cold temperatures of 0°C to 2°C during storage and transport and carry inoculum on infected fruit to Australia. On the basis of these factors, the likelihood of importation of *S. pyriputrescens* on the PNW-USA apple pathway is assessed as High.

#### **Likelihood of distribution**

The likelihood that *S. pyriputrescens* will be distributed in Australia in a viable state, as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host, is assessed as Low.

The following information provides supporting evidence for this assessment.

It is likely that some apples from the PNW-USA infected with *S. pyriputrescens* will be distributed within Australia.

- Imported apple fruit are intended for human consumption in Australia. It is expected that when apple fruit arrives in Australia, they will be distributed throughout Australia for wholesale or retail sale. Major population centres are likely to receive most of the imported fruit.
- Symptoms of infection by *S. pyriputrescens* start to be apparent after 1 to 2 months of cold storage (Sikdar, Willett & Mazzola 2018) and disease incidence commonly increases as the storage period extends up to about 5 to 6 months (Xiao, Kim & Boal 2014).

- Apple consignments may not be processed or handled until they arrive at the retail points within Australia. Any fruit showing symptoms of *S. pyriputrescens* infection at this point are likely to be removed from further distribution and discarded into managed waste systems. Commercial waste of imported apple fruit may also be generated prior to or during retail sale and discarded in the same way. Potential exposure to suitable host plants from waste discarded into managed waste systems is likely to be negligible.
- However, some fruit infected with *S. pyriputrescens* may not display symptoms and therefore may be sold to consumers.
- *Sphaeropsis pyriputrescens* can survive and overwinter, often as pycnidia (WSU 2005; Xiao, Kim & Boal 2014). It is likely that *S. pyriputrescens* in infected fruit will survive temperatures during cold storage and transport used during distribution of fruit within Australia.
- Pycnidia can form on the surface of decaying fruit (Xiao, Rogers & Boal 2004), and conidia from the pycnidia may provide a source of inoculum (WSU 2005) after disposal of fruit or fruit waste.
- Some apple waste infected with *S. pyriputrescens* may be discarded into the Australian environment.

Known hosts of *S. pyriputrescens* are available in various parts of Australia.

- Known plant host species of *S. pyriputrescens* are limited, however, hosts such as *Malus* spp. (apple and crabapple) and *Pyrus communis* (pear) (Kim & Xiao 2008; Xiao & Boal 2005b; Xiao & Rogers 2004; Xiao 2006) are present in high numbers in commercial orchard districts, and common in suburban and rural areas.

*Sphaeropsis pyriputrescens* is likely to produce only a limited amount of inoculum (conidia) on discarded fruit waste.

- Further development of *S. pyriputrescens* on infected and discarded fruit is likely to be restricted due to colonisation by and competition with saprophytic fungi or bacteria.
- Colonisation by saprophytes is likely to speed up disintegration of discarded fruit/fruit cores, and thus further limit production and spread of inoculum of *S. pyriputrescens*.
- The fungus does not grow at or above 30°C (Narayanasamy 2011), therefore the inoculum production of *S. pyriputrescens* on discarded fruit may not be supported in hot and dry climates. Dispersal of conidia of *S. pyriputrescens* to a nearby host from fruit waste discarded on the ground is likely to be restricted, particularly during hot and dry conditions, but is possible under favourable Australian conditions.
- Fungal conidia are dispersed by water splash (rain/irrigation) (PNW Handbooks 2020b; Sikdar et al. 2016; Xiao 2013b). Intermittent rains may provide the best dispersal mechanism (Coventry 2011).
- Many regions of Australia have hot and dry summers with maximum temperatures over 30°C for periods of weeks to months (Bureau of Meteorology 2018). Dispersal of conidia of *S. pyriputrescens* from fruit waste discarded during hot and dry conditions to a nearby host is likely to be restricted.
- During the remainder of the year the climate in some Australian regions could support conidial dispersal.

*Sphaeropsis pyriputrescens* has the ability to persist for long periods and survive low temperatures during storage and transportation in Australia. Some infected fruit waste may be discarded into the Australian environment. Hosts of *S. pyriputrescens* are widely distributed in various parts of Australia. Inoculum production on fruit waste discarded during hot and dry

conditions is likely to be restricted. Inoculum production may also be restricted due to colonisation of discarded fruit waste by saprophytic fungi or bacteria. Conidial dispersal is also likely to be restricted if infected fruit waste is discarded into the Australian environment during hot and dry conditions. For the reasons outlined, the likelihood of distribution for *S. pyriputrescens* on apples from the PNW-USA is assessed as Low.

### Overall likelihood of entry

The overall likelihood of entry is determined by combining the likelihoods of importation and distribution using the matrix of rules shown in Table 2.2.

The likelihood that *S. pyriputrescens* will enter Australia as a result of trade in the commodity and be distributed in a viable state to a susceptible host is assessed as Low.

#### 4.23.2 Likelihood of establishment

The likelihood that *S. pyriputrescens* will establish within Australia, based on a comparison of factors in the source and destination areas that affect pest survival and reproduction, is assessed as Moderate.

The following information provides supporting evidence for this assessment.

Known hosts of *Sphaeropsis pyriputrescens* are widely present within Australia and climatic conditions in regions where hosts are present are likely to be suitable for the establishment of *S. pyriputrescens*.

- Plant hosts of *S. pyriputrescens* (apple, pears and crabapple) (Kim & Xiao 2008; Xiao & Boal 2005b; Xiao & Rogers 2004; Xiao 2006) are widely present within Australia in commercial orchard districts and suburban and rural areas.
- *Sphaeropsis pyriputrescens* can survive and grow over a wide range of temperatures. Under experimental conditions, mycelia of the fungus can grow at temperatures from  $-3^{\circ}\text{C}$  to  $25^{\circ}\text{C}$  (Kim, Xiao & Rogers 2005), indicating suitable conditions for establishment of the fungus will be available in various parts of Australia.
- Conidia of *S. pyriputrescens* germinate over a wide temperature range from  $0^{\circ}\text{C}$  to  $30^{\circ}\text{C}$  (Narayanasamy 2011; WSU 2005), but require a minimum period of 4 to 8 hours of moisture to produce germ tubes at optimum temperature (Xiao 2015). *Sphaeropsis pyriputrescens* requires 20 to 24 hours of dampness to reach germination peaks.
- Some regions of southern Australia are considered to have climates similar to the PNW-USA for most of the year; these conditions are likely to favour survival and establishment of *S. pyriputrescens*.
- *S. pyriputrescens* is unlikely to be able to establish in parts of Australia during the hot, dry summer conditions as the fungus does not grow at or above  $30^{\circ}\text{C}$  (Kim, Xiao & Rogers 2005; Narayanasamy 2011; Xiao & Boal 2005b).
- The overwintering and survival properties of pycnidia of *S. pyriputrescens* on dead and living tissues of hosts may allow the pathogen to survive and re-grow when favourable conditions are available in Australia.

Known hosts of *S. pyriputrescens* are limited to apples, crabapples and pears, however, these hosts are widely present within Australia. The cooler optimal temperatures and dampness durations required for successful conidial germination and mycelial growth exist in many regions of Australia. Suitable conditions will enable the fungus to successfully establish after

being distributed to suitable hosts in a viable state. Successful establishment is likely to be limited during the hot, dry Australian summer. The ability of the pathogen to survive on both live and dead tissues of its hosts by forming pycnidia will allow the pathogen to persist and initiate subsequent cycles of infection.

For the reasons outlined, the likelihood of *S. pyriputrescens* establishing in Australia from imported apples from the PNW-USA is rated as Moderate.

#### 4.23.3 Likelihood of spread

The likelihood that *S. pyriputrescens* will spread within Australia, based on a comparison of factors in the source and destination areas that affect the expansion of the geographic distribution of the pest, is assessed as Moderate.

The following information provides supporting evidence for this assessment.

It is likely that *S. pyriputrescens* would be able to spread between susceptible hosts in Australia, once established.

- *Sphaeropsis pyriputrescens* has a limited number of host species such as apple, crabapple and pear (Kim & Xiao 2008; Xiao & Boal 2005b; Xiao & Rogers 2004; Xiao 2006), however these hosts are common in Australia in commercial orchard districts and suburban and rural areas.
- Pycnidia and conidia may provide adequate sources of inoculum (WSU 2005) for spread. Suitable climates for the spread of *S. pyriputrescens* exist in Australia.
- Climates suitable for *S. pyriputrescens* exist in many parts of temperate southeastern and southwestern Australia, where host plants are present.
- Hot, dry climatic conditions in some parts of Australia during summer, with regular maximum temperatures of over 30°C for periods of weeks to months, are unlikely to be conducive for the spread of the pathogen.

Natural dispersal of the pathogen over short distances is by movement of conidia.

- Pycnidia and conidia provide an important source of inoculum in orchards (Xiao 2007) once the pathogen is established.
- Natural dispersal of the pathogen is mainly through conidial spread from one host to another by water splash (rain/irrigation). Dampness also creates conditions conducive for fruit infection (PNW Handbooks 2020b; Sikdar et al. 2016; Xiao 2013b).

Long distance spread of *S. pyriputrescens* is likely to occur by human-assisted activities.

- Domestic trade of apple fruit and planting materials may aid the long distance spread of *S. pyriputrescens*.

Hosts of *S. pyriputrescens*, such as apples, pears and crabapples, are widely present in Australia. Most apple and pear production regions within Australia possess optimal conditions for growth and spread of this fungus over most of the year. *Sphaeropsis pyriputrescens* may also spread within Australia as a result of domestic movement of fruit and planting materials.

For the reasons outlined, the likelihood of spread of *S. pyriputrescens* within Australia is rated as Moderate.

#### 4.23.4 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules for combining qualitative likelihood shown in Table 2.2.

The overall likelihood that *S. pyriputrescens* will enter Australia as a result of trade of apples from the PNW-USA, be distributed in a viable state to a susceptible host, establish in the area and subsequently spread within Australia is assessed as Low.

#### 4.23.5 Consequences

The potential consequences of the entry, establishment and spread of *S. pyriputrescens* in Australia have been estimated according to the methods described in Table 2.3.

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

The reasoning for these ratings is provided below:

Criterion	Estimate and rationale
<b>Direct</b>	
Plant life or health	<p>E - Significant at the regional level:</p> <p><i>Sphaeropsis pyriputrescens</i> causes fruit decay of apple and pear in storage (Xiao &amp; Rogers 2004; Xiao, Rogers &amp; Boal 2004). It also causes twig dieback and cankers on apple and crabapple trees (Xiao &amp; Boal 2005b; Xiao 2015).</p> <p><i>Sphaeropsis pyriputrescens</i> 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 3-year period (2003–2005) in central Washington State (Kim &amp; Xiao 2008).</p> <p>One grower lot in Washington in 2003 reported 24% of Red Delicious apples were infected by <i>Sphaeropsis pyriputrescens</i> after 9 months of storage in controlled atmosphere. Another grower lot reported 15–20% of fruit were infected after 10 months of storage (Kim &amp; Xiao 2008).</p> <p>Orchard hygiene and chemical application practices already applied in Australia in apple production areas may mitigate the consequences of the pest.</p>
Other aspects of the environment	<p>A - Indiscernible at the local level:</p> <p>There are no known direct consequences of this pathogen on other aspects of the environment.</p>
<b>Indirect</b>	
Eradication, control etc.	<p>E - Significant at the regional level:</p> <p>Recommended cultural measures for the control of <i>S. pyriputrescens</i> include removal of cankers and twigs with dieback symptoms (WSU 2005). Research on the effectiveness of various fungicides in controlling <i>S. pyriputrescens</i> has been extensive (Xiao 2007; Xiao 2015). High pressure washing and chlorine dipping at 100ppm or more are standard procedures in packing houses in the USA (Washington State University 2018b). This can be effective in removing surface contamination by fungal spores (Brown 2002; Kupferman 1984; Suslow 2004).</p> <p>Implementation of these control measures would result in an increase in costs of production. Additionally, costs for crop monitoring and consultant's advice to manage the pest may be incurred by the producer.</p>

Criterion	Estimate and rationale
Domestic trade	E - Significant at the regional level: The presence of <i>S. pyriputrescens</i> in commercial production areas could result in the implementation of interstate quarantine measures, potentially causing loss of markets and subsequent industry adjustment.
International trade	E - Significant at the regional level: Australia exports around 5,000 tonnes of apples per year. The presence of <i>S. pyriputrescens</i> in commercial production areas of apple and pear would have a significant effect at the regional level due to potential limitations on accessing international markets where this pathogen is absent. To date, <i>S. pyriputrescens</i> has only been recorded from the USA and Canada (Stokes, Sholberg & O'Gorman 2007; Xiao & Rogers 2004; Xiao, Rogers & Boal 2004). The presence of <i>S. pyriputrescens</i> in Australia would likely have a significant effect at the regional level due to potential limitations of accessing international markets where this pathogen is not present.
Non-commercial and environmental	B - Minor significance at the local level: Additional fungicide applications or other control activities would likely be required to control this disease. Any additional fungicide usage may affect the environment.

#### 4.23.6 Unrestricted risk estimate

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

<b>Unrestricted risk estimate for <i>Sphaeropsis pyriputrescens</i></b>	
Overall likelihood of entry, establishment and spread	Low
Consequences	Moderate
Unrestricted risk	Low

As indicated, the unrestricted risk estimate for *S. pyriputrescens* on apples from the PNW-USA is assessed as Low, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for this pest on the PNW-USA apple pathway.

## 4.24 *Truncatella* leaf spot

### *Truncatella hartigii* (EP)

*Truncatella hartigii* (synonym: *Pestalotia hartigii*) is an ascomycete fungal pathogen belonging to the family Amphisphaeriaceae.

*Truncatella hartigii* has a wide host range across diverse plant families including Asteraceae (for example, genus *Lactuca*), Fagaceae (*Fagus* sp.), Oleaceae (*Fraxinus* sp., *Olea* sp.), Pinaceae (*Abies* sp., *Picea* sp., *Pinus* sp., *Pseudotsuga* sp.), Restionaceae (*Cannomois* sp., *Rhodocoma* sp.) and Rosaceae (*Malus* sp., *Pyrus* sp.) (Cooke 1906; Farr & Rossman 2020; Lee, Crous & Wingfield 2006; Spaulding 1956; Vujanovic, St-Arnaud & Neumann 2000). *Truncatella hartigii* has been recorded from Asia, Europe, South Africa and North America (Farr & Rossman 2020) and has also been reported to cause leaf spot and post-harvest fruit rot of apple in India (Chaudhary, Puttoo & Ashraf 1987; Fatima 2019). Collection records of *T. hartigii* on apple in the PNW-USA are very old (Heald & Ruehle 1931; Zeller 1929).

More recent literature (Pscheidt & Ocamb 2021c) does not list this fungus as one of the pathogens of concern on apple fruit in the PNW-USA. It was reported earlier under fungi causing miscellaneous rots rarely found in the PNW-USA (Pierson, Ceponis & McColloch 1971; Rosenberger 1990b; Shaw 1973), but the authors did not specify collection events, indicating that the reports may have been based on older literature. APHIS (2009) has claimed that *T. hartigii* has not been recorded on apples in PNW-USA in recent decades. Recent surveys of post-harvest pathogens of apples in the PNW-USA did not detect *T. hartigii* (Amiri & Ali 2016; Kim & Xiao 2008). This information suggests that *T. hartigii*, if still present in the PNW-USA, is likely to be of low prevalence, be rare on apples and, not cause economic concern in the region.

In India, apple leaf spots caused by *T. hartigii* are irregular, large and greyish-white with brown margins on both sides of the infected leaf. Numerous fungal fructifications that are dark, scattered, discoid and sub-epidermal are visible on the leaf spot (Chaudhary, Puttoo & Ashraf 1987). On infected apple fruit, brown lesions gradually develop during cold storage (Agarwala & Sharma 1968). Shrivelling of fruits is also a common symptom (Fatima 2019). *Truncatella hartigii* can cause seed rots and can be seed-borne (Chaudhary, Puttoo & Ashraf 1987). *Truncatella hartigii* was also frequently associated with necrotic lesions on cones/seeds of pine (*Pinus* spp.) (Vujanovic, St-Arnaud & Neumann 2000).

Conidia produced in pycnidia or acervuli initiate infections as reported in the genus *Pinus* (Ivanová 2016). Pycnidia can be seen as brown or black masses on lesions (Ivanová 2016). This pathogen may produce large numbers of conidia, which are dry spores easily dispersed by air or by water splash (Ivanová 2016) that initiate infection leading to production of hyphae that colonise fruit internally including the seed. However, apart from laboratory studies by Chaudhary, Puttoo & Ashraf (1987) reporting isolation of *T. hartigii* from decaying apple seeds and leaves of apple seedlings, there is no other evidence for this pathogen being seed-borne on apple.

The risk scenario of biosecurity concern for *T. hartigii* is that conidia may be present on apple fruit or the fruit or seeds may be internally colonised enabling symptomless infected fruit to enter Australia and result in establishment and spread of the pathogen.

*Truncatella hartigii* has been assessed previously in the existing import policy for fresh apple fruit from the People's Republic of China (Biosecurity Australia 2010a). In that policy, the unrestricted risk estimate was assessed as Negligible, which achieves the ALOP for Australia. Therefore, no specific risk mitigation measures are required for *T. hartigii* on the fresh apples from China pathway.

The department assessed the likelihood of importation of *T. hartigii* on fresh apple fruit from China as Very Low (Biosecurity Australia 2010a), largely due to the absence of any records of *T. hartigii* on apples in China. However, the differences in pest prevalence, climate and horticultural practices between the export areas make it necessary to re-assess the likelihood of importation of *T. hartigii* associated with the PNW-USA apple pathway.

Previous assessment of *T. hartigii* on apples from China rated the likelihood of distribution as High. Apples from the PNW-USA are expected to be distributed in Australia, as a result of processing, sale or disposal, in a similar way to apples from China. Apples can be imported all year round, therefore, there would be no seasonal differences between both import pathways to contribute to variation in the risk rating for likelihood of distribution. *Truncatella hartigii* can be seed-borne (Chaudhary, Puttoo & Ashraf 1987), therefore, discarded apple cores may give rise to infected seedlings. Fruit infected with *T. hartigii* may be discarded in the natural environment, including near a suitable host. Therefore, the same rating of High for the likelihood of distribution for *T. hartigii* on the China apple pathway is adopted for *T. hartigii* on the PNW-USA apple pathway.

The likelihoods of establishment and spread of *T. hartigii* in Australia from the PNW-USA apple pathway have also been assessed as similar to the previous assessments of High and High, respectively, for apples from the People's Republic of China. These likelihoods relate specifically to events that occur in Australia and are principally independent of the import pathway. The consequences of entry, establishment and spread for *T. hartigii* are also independent of the import pathway and have been assessed as similar to the existing assessment of Low for the apples from China pathway. Therefore, the ratings for likelihoods of establishment and spread, and the rating for overall consequences for *T. hartigii* on the China apple pathway have been adopted for *T. hartigii* on the PNW-USA apple pathway.

The department has also reviewed the latest literature—for example, Farr and Rossman (2020); Fatima (2019); Ivanová (2016) and Pusz et al. (2015). No new information has been identified that would significantly change the risk ratings for distribution, establishment, spread or consequences as set out for *T. hartigii* in the existing policy.

#### **4.24.1 Likelihood of entry**

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

##### **Likelihood of importation with apple fruit from the PNW-USA**

The likelihood that *T. hartigii* will arrive in Australia with the importation of apples from PNW-USA is assessed as Low.

The following information provides supporting evidence for this assessment.

*Truncatella hartigii* is likely to be present in the PNW-USA at low prevalence and is unlikely to be associated with commercially produced apple fruit.

- There are old records of *T. hartigii* on apples in the PNW-USA (Heald & Ruehle 1931; Zeller 1929).
- Early literature (Pierson, Ceponis & McColloch 1971; Rosenberger 1990b; Shaw 1973) listed this fungus as one of the rarely found pathogens causing miscellaneous apple fruit storage rots in the PNW-USA but did not mention specific collection events. The listings may have been based on older literature.
- *Truncatella hartigii* is one of several miscellaneous post-harvest fungi that can cause post-harvest rots of minor importance in apples (Kim & Xiao 2008; Pierson, Ceponis & McColloch 1971; Washington State University Extension 2020; Xiao & Kim 2008). *Truncatella hartigii* causes infection in the field that is asymptomatic and later develops as a storage rot (Pierson, Ceponis & McColloch 1971; Rosenberger 1990b; Shaw 1973). *Truncatella hartigii* is rarely found on apples from commercial orchards under cold storage (Rosenberger 1990b).
- More recent literature does not list this fungus as one of the pathogens of concern on apple fruit in the PNW-USA (Amiri & Ali 2016; Pscheidt & Ocamb 2021c; WSU 2009).
- Surveys of post-harvest pathogens of apples in the PNW-USA from 2003-2005 did not detect *T. hartigii* (Kim & Xiao 2008). More recent surveys, including a state-wide survey in Washington in 2015, did not detect this pathogen (Amiri & Ali 2016).
- APHIS (2009) claimed that *T. hartigii* has not been recorded on apples in PNW-USA in recent decades. The absence of recent reports suggests that this pathogen, if present, is rare on commercially produced apples in the PNW-USA.

Fruit showing symptoms at the time of packing are likely to be rejected, however, fruit infected with *T. hartigii* that have no symptoms may be harvested and packed for export.

- *Truncatella hartigii* is a fungus that causes post-harvest fruit rot of apple (Chaudhary, Puttoo & Ashraf 1987; Fatima 2019). On apple fruit, brown lesions develop gradually during cold storage (Fatima 2019).
- Harvested apples are normally cold-stored at 0° to 2°C (Good Fruit Grower 2014; Iowa State University Extension and Outreach 2008; Kupferman 1996; University of Maine 2020; Washington Apple Commission 2020) prior to export. Storage period may vary from 1 day to more than 11 months (Kupferman 1996).
- Fruit that are cold-stored for a period of time are likely to express visible symptoms and not be packed for export.
- However, infected apples that are packed shortly after harvest are likely to be symptomless or exhibit only mild symptoms, and may be packed for export.

*Truncatella hartigii* may survive cold temperatures during storage in the PNW-USA and transport to Australia.

- *Truncatella hartigii* may survive storage and transport to Australia as it grows slowly at 0°C (Pierson, Ceponis & McColloch 1971).
- Sea freight, which takes about five weeks, is likely to be the preferred method of transport of apples from the PNW-USA to Australia and the fruit will be maintained at low temperatures to maintain fruit quality (Iowa State University Extension and Outreach 2008; University of Maine 2020; WSU Tree Fruit 2021c).

Infections of fruit are usually asymptomatic at harvest, and gradually develop during cold storage. Symptomless infected fruit may be harvested and packed for export. *Truncatella hartigii* may survive cold temperatures during storage in the PNW-USA and transport to Australia. However, the association of *T. hartigii* with commercially grown apples in the PNW-USA is rare, and there have been no reports of *T. hartigii* on apples in the PNW-USA for many decades. For the reasons outlined, the likelihood of importation of *T. hartigii* on imported apples sourced from the PNW-USA apple pathway is assessed as Low.

#### **Likelihood of distribution**

The likelihood that *T. hartigii* will be distributed within Australia in a viable state, as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to a susceptible part of a host is considered to be similar to *T. hartigii* on apples from China.

Therefore, the same rating of High for the likelihood of distribution previously assessed for *T. hartigii* on apples from China pathway is adopted for *T. hartigii* on the apples from PNW-USA pathway.

#### **Overall likelihood of entry**

The overall likelihood of entry is determined as Low by combining the assessed likelihood of importation of Low with the adopted likelihood of distribution of High, using the matrix of rules in Table 2.2.

#### **4.24.2 Likelihoods of establishment and spread**

The likelihoods of establishment and spread for *T. hartigii* are independent of the import pathway and are considered similar to those previously assessed for the apples from China pathway.

Based on the previous assessment for apples from China (Biosecurity Australia 2010a), the likelihoods of establishment and spread for *T. hartigii* are assessed as High and High, respectively.

#### **4.24.3 Overall likelihood of entry, establishment and spread**

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that *T. hartigii* will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as Low.

#### **4.24.4 Consequences**

The potential consequences of the entry, establishment and spread of *T. hartigii* in Australia are similar to those in the previous assessment for *T. hartigii* on the apples from China pathway, which were assessed as Low (Biosecurity Australia 2010a). The overall consequences for *T. hartigii* on the apples from PNW-USA pathway are also assessed as Low.

#### 4.24.5 Unrestricted risk estimate

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

<b>Unrestricted risk estimate for <i>Truncatella hartigii</i></b>	
Overall likelihood of entry, establishment and spread	Low
Consequences	Low
Unrestricted risk	Very Low

The unrestricted risk estimate for *T. hartigii* on apples from the PNW-USA has been assessed as Very Low, which achieves the ALOP for Australia. Therefore, no specific risk management measures are required for *T. hartigii* on the PNW-USA apple pathway.

## 4.25 Apple scar skin

### **Apple scar skin viroid (EP)**

Apple scar skin and 'dapple apple' are diseases caused by *Apple scar skin viroid* (ASSVd). *Apple scar skin viroid* is a small circular nucleic acid molecule, which is a member of the genus *Apscaviroid* in the family *Pospiviroidae* (Di Serio et al. 2014).

*Apple scar skin viroid* is found in Asia (China, India, Iran, Japan, Republic of Korea and Turkey), Europe (UK and Greece) and the Americas (Argentina, Canada and the United States) (EFSA PLH Panel et al. 2019; Hadidi et al. 2017; Koganezawa et al. 2003). Apple scar skin and 'dapple apple' have been listed as diseases of apple in the PNW-USA (Pscheidt & Ocamb 2021b), but the incidences of disease are relatively rare (Koganezawa et al. 2003). The form in which the disease presents is dependent on the variant of ASSVd and/or apple cultivar (EFSA PLH Panel et al. 2019). Some commonly grown cultivars in the PNW-USA, such as Golden Delicious, Granny Smith and Pink Lady, are tolerant to ASSVd (Desvignes et al. 1999; di Serio et al. 2001). The main recommended management measures in the PNW-USA are use of disease-free planting materials (including scions), and use of clean pruning and cutting tools (Pscheidt & Ocamb 2021b).

*Apple scar skin viroid* is known to naturally infect apple, wild apple, pear, wild pear, apricot, peach, sweet cherry and wild cherry. Under experimental grafting conditions, it can also infect species of *Chaenomeles*, *Cydonia*, *Pyronia* and *Sorbus* (Koganezawa et al. 2003; Zhao & Niu 2008). *Apple scar skin viroid* spreads systemically through host plants (Koganezawa et al. 2003). In apple hosts, ASSVd has been found in fruit, seed, anthers, petals, receptacles, leaves, bark and roots (Hadidi et al. 1991; Kim et al. 2006). *Apple scar skin viroid* is seed-borne in apple, but viroid transmission from apple seeds to seedlings has not been commonly reported (Desvignes et al. 1999), with the exception of a report that seedlings germinated from ASSVd-infected apple seeds had a 7.7% infection rate (Kim et al. 2006). *Apple scar skin viroid* is not known to be pollen-transmitted (EFSA PLH Panel et al. 2019) but is known to be spread by grafting and budding, infected rootstocks, and contaminated equipment (Grove et al. 2003; Hadidi et al. 1991). Natural slow spread of ASSVd between trees may occur, with horizontal transmission by root-to-root contact as the proposed mechanism by (Desvignes et al. 1999). Under experimental conditions, it has been shown that ASSVd can be transmitted to herbaceous plant species such as bean and cucumber by the greenhouse whitefly *Trialeurodes vaporariorum* (Koganezawa et al. 2003; Kyriakopoulou & Hadidi 1998; Walia et al. 2015). However, there are no data reported regarding insect vector transmission of ASSVd in nature (Pscheidt & Ocamb 2021b; Walia et al. 2015).

The symptoms of disease are usually restricted to the fruit in most apple varieties (Koganezawa et al. 2003). Affected apples bear small circular spots near the calyx (Koganezawa et al. 2003). As the fruit mature, the spots enlarge and increasingly contrast with the darkening background of the skin. Larger spots may coalesce to form a broad band of dappling. In cases of more severe disease the circular patches become brown and necrotic, and fissures appear on the fruit (Koganezawa et al. 2003); infected fruit thus become unmarketable (Pscheidt & Ocamb 2021b). Some apple cultivars may also develop leaf roll or leaf epinasty symptoms under certain conditions (Koganezawa et al. 2003). Trees of tolerant apple cultivars may not express symptoms for some years after infection by the viroid (Desvignes et al. 1999; Kwon et al. 2002) and may continue to produce asymptomatic fruit.

The risk scenario of biosecurity concern for ASSVd is that symptomless infected fruit may enter Australia and result in the establishment and spread of this viroid.

*Apple scar skin viroid* has been assessed previously in the existing import policies for fresh apple fruit from the People's Republic of China (Biosecurity Australia 2010a) and pears from the People's Republic of China (Biosecurity Australia 2005). In the policy for apples from China, the unrestricted risk estimate for ASSVd was assessed as Very Low, which achieves the ALOP for Australia.

The department assessed the likelihood of importation of ASSVd on fresh apple fruit from China as Moderate (Biosecurity Australia 2010a). However, differences in pest prevalence, climate and horticultural practices between export areas make it necessary to re-assess the likelihood of importation of ASSVd associated with the PNW-USA apple pathway.

Previous assessment of ASSVd on the fresh apple fruit from China pathway rated the likelihood of distribution as High. Apples from the PNW-USA are expected to be distributed in Australia, as a result of the processing, sale or disposal, in a similar way to apples from China. Apples can be imported all year round, therefore, there would be no seasonal differences between both import pathways to contribute to variation in the risk rating for likelihood of distribution. It is expected that once the apple fruit have arrived in Australia, they will be distributed throughout Australia for wholesale or retail sale. Imported apple fruit are intended for human consumption. Apple cores are usually not consumed, and are discarded complete with seed. Some apple cores with viable infected seed may be discarded into the environment where ASSVd host plants could be available. Some of the ASSVd-infected seed may grow into apple seedlings that are infected by ASSVd (Kim et al. 2006). Therefore, the same rating of High for the likelihood of distribution for ASSVd on the apples from China pathway is adopted for the PNW-USA apple pathway.

The likelihoods of establishment and spread of ASSVd in Australia from the PNW-USA apple pathway will be similar to those of previous assessments of Moderate and Low, respectively, for apple fruit from China. These likelihoods relate specifically to events that occur in Australia and are principally independent of the import pathway. The consequences of entry, establishment and spread for ASSVd are also independent of the import pathway and have been assessed as similar to the existing assessment of Moderate for the apples from China pathway. On these bases, the ratings for likelihoods of establishment and spread, and the rating for the overall consequences of ASSVd on the China apple pathway have been adopted for ASSVd on the PNW-USA apple pathway.

The department has also reviewed the latest literature—for example, EFSA PLH Panel et al. (2019); Hadidi et al. (2011); Hadidi et al. (2017); Pscheidt and Ocamb (2021b); Walia et al. (2014) and Walia et al. (2015). No new information has been identified that would significantly change the risk ratings for distribution, establishment, spread and consequences.

#### **4.25.1 Likelihood of entry**

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

### Likelihood of importation with apple fruit from the PNW-USA

The likelihood that ASSVd will arrive in Australia with imported apples from the PNW-USA is assessed as Moderate.

The following information provides supporting evidence for this assessment.

*Apple scar skin viroid* is present and associated with apple production in the PNW-USA.

- *Apple scar skin viroid* is present in Washington and has been listed as a disease of apple in the PNW-USA (Grove et al. 2003; Hadidi et al. 1991; Pscheidt & Ocamb 2021b). The incidence and presence of apple scar skin and dapple apple disease in the PNW-USA is, however, low (Agrios 1989; Koganezawa et al. 2003) or rare (Pscheidt & Ocamb 2021b).
- ASSVd spreads systemically through apple trees and is likely to be present in fruit and seeds from ASSVd-infected trees (Hadidi et al. 1991).

Fruit symptomatically infected with ASSVd are likely to be detected during harvesting and post-harvesting processes.

- Depending on the sequence variant of ASSVd and/or apple cultivar, infected fruit may show scar skin or dapple apple disease symptoms (EFSA PLH Panel et al. 2019). Affected apple fruit bear small circular spots near the calyx end, and as the fruit mature, the spots enlarge and increasingly contrast with the darker background of the skin. Larger spots may coalesce to form a broad band of dappling. In the case of the more severe scar skin, the circular patches become brown and necrotic, and fissures appear on the fruit. The infected fruit thus become unmarketable.
- In susceptible apple cultivars such as Red Delicious, which is the most common apple cultivar in PNW-USA, symptoms are usually present at the calyx end of the fruit, and include skin scarring, cracking and dappling. Infected fruit may remain small and hard and may develop an unpleasant flavour (CABI 2022).
- Almost all fruit on ASSVd-infected trees of susceptible cultivars will show symptoms and be unmarketable (Koganezawa et al. 2003). Infected fruit from susceptible cultivars are likely to be removed during harvesting, grading and packing processes.
- Some apple varieties, such as Fuji and Gala, are slightly sensitive and can produce both asymptomatic and symptomatic fruit (Desvignes et al. 1999; di Serio et al. 2001).

Fruit infected with ASSVd with no or mild symptoms may not be detected during harvest and post-harvest processes.

- Some apple varieties are tolerant of ASSVd, and may carry the viroid but show no symptoms (Koganezawa et al. 2003).
- Commonly grown cultivars in the PNW-USA, including Golden Delicious, Granny Smith and Pink Lady, are tolerant to ASSVd (Desvignes et al. 1999; di Serio et al. 2001). Trees of tolerant apple cultivars may not express symptoms for some years after infection by the viroid (Desvignes et al. 1999; Kwon et al. 2002) and may continue to produce asymptotically-infected fruit.
- Symptomless fruit infected with the viroid are not likely to be detected during harvesting, grading and packing processes, and may be exported to Australia.

*Apple scar skin viroid* may survive cold temperatures during storage in the PNW-USA and transport to Australia.

- Harvested apples are normally cold-stored and transported at 0°C to 2°C (WSU Tree Fruit 2021c).
- ASSVd in infected apple fruit may survive cold temperatures during storage and transport, based on knowledge that it survives in infected apple trees at sub-zero temperatures in the PNW-USA.

*Apple scar skin viroid* is present in the PNW-USA, but apple scar skin or dapple apple disease is not common in PNW-USA. Some apple cultivars grown in the PNW-USA are susceptible to ASSVd and infected fruit display visible disease symptoms. However, some apple cultivars are tolerant to ASSVd and infected fruit may not show symptoms. Symptomatic fruit are likely to be removed during harvest or packing house processes. However, infected fruit with no or mild symptoms may be harvested and packed for export to Australia. For the reasons outlined, the likelihood estimate for importation of ASSVd on the PNW-USA apple pathway is assessed as Moderate.

#### **Likelihood of distribution**

The likelihood that ASSVd will be distributed within Australia in a viable state, as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to susceptible part of a host is considered to be similar to ASSVd on apples from China.

Therefore, the same rating of High for the likelihood of distribution previously assessed for ASSVd on the apples from China pathway is adopted for ASSVd on the apples from PNW-USA pathway.

#### **Overall likelihood of entry**

The overall likelihood of entry is determined as Moderate by combining the assessed likelihood of importation of Moderate with the adopted likelihood of distribution of High, using the matrix of rules in Table 2.2.

#### **4.25.2 Likelihoods of establishment and spread**

The likelihoods of establishment and spread for ASSVd are independent of the import pathway and are considered similar to those previously assessed for the apples from China pathway.

Based on the previous assessment for apples from China (Biosecurity Australia 2010a), the likelihoods of establishment and spread for ASSVd are assessed as Moderate and Low, respectively.

#### **4.25.3 Overall likelihood of entry, establishment and spread**

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that ASSVd will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as Very Low.

#### 4.25.4 Consequences

The potential consequences of the entry, establishment and spread of ASSVd in Australia are similar to those in the previous assessment for ASSVd on the apples from China pathway, which were assessed as Moderate (Biosecurity Australia 2010a). The overall consequences for ASSVd on apples from the PNW-USA pathway are also assessed as Moderate.

#### 4.25.5 Unrestricted risk estimate

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

<b>Unrestricted risk estimate for <i>Apple scar skin viroid</i></b>	
Overall likelihood of entry, establishment and spread	Very Low
Consequences	Moderate
Unrestricted risk	Very Low

The unrestricted risk estimate for ASSVd on apples from the PNW-USA has been assessed as Very Low, which achieves the ALOP for Australia. Therefore, no specific risk management measures are required for ASSVd on the PNW-USA apple pathway.

## 4.26 Tobacco necrosis viruses

### ***Tobacco necrosis virus A (EP) and Tobacco necrosis virus D (EP)***

Tobacco necrosis viruses (TNVs) A and D are members of the genera *Alphanecrovirus* and *Betanecrovirus*, respectively, and are recognised as distinct species within the family Tombusviridae (Adams, King & Carstens 2013; Coutts et al. 1991; ICTV 2020; Meulewaeter, Seurinck & Van Emmelo 1990; NCBI 2020). *Tobacco necrosis virus A* (TNV-A) and *Tobacco necrosis virus D* (TNV-D) have been reported in apples in the PNW-USA and are grouped together in this PRA because of their related biologies, on the bases of which they are predicted to pose similar risks. In this assessment the term ‘Tobacco necrosis viruses, TNVs’ is used to refer to these species. Specific names are used when the information relates to an individual species.

Tobacco necrosis viruses are reported to have a worldwide distribution (Brunt & Teakle 1996; Uyemoto 1981). They have been reported from Europe, Asia, Africa, eastern and western America and Australia (CABI 2020a). Tobacco necrosis viruses are common in Oregon (APHIS 2007). Tobacco necrosis viruses have been reported from Queensland and Victoria (Finlay & Teakle 1969; Teakle 1988), but there are no reports of infections of apples in Australia.

Tobacco necrosis viruses A and D have a wide host range, including some important commercial crops such as apple, strawberries, carrots, potatoes, cabbage, cucumber, zucchini, soybeans and common beans (Bos 1999; Gibbs & Harrison 1976; Martin & Tzanetakis 2006; Smith et al. 1988; Teakle 1988; Uyemoto 1981; Zitikaite & Staniulis 2009). Tobacco necrosis viruses affect different hosts in different ways. Tobacco necrosis viruses have been detected in apple causing symptomless systemic infections (Nemeth 1986a; Uyemoto & Gilmer 1972). While TNV particles have been detected in low concentrations in infected apple fruit, their distribution within apple tissue may be erratic (Uyemoto & Gilmer 1972).

Tobacco necrosis virus A and TNV-D are transmitted by the root-infecting chytrid fungus, *Olpidium brassicae* (Wor.) (Rochon et al. 2004). *Tobacco necrosis virus D* is also transmitted by a related chytrid *Olpidium* sp. (Kassanis & MacFarlane 1964; Sasaya & Koganezawa 2006). Virus particles released from roots of living hosts and other plant matter are acquired from soil water by fungal zoospores and transmitted when the spores infect the roots of another suitable host. Tobacco necrosis virus particles are stable in the environment, and retain infectivity for a lengthy period. Tobacco necrosis virus can tolerate temperatures up to 95°C (Brunt & Teakle 1996; Gibbs & Harrison 1976) and can remain viable after storage in vitro at -20°C (Gibbs & Harrison 1976; Kassanis 1970; Nemeth 1986a).

Tobacco necrosis viruses have been assessed previously in the existing import policies for stone fruit from California, Idaho, Oregon and Washington (Biosecurity Australia 2010b), fresh apple fruit from the People’s Republic of China (Biosecurity Australia 2010a), table grapes from the People’s Republic of China (Biosecurity Australia 2011a), table grapes from Japan (Department of Agriculture 2014), nectarines from the People’s Republic of China (DAWR 2016a), and table grapes from India (DAWR 2016b). In those policies, the unrestricted risk estimates were assessed as achieving the ALOP for Australia. Therefore, no specific risk mitigation measures are required for TNVs on these pathways.

Previous assessments of TNVs for fresh apple fruit from the People's Republic of China and stone fruit from California, Idaho, Oregon and Washington rated the likelihood of importation as Moderate. *Tobacco Necrotic Virus A* and TNV-D are reported as widely prevalent in Oregon but not in Washington or Idaho. Strains of TNVs were reported naturally infecting several apple cultivars in the USA (Uyemoto and Gilmer 1972) and association with apple trees has also been reported (Zitikaite & Staniulis 2009). Nemeth (1986a), Uyemoto (1972) and Uyemoto & Gilmer (1972) detected TNVs in apple and other fruit trees causing symptomless systemic infections. However, infections caused by TNVs on fruiting vegetable crops led to expression of various spotting or mottling symptoms on leaves or fruits and necrotic symptoms on older leaves (Zitikaite & Staniulis 2009). While TNV particles have been detected in low concentrations in apple fruit, their distribution within apple tissue is not confirmed (Uyemoto & Gilmer 1972). For the above reasons, the likelihood of importation of TNVs on apples from the PNW-USA is considered to be the same as the previous assessments of Moderate for apples from China and stone fruit from California, Idaho, Oregon and Washington.

Previous assessments of TNVs for fresh apple fruit from the People's Republic of China and stone fruit from California, Idaho, Oregon and Washington rated the likelihood of distribution as Moderate. Fresh apple fruit from the PNW-USA is expected to be distributed in Australia, as a result of the processing, sale or disposal, in a similar way to those fruit commodities assessed previously. Apples can be imported all year round, therefore, there would be no seasonal differences between these import pathways to contribute to variation in the risk rating for likelihood of distribution. Hosts, which include important commercial crops, are likely to be continuously available in Australia. The presence of vectors in Australia (ALA 2020; CABI 2020a) is ameliorated by the likely low concentration of TNV particles in apple flesh (Uyemoto & Gilmer 1972) and the assessed low likelihood that infected fruit waste will be discarded near a plant host while vector chytrids are active. These factors lead to the same assessed rating of Moderate for the likelihood of distribution for TNVs on the apples from PNW-USA apple pathway.

The likelihoods of establishment and spread of TNVs in Australia are assessed as similar to previous assessments for the apples from China and stone fruit from California, Idaho, Oregon and Washington pathways, as High and High, respectively. These likelihoods relate specifically to events that occur in Australia and are principally independent of the import pathway. The consequences of entry, establishment and spread for TNVs are also independent of the import pathway and have been assessed as similar to these existing policies of Very Low. Therefore, the existing ratings for the likelihoods of entry, of establishment and of spread and the ratings for overall consequences of TNVs from these existing policies have been adopted for the PNW-USA apple pathway.

The department has also reviewed the latest literature —for example, Díaz-Cruz et al. (2017) and Newburn and White (2017). No new information has been identified that would significantly change the risk ratings for importation, distribution, establishment, spread and consequences as set out for TNVs in the existing policies.

#### **4.26.1 Likelihood of entry**

The likelihood of entry is considered in 2 parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

### **Likelihood of importation**

The likelihood that Tobacco necrosis viruses will be imported into Australia in a viable state on apples from the PNW-USA is considered to be similar to the previous assessments for Tobacco necrosis viruses on fresh apple from China and stone fruit from California, Idaho, Oregon and Washington. Therefore, the same rating of Moderate for the likelihood of importation previously assessed for Tobacco necrosis viruses on the fresh apple from China and stone fruit from California, Idaho, Oregon and Washington pathways is adopted for Tobacco necrosis viruses on the apples from PNW-USA pathway.

### **Likelihood of distribution**

The likelihood that Tobacco necrosis viruses will be distributed within Australia in a viable state, as a result of the processing, sale or disposal of apples from the PNW-USA, and subsequently transfer to susceptible hosts is considered to be similar to Tobacco necrosis viruses on apples from China and stone fruit from California, Idaho, Oregon and Washington.

Therefore, the same rating of Moderate for the likelihood of distribution previously assessed for Tobacco necrosis viruses on apples from China and stone fruit from California, Idaho, Oregon and Washington pathways is adopted for Tobacco necrosis viruses on the apples from PNW-USA pathway.

### **Overall likelihood of entry**

The overall likelihood of entry is determined as Low by combining the adopted likelihood of importation of Moderate with the adopted likelihood of distribution of Moderate, using the matrix of rules in Table 2.2.

#### **4.26.2 Likelihoods of establishment and spread**

The likelihoods of establishment and spread for Tobacco necrosis viruses are independent of the import pathway and are considered similar to those previously assessed for apples from China and stone fruit from California, Idaho, Oregon and Washington pathways.

Based on the previous assessments, likelihoods of establishment and spread for Tobacco necrosis viruses are assessed as High and High, respectively.

#### **4.26.3 Overall likelihood of entry, establishment and spread**

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that Tobacco necrosis viruses will enter Australia as a result of trade in apples from the PNW-USA, be distributed in a viable state to a susceptible part of a host, establish in Australia and subsequently spread within Australia is assessed as Low.

#### **4.26.4 Consequences**

The potential consequences of the entry, establishment and spread of Tobacco necrosis viruses in Australia are similar to those in the previous assessment for Tobacco necrosis viruses on the apples from China and stone fruit from California, Idaho, Oregon and Washington pathways, which were assessed as Very Low. The overall consequences for Tobacco necrosis viruses on the apples from PNW-USA pathway are also assessed as Very Low.

#### 4.26.5 Unrestricted risk estimate

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

<b>Unrestricted risk estimate for Tobacco necrosis viruses</b>	
Overall likelihood of entry, establishment and spread	Low
Consequences	Very Low
Unrestricted risk	Negligible

The unrestricted risk estimate for Tobacco necrosis viruses on apples from the PNW-USA has been assessed as Negligible, which achieves the ALOP for Australia. Therefore, no specific risk management measures are required for Tobacco necrosis viruses on the PNW-USA apple pathway.

## 4.27 Pest risk assessment conclusions

Table 4.8 Summary of unrestricted risk estimates for quarantine and regulated pests associated with apples from the Pacific Northwest

Pest name	Likelihood of			Establishment	Spread	EES	Consequences	URE
	Entry		Overall				Overall	
	Importation	Distribution						
<b>Flat mites [Trombidiformes: Tenuipalpidae]</b>								
<i>Cenopalpus pulcher</i> (EP)	Low	Moderate	<b>Low</b>	High	Moderate	Low	Moderate	<b>Low</b>
<b>Spider mites [Trombidiformes: Tetranychidae]</b>								
<i>Tetranychus mcDanieli</i> (EP)	High	Moderate	<b>Moderate</b>	High	High	Moderate	Low	<b>Low</b>
<i>Tetranychus pacificus</i> (EP)	Moderate	Moderate	<b>Low</b>	High	High	Low	Low	<b>Very Low</b>
<i>Tetranychus turkestanii</i> (EP)	Moderate	Moderate	<b>Low</b>	High	High	Low	Low	<b>Very Low</b>
<b>Weevils [Coleoptera: Curculionidae]</b>								
<i>Anthonomus quadrigibbus</i>	Low	Moderate	<b>Low</b>	Moderate	Moderate	Low	Low	<b>Very Low</b>
<b>Gall midges [Diptera: Cecidomyiidae]</b>								
<i>Dasineura mali</i> (EP)	Low	Very Low	<b>Very Low</b>	Moderate	Moderate	Very Low	Low	<b>Negligible</b>
<b>Fruit flies [Diptera: Tephritidae]</b>								
<i>Rhagoletis pomonella</i> (EP)	High	Moderate	<b>Moderate</b>	High	Moderate	Low	High	<b>Moderate</b>
<b>Scale bugs [Hemiptera: Diaspididae]</b>								
<i>Parlatoria pergandii</i> (GP, WA)	Low	Moderate	<b>Low</b>	High	High	Low	Low	<b>Very Low</b>
<b>Lygus bugs [Hemiptera: Miridae]</b>								
<i>Lygus elisus</i> (EP)	Very Low	Moderate	<b>Very Low</b>	High	Moderate	Very Low	Moderate	<b>Very Low</b>
<i>Lygus hesperus</i> (EP)	Very Low	Moderate	<b>Very Low</b>	High	Moderate	Very Low	Moderate	<b>Very Low</b>
<i>Lygus lineolaris</i> (EP)	Very Low	Moderate	<b>Very Low</b>	High	Moderate	Very Low	Moderate	<b>Very Low</b>
<b>Mealybugs [Hemiptera: Pseudococcidae]</b>								
<i>Phenacoccus aceris</i> (GP)	High	Moderate	<b>Moderate</b>	High	High	Moderate	Low	<b>Low</b>
<i>Pseudococcus maritimus</i> (GP)	High	Moderate	<b>Moderate</b>	High	High	Moderate	Low	<b>Low</b>

Pest name	Likelihood of			Establishment	Spread	EES	Consequences	URE
	Entry		Overall				Overall	Overall
	Importation	Distribution						
<b>Cutworms [Lepidoptera: Noctuidae]</b>								
<i>Lacanobia subjuncta</i>	Low	Moderate	<b>Low</b>	High	High	Low	Low	<b>Very Low</b>
<b>Leafroller and fruit moths [Lepidoptera: Tortricidae]</b>								
<i>Archips argyrospila</i> (EP)	Moderate	Moderate	<b>Low</b>	High	High	Low	Moderate	<b>Low</b>
<i>Archips podana</i> (EP)	Moderate	Moderate	<b>Low</b>	High	High	Low	Moderate	<b>Low</b>
<i>Archips rosana</i> (EP)	Moderate	Moderate	<b>Low</b>	High	High	Low	Moderate	<b>Low</b>
<i>Argyrotaenia franciscana</i> (EP)	Moderate	Moderate	<b>Low</b>	High	High	Low	Moderate	<b>Low</b>
<i>Choristoneura rosaceana</i> (EP)	Moderate	Moderate	<b>Low</b>	High	High	Low	Moderate	<b>Low</b>
<i>Pandemis pyrusana</i> (EP)	Moderate	Moderate	<b>Low</b>	High	High	Low	Moderate	<b>Low</b>
<i>Cydia pomonella</i> (EP, WA)	Moderate	Moderate	<b>Low</b>	High	High	Low	Moderate	<b>Low</b>
<i>Grapholita molesta</i> (EP, WA)	Very Low	Moderate	<b>Very Low</b>	High	High	Very Low	Moderate	<b>Very Low</b>
<i>Grapholita packardi</i> (EP)	Very Low	Moderate	<b>Very Low</b>	High	High	Very Low	Moderate	<b>Very Low</b>
<i>Grapholita prunivora</i> (EP)	Very Low	Moderate	<b>Very Low</b>	High	High	Very Low	Moderate	<b>Very Low</b>
<b>Ermine moths [Lepidoptera: Yponomeutidae]</b>								
<i>Argyresthia conjugella</i> (EP)	Low	Moderate	<b>Low</b>	High	Moderate	Low	Low	<b>Very Low</b>
<b>Thrips [Thysanoptera: Thripidae]</b>								
<i>Frankliniella occidentalis</i> (GP, RA, NT)	High	Moderate	<b>Moderate</b>	High	High	Moderate	Low	<b>Low</b>
<i>Frankliniella tritici</i> (GP)	High	Moderate	<b>Moderate</b>	High	High	Moderate	Low	<b>Low</b>
<b>Bacteria</b>								
<i>Erwinia amylovora</i> (EP)	Moderate	Extremely Low	<b>Extremely Low</b>	High	High	Extremely Low	High	<b>Very Low</b>
<b>Fungi</b>								
<i>Coprinopsis psychromorbida</i>	Low	Very Low	<b>Very Low</b>	Moderate	Moderate	Very Low	Low	<b>Negligible</b>

Pest name	Likelihood of			Establishment	Spread	EES	Consequences	URE
	Entry		Overall				Overall	
	Importation	Distribution						
<i>Discula pyri</i>	Low	Low	<b>Very Low</b>	Moderate	Moderate	Very Low	Moderate	<b>Very Low</b>
<i>Gymnosporangium clavipes</i>	Low	Moderate	<b>Low</b>	Moderate	High	Low	Moderate	<b>Low</b>
<i>Gymnosporangium juniperi-virginianae</i>	Low	Moderate	<b>Low</b>	Moderate	High	Low	Moderate	<b>Low</b>
<i>Gymnosporangium libocedri</i>	Low	Moderate	<b>Low</b>	Moderate	High	Low	Moderate	<b>Low</b>
<i>Neofabraea malicorticis</i> (EP)	High	High	<b>High</b>	Moderate	Moderate	Low	Low	<b>Very Low</b>
<i>Neonectria ditissima</i> (EP)	Very Low	Very Low	<b>Extremely Low</b>	Moderate	Moderate	Extremely Low	Low	<b>Negligible</b>
<i>Phacidiopycnis washingtonensis</i>	High	Low	<b>Low</b>	Moderate	Moderate	Low	Moderate	<b>Low</b>
<i>Phyllosticta arbutifolia</i> (EP)	Low	Moderate	<b>Low</b>	Moderate	Moderate	Low	Moderate	<b>Low</b>
<i>Sphaeropsis pyriputrescens</i>	High	Low	<b>Low</b>	Moderate	Moderate	Low	Moderate	<b>Low</b>
<i>Truncatella hartigii</i> (EP)	Low	High	<b>Low</b>	High	High	Low	Low	<b>Very Low</b>
<b>Viroids</b>								
<i>Apple scar skin viroid</i> (EP)	Moderate	High	<b>Moderate</b>	Moderate	Low	Very Low	Moderate	<b>Very Low</b>
<b>Viruses</b>								
<i>Tobacco necrosis virus A</i> (EP)	Moderate	Moderate	<b>Low</b>	High	High	Low	Very Low	<b>Negligible</b>
<i>Tobacco necrosis virus D</i> (EP)	Moderate	Moderate	<b>Low</b>	High	High	Low	Very Low	<b>Negligible</b>

EP Species has been assessed previously and import policy already exists. GP Species has been assessed previously in a group policy. NT Pest of quarantine concern for Northern Territory RA Regulated article, refer to Section 4.14 for definition of a regulated article. WA Pest of quarantine concern for Western Australia.

#### 4.28 Summary of assessment of quarantine pests of concern

This section provides a summary of the process of assessment of potential and confirmed quarantine pests of concern (shown in Figure 4).

The pest categorisation process (Appendix A: Initiation and categorisation for pests of fresh apple fruit from the Pacific Northwest States of the USA) identified 216 pests. Of these 216 pests:

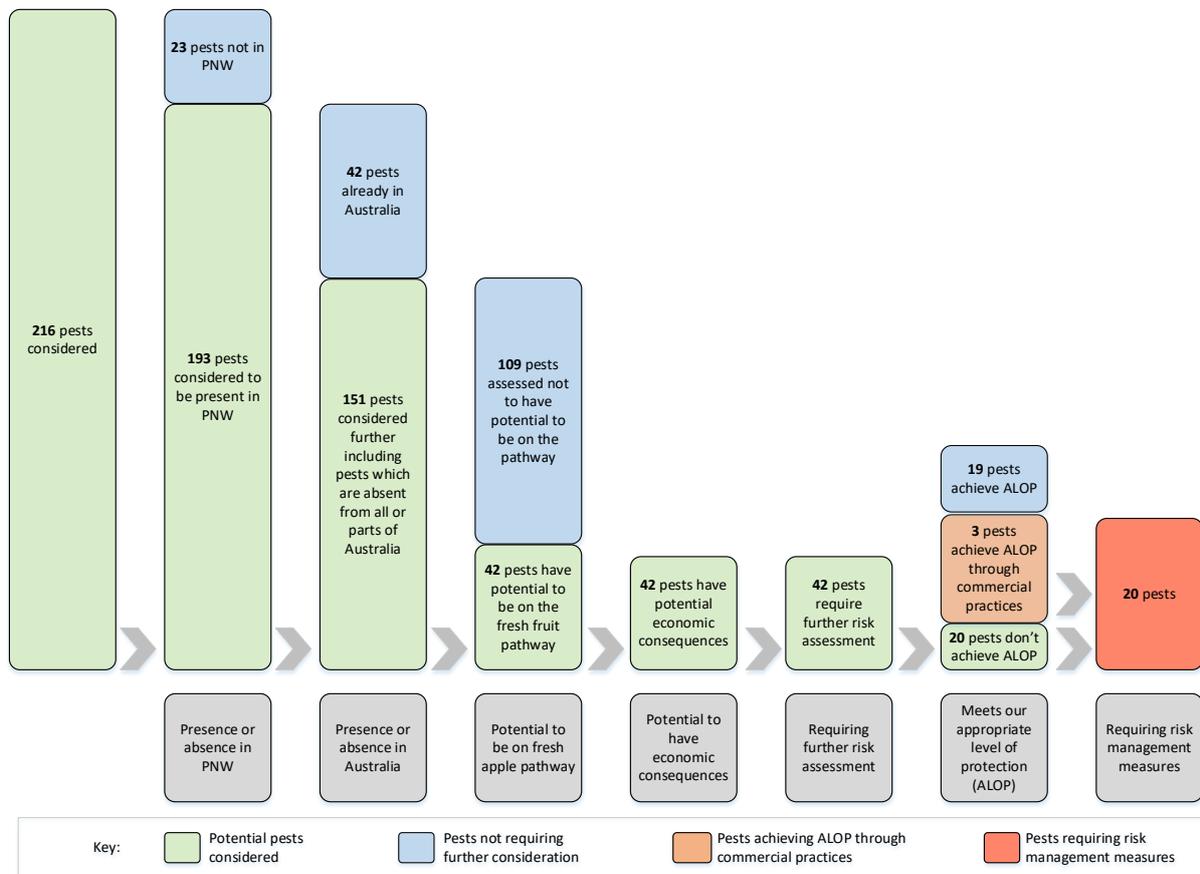
- 23 pests are present in the United States of America, but not recorded from the Pacific Northwest, and therefore were not considered further;
- 42 of the remaining 193 pests are already present in Australia, and not under official control, and therefore were not considered further;
- 109 of the 151 remaining pests were assessed as not having potential to be on the pathway of apples, and therefore did not undergo further assessment.

The outcome of the above process left 42 pests that required further consideration that is, pest risk assessment. Pest risk assessments for these 42 pests were subsequently completed:

- The estimated unrestricted risks for 19 pests were assessed as achieving the ALOP for Australia, and therefore no specific risk management measures are required for these pests on this pathway. These pests are:
  - Apple curculio (*Anthonomus quadrigibbus*)
  - Apple fruit moth (*Argyresthia conjugella*)
  - Apple scar skin (*Apple scar skin viroid*)
  - Bull's-eye rot (*Neofabraea malicorticis*)
  - Chaff scale (*Parlatoria pergandii*)
  - Cherry fruitworm (*Grapholita packardii*)
  - Coprinus rot (*Coprinopsis psychromorbida*)
  - Lacanobia fruitworm (*Lacanobia subjuncta*)
  - Lesser appleworm (*Grapholita prunivora*)
  - Lucerne plant bug (*Lygus elisus*)
  - Oriental fruit moth (*Grapholita molesta*)
  - Pacific spider mite (*Tetranychus pacificus*)
  - Phacidiopycnis rot (*Discula pyri*)
  - Strawberry spider mite (*Tetranychus turkestanii*)
  - Tarnished plant bug (*Lygus lineolaris*)
  - Tobacco necrosis virus A
  - Tobacco necrosis virus D
  - Truncatella leaf spot (*Truncatella hartigii*) and
  - Western tarnished plant bug (*Lygus hesperus*).
- The estimated risks for three pests achieved the ALOP, taking into consideration industry commercial control practices already in place in PNW-USA, which are comparable to those previously assessed in the policy for apples from New Zealand (Biosecurity Australia 2011b). These pests are:
  - European canker (*Neonectria ditissima*)
  - Fire blight (*Erwinia amylovora*) and
  - Apple leafcurling midge (*Dasineura mali*).
- The estimated unrestricted risks for 20 quarantine pests were assessed as not achieving the ALOP for Australia, and therefore these 20 pests require specific risk management measures for this pathway. These pests are:

- Apple blotch (*Phyllosticta arbutifolia*)
- Apple maggot (*Rhagoletis pomonella*)
- Apple mealybug (*Phenacoccus aceris*)
- Cedar quince rust (*Gymnosporangium clavipes*)
- Cedar apple rust (*Gymnosporangium juniperi-virginianae*)
- Codling moth (*Cydia pomonella*)
- Eastern flower thrips (*Frankliniella tritici*)
- European leafroller (*Archips rosana*)
- Flat scarlet mite (*Cenopalpus pulcher*)
- Fruit tree leafroller (*Archips argyrospila*)
- Grape mealybug (*Pseudococcus maritimus*)
- Large fruit tree tortrix (*Archips podana*)
- McDaniel spider mite (*Tetranychus mcdanieli*)
- Oblique-banded leafroller (*Choristoneura rosaceana*)
- Orange tortrix (*Argyrotaenia franciscana*)
- Pandemis leafroller (*Pandemis pyrusana*)
- Pacific coast pear rust (*Gymnosporangium libocedri*)
- Speck rot (*Phacidiopycnis washingtonensis*)
- Sphaeropsis rot (*Sphaeropsis pyriputrescens*)
- Western flower thrips (*Frankliniella occidentalis*).

Figure 4 Summary of assessment of quarantine pests of concern



## 5 Pest risk management

Pest risk management evaluates and selects options for measures for quarantine pests and regulated articles identified in Chapter 4 as having a URE that does not achieve the ALOP for Australia. This chapter recommends specific risk management measures for these pests and regulated articles (Section 5.1). This chapter also recommends the operational system for the assurance, maintenance and verification of the phytosanitary status (Section 5.2). Both specific risk management measures (Section 5.1) and the operational system (Section 5.2) are required to reduce the risk of introduction of these quarantine pests and regulated articles to achieve the ALOP for Australia. These measures are in addition to existing commercial production practices for fresh apple fruit in the PNW-USA, described in Chapter 3, as these practices have been considered in assessing the URE.

### 5.1 Pest risk management measures and phytosanitary procedures

This section describes the recommended risk management measures for the 20 quarantine pests (1 of which is also a regulated article), assessed in Chapter 4 as posing a URE that does not achieve the ALOP for Australia. This section also describes specific commercial production practices that are mandatory for 3 quarantine pests, as these practices were considered in assessment of the URE of these pests as achieving the ALOP for Australia.

Historical trade and pest interception data of other similar pathways, as described in section 5.1.1, have been considered in determining the appropriate risk management measures for the importation of fresh apple fruit from the PNW-USA.

Finalisation of the import conditions may be undertaken with input from the Australian states and territories, and the USDA-APHIS, as appropriate.

#### 5.1.1 Analysis of pest interception data

Australia currently allows imports of fresh apples from China and New Zealand. During the period spanning January 2011 to July 2020, 274 consignments of fresh apples were imported into Australia from China, totalling 5,065 tonnes. There were very few pest interceptions, most of which were unidentified species of mites from four families, namely Tarsonemidae, Tydeidae, Acaridae and Phytoseiidae. Two consignments of apples from China contained unidentified leafroller moths. During the period spanning August 2011 to July 2020, 75 consignments of fresh apples were imported into Australia from New Zealand, totalling 1,743 tonnes. During this period there were two interceptions of apple leafcurling midge, each of one live larva/pupa in 2011, and there has been no interception of this pest since. In addition, there was detection of a live thrips of concern in the family Phlaeothripidae during this period.

The USA also has access to the Australian market for cherries (permitted counties in California, Idaho, Oregon and Washington), stone fruit (California, Idaho, Oregon and Washington), table grapes (California) and citrus (California and Arizona). The horticultural practices and major production areas for these commodities in the PNW-USA are considered to be very similar to those for apples. The key pests associated with stone fruit and apples in the PNW-USA largely overlap, and pest prevalences and pressures on the production systems are also comparable. The risk analysis for stone fruit from California and the PNW states identified 20 quarantine pests for Australia that require specific risk management measures. During the period spanning January 2015 to July 2020, a total of 3,913 consignments of fresh stone fruit were imported into

Australia from the USA, totalling 15,688 tonnes. There were a few pest interceptions, including arthropods of families such as Thripidae (thrips), Phytoseiidae (mites), Sciaridae (fungal gnats) and Pyralidae (pyralid moths).

### **5.1.2 Pest risk management for quarantine pests and regulated article**

Recommended specific risk management measures for the 20 quarantine pests (1 of which is also a regulated article) associated with fresh apples from the PNW-USA are listed in Table 5.1. Specific commercial production practices are recommended to be mandatory for *D. mali*, *E. amylovora* and *N. ditissima*, as these practices were considered in assessment of the URE of these pests as achieving the ALOP for Australia. These are listed in Table 5.2.

**Table 5.1 Risk management measures recommended for quarantine pests and a regulated article potentially associated with apples from the Pacific Northwest states, USA**

<b>Pest</b>	<b>Common name</b>	<b>Measures</b>
<b>Fruit Flies [Diptera: Tephritidae]</b>		
<i>Rhagoletis pomonella</i> (EP)	Apple maggot	PFA, PFPP or PFPS <b>a</b> OR An appropriate pre-export phytosanitary treatment approved by the department
<b>Flat Mites [Trombidiformes: Tenuipalpidae]</b>		
<i>Cenopalpus pulcher</i> (EP)	Flat scarlet mite	
<b>Spider Mites [Trombidiformes: Tetranychidae]</b>		
<i>Tetranychus mcDanieli</i>	McDaniel spider mite	
<b>Mealybugs [Hemiptera: Pseudococcidae]</b>		
<i>Phenacoccus aceris</i> (GP)	Apple mealybug	Pre-export visual inspection and, if found remedial action <b>b</b>
<i>Pseudococcus maritimus</i> (GP)	Grape mealybug	
<b>Thrips [Thysanoptera: Thripidae]</b>		
<i>Frankliniella occidentalis</i> (GP, RA, NT) <b>c</b>	Western flower thrips	
<i>Frankliniella tritici</i> (GP)	Eastern flower thrips	
<b>Moths [Lepidoptera: Tortricidae]</b>		
<i>Archips argyrospila</i> (EP)	Fruit tree leafroller	In-field controls <b>d</b> AND
<i>Archips podana</i> (EP)	Large fruit tree tortrix	Pre-export inspection and, if found, remedial action <b>b</b>
<i>Archips rosana</i> (EP)	European leafroller	
<i>Argyrotaenia franciscana</i> (EP)	Orange tortrix	OR
<i>Choristoneura rosaceana</i> (EP)	Oblique-banded leafroller	An appropriate pre-export phytosanitary treatment approved by the department
<i>Pandemis pyrusana</i> (EP)	Pandemis leafroller	
<i>Cydia pomonella</i> (EP, WA)	Codling moth	PFA, PFPP or PFPS <b>a</b> OR Systems approach approved by the department OR An appropriate pre-export phytosanitary treatment approved by the department
<b>Fungi</b>		
<i>Gymnosporangium clavipes</i>	Cedar quince rust	Pre-export visual inspection, and if found remedial action <b>e</b>
<i>Gymnosporangium juniperi-virginianae</i>	Cedar apple rust	
<i>Gymnosporangium libocedri</i>	Pacific coast pear rust	
<b>Fungi</b>		
<i>Phacidiopycnis washingtonensis</i>	Speck rot	Systems approach approved by the department <b>f</b>
<i>Phyllosticta arbutifolia</i> (EP)	Apple blotch	
<i>Sphaeropsis pyriputrescens</i>	Sphaeropsis rot	

**a** PFA is pest free area, PFPP is pest free place of production, PFPS is pest free production site. **b** Remedial action by APHIS may include applying an approved treatment (such as methyl bromide fumigation) to the consignment to ensure that the pest is no longer viable or withdrawing the consignment from export to Australia. **c** Thrips species that is also identified as a regulated article for Australia as it vectors emerging quarantine orthospoviruses, assessed in the thrips Group PRA (DAWR 2017) as posing a URE that does not achieve the ALOP for Australia. **d** In-field controls (as described in Chapter 3). **e** Remedial action by APHIS by withdrawing the consignment from export to Australia. **f** Systems approach for post-harvest rot fungi involving in-field control, pre-harvest and post-harvest fungicide applications, sourcing only mature symptomless fruit, and pre-export visual inspection post-cold storage. **EP** Species has been assessed previously and import policy already exists. **GP** Species has been assessed previously in a group PRA and the group PRA has been applied. **RA** Regulated article. **NT** Pest of biosecurity concern for the Northern Territory. **WA** Pest of biosecurity concern for Western Australia.

**Table 5.2 Specific commercial production practices that are recommended to be mandatory for *D. mali*, *E. amylovora* and *N. ditissima* associated with apples from the Pacific Northwest states**

<b>Pest</b>	<b>Common name</b>	<b>Mandatory commercial production practices</b>
<b>Gall midges [Diptera: Cecidomyiidae]</b>		
<i>Dasineura mali</i> (EP)	Apple leafcurling midge	In-field monitoring and controls <b>a</b> AND Packing house sanitation <b>b</b> AND Pre-export visual inspection and, if found remedial action <b>c</b>
<b>Bacteria</b>		
<i>Erwinia amylovora</i> (EP)	Fire blight	In-field monitoring and controls <b>a</b> AND Fruit maturity testing <b>d</b> AND Packing house sanitation <b>b</b> AND Pre-export visual inspection and if found remedial action <b>e</b>
<b>Fungi</b>		
<i>Neonectria ditissima</i> (EP)	European canker	In-field monitoring and controls <b>a</b> AND Packing house sanitation <b>b</b> AND Pre-export visual inspection and if found remedial action <b>e</b>

**a** In-field monitoring and controls (as described in Chapter 3) **b** Packing house sanitation including sanitiser application, high pressure washing, brushing and waxing. **c** Remedial action by APHIS may include applying an approved treatment (such as methyl bromide fumigation) to the consignment to ensure that the pest is no longer viable or withdrawing the consignment from export to Australia. **d** Fruit maturity testing pre-harvest/post-harvest. **e** Remedial action by APHIS may include withdrawing the consignment from export to Australia.

The Australian Government Department of Agriculture, Fisheries and Forestry (the department) recommends the following specific risk management measures for the identified quarantine pests and regulated article:

- For apple maggot
  - pest free areas, pest free places of production or pest free production sites, or
  - an appropriate pre-export phytosanitary treatment approved by the department.
- For mites, mealybugs and thrips
  - pre-export visual inspection and, if found, remedial action.
- For leaf rollers
  - in-field controls and pre-export inspection and, if found, remedial action, or
  - an appropriate pre-export phytosanitary treatment (such as methyl bromide fumigation) approved by the department.
- For codling moth

- pest free areas, pest free places of production or pest free production sites, or
- systems approach approved by the department, or
- an appropriate pre-export phytosanitary treatment (such as methyl bromide fumigation) approved by the department.
- For *Gymnosporangium* rusts:
  - pre-export visual inspection and, if found, remedial action.
- For fungal pathogens causing post-harvest rots (speck rot, *Sphaeropsis* rot and apple blotch):
  - systems approach approved by the department.

The department recommends the following specific commercial production practices as mandatory practices for apple leafcurling midge, fire blight and European canker.

- For apple leafcurling midge:
  - in-field monitoring and controls, packing house procedures including sorting, grading and packing house sanitation, and pre-export visual inspection and, if found, remedial action.
- For fire blight:
  - in-field monitoring and controls, fruit maturity testing, packing house sanitation, and pre-export visual inspection and, if found, remedial action.
- For European canker:
  - in-field monitoring and controls, packing house sanitation, and pre-export visual inspection and, if found, remedial action.

Details of all the risk management measures and specific commercial production practices that are mandatory to meet the Australian import requirements will be documented in the *Work plan for the export of fresh apples from the Pacific Northwest states of United States of America to Australia* to be developed by USDA-APHIS as part of the operational system.

#### **Management for *Rhagoletis pomonella***

For *R. pomonella*, the department recommends the options of pest free area (PFA), pest free place of production (PFPP), pest free production site (PFPS) or a pre-export phytosanitary treatment approved by the department as a measure for this pest.

The objective of each recommended measure is to reduce the risk associated with this pest to achieve the ALOP for Australia when applied in combination with the operational system outlined in Section 5.2.

#### *Recommended measure 1: Pest free area, pest free place of production or pest free production site*

The requirements for establishing and maintaining pest free areas are set out in ISPM 4: *Requirements for the establishment of pest free areas* (FAO 2021b), and more specifically for fruit flies in ISPM 26: *Establishment of pest free areas for fruit flies (Tephritidae)* (FAO 2021g). The requirements for establishing and maintaining pest free places of production or pest free production sites are set out in ISPM 10: *Requirements for the establishment of pest free places of production and pest free production sites* (FAO 2021d).

The department recognises that *R. pomonella* is under official control in PNW-USA, and that the major apple growing regions in Washington state have been declared pest free areas under the Washington Agriculture Code Title 16, Chapter 470-105 (Washington State Legislature 2018). The movement of host materials into the states of Idaho, Oregon and Washington is restricted under Federal and/or State quarantine for several pests, including *R. pomonella*. Should the USA wish to use PFA, PFPP or PFPS as a measure to manage the risk posed by *R. pomonella*, USDA-APHIS will need to provide a submission detailing the areas covered by the PFA, PFPP or PFPS claim for approval by the department. The submission demonstrating PFA must fulfil the requirements set out in ISPM 4, and more specifically ISPM 26. The submission demonstrating PFPP or PFPS must fulfil the requirements set out in ISPM 10.

If *R. pomonella* is detected in a recognised PFA, PFPP or PFPS, or if other tephritid fruit flies are detected anywhere within PNW-USA that contribute to an outbreak situation, under the Federal Regulation 7CFR301.32 (USDA-APHIS 2019), APHIS is required to notify the department within 48 hours of detection. The United States Federal and/or State emergency action plans for outbreaks will need to be activated, including establishing a delimiting survey by setting up additional traps to identify the extent of the fruit fly outbreak and determine the site of the outbreak, the surrounding area and the buffer area. Fruit sampling must also be conducted. Exports of fresh apple fruit from the *R. pomonella* or other fruit fly outbreak areas must be suspended or undergo an appropriate phytosanitary treatment approved by the department.

*Recommended measure 2: An appropriate pre-export phytosanitary treatment approved by the department*

For fresh apple fruit sourced from outside the recognised *R. pomonella* PFA, PFPP or PFPS, or where the area, place or site freedom status has been suspended, an appropriate pre-export phytosanitary treatment approved by the department for *R. pomonella* must be undertaken. Should the USA wish to use a pre-export phytosanitary treatment, USDA-APHIS will need to provide Australia with a submission demonstrating efficacy of the proposed treatment for approval by the department.

### **Management for mites, mealybugs and thrips**

For *C. pulcher*, *T. mcdanieli*, *P. aceris*, *P. maritimus*, *F. occidentalis* and *F. tritici*, the department recommends pre-export visual inspection and, if found, remedial action. The method used for visual inspection must be able to detect all life stages of these pests, for example by using visual aids such as hand lens, where necessary. The inspection should be consistent with ISPM 23: Guidelines for inspection (FAO 2021f) and ISPM 31: Methodologies for sampling of consignments (FAO 2021h) and provide a 95% level of confidence that infestation greater than 0.5% will be detected. The objective of this recommended measure is to reduce the risk associated with these pests to achieve the ALOP for Australia when applied in combination with the operational system outlined in Section 5.2.

Recommended measure: Pre-export visual inspection and, if detected, remedial action

All consignments of fresh apples for export to Australia must be inspected by APHIS/US regulatory officials in accordance with ISPM 23 and ISPM 31. Each consignment must be found free of *C. pulcher*, *T. mcdanieli*, mealybugs and thrips. Export consignments found to contain any of these pests must be subject to remedial action. Remedial action by APHIS/US regulatory officials may include withdrawing the consignment from export to Australia or, applying an

approved treatment (such as methyl bromide fumigation) to ensure that the pest is no longer viable.

### **Management for leafrollers**

To manage the risk posed by leafrollers the department recommends the options of in-field controls and pre-export inspection, or an appropriate pre-export phytosanitary treatment. The objective of each of the recommended measures is to reduce the risk associated with these pests to achieve the ALOP for Australia when applied in combination with the operational system outlined in Section 5.2.

*Recommended measure 1: In-field controls, pre-export visual inspection and, if detected, remedial action*

Under this option, all apple consignments for export to Australia must be sourced from apple orchards undertaking commercial practices as in-field controls against *Archips argyrospila*, *Archips podana*, *Archips rosana*, *Argyrotaenia franciscana*, *Choristoneura rosaceana* and *Pandemis pyrusana*.

All apple consignments for export to Australia must be inspected and found free of *Archips argyrospila*, *Archips podana*, *Archips rosana*, *Argyrotaenia franciscana*, *Choristoneura rosaceana* and *Pandemis pyrusana*.

Export consignments found to contain any of these pests will be subject to remedial action. Remedial action may include withdrawing the consignment from export to Australia or applying an appropriate pre-export phytosanitary treatment approved by the department to ensure that the pest is no longer viable.

*Recommended measure 2: An appropriate pre-export phytosanitary treatment (such as methyl bromide fumigation) approved by the Department of Agriculture, Fisheries and Forestry*

Export consignments must have a pre-export phytosanitary treatment applied that is approved by the department to manage the risk posed by *Archips argyrospila*, *Archips podana*, *Archips rosana*, *Argyrotaenia franciscana*, *Choristoneura rosaceana* and *Pandemis pyrusana*. Should the USA wish to use the treatment option, USDA-APHIS will need to provide a submission demonstrating efficacy of the proposed measure for consideration by the department.

### **Management for codling moth**

To manage the risk posed by codling moth the department recommends the options of pest free area (PFA), pest free place of production (PFPP) or pest free production site (PFPS); a systems approach approved by the department; or a pre-export phytosanitary treatment approved by the department as a measure for this pest.

The objective of each recommended measure is to reduce the risk associated with this pest to achieve the ALOP for Australia when applied in combination with the operational system outlined in Section 5.2.

*Recommended measure 1: Pest free area, pest free place of production or pest free production site*

The requirements for establishing and maintaining pest free areas are set out in ISPM 4: *Requirements for the establishment of pest free areas* (FAO 2021b). The requirements for establishing and maintaining pest free places of production or pest free production sites are set

out in ISPM 10: *Requirements for the establishment of pest free places of production and pest free production sites* (FAO 2021d).

*Recommended measure 2: Systems approach*

Under this option, all apple consignments for export to Australia must be sourced from apple orchards undertaking a systems approach to manage codling moth, which is approved by the department.

All apple consignments for export to Australia must be inspected and any fruit with suspected infestation must be cut and examined and found free of codling moth.

Export consignments found to contain codling moth will be subject to remedial action. Remedial action may include withdrawing the consignment from export to Australia or applying an appropriate pre-export phytosanitary treatment approved by the department to ensure that the pest is no longer viable.

*Recommended measure 3: An appropriate pre-export phytosanitary treatment (such as methyl bromide fumigation or cold treatment) approved by the Department of Agriculture, Fisheries and Forestry*

Export consignments must have a pre-export phytosanitary treatment applied that is approved by the department to manage the risk posed by codling moth. Should the USA wish to use the treatment option, USDA-APHIS will need to provide a submission demonstrating efficacy of the proposed measure for consideration by the department.

**Management for *Gymnosporangium* rusts**

For *Gymnosporangium clavipes*, *G. juniperi-virginianae* and *G. libocedri*, the department recommends pre-export visual inspection and, if found, remedial action. The objective of the recommended measure is to reduce the risk associated with these pests to achieve the ALOP for Australia when applied in combination with the operational system outlined in Section 5.2.

*Recommended measure: Pre-export visual inspection and, if found, remedial action*

All apple consignments for export to Australia must be inspected and found free of all fungal stages or symptoms of *G. clavipes*, *G. juniperi-virginianae* and *G. libocedri*.

Export consignments in which pathogens or symptoms of concern to Australia are detected must be withdrawn from export.

**Management for *Phacidiopycnis washingtonensis*, *Phyllosticta arbutifolia* and *Sphaeropsis pyriputrescens***

For *Phacidiopycnis washingtonensis*, *Phyllosticta arbutifolia* and *Sphaeropsis pyriputrescens*, the department recommends a systems approach. The objective of the recommended measure is to reduce the risk associated with these pests to achieve the ALOP for Australia when applied in combination with the operational system outlined in Section 5.2.

*Recommended measure: Systems approach*

USDA-APHIS has provided the department with a submission for a systems approach as a measure for *P. washingtonensis*, *P. arbutifolia* and *S. pyriputrescens*. The department has

reviewed the submission and considers it to be adequate for mitigating the risk of these pests on the apples from the PNW-USA pathway. Australia's requirements for the systems approach to manage the risk posed by these fungi are as follows:

- orchard management for apples from the PNW-USA through in-field control and monitoring of Manchurian crabapple (*Malus baccata*) pollinisers for signs of infection, and, pruning and removal of infected tissue or dead/dying branches, as outlined in Chapter 3
- pre-harvest fungicide applications
- sourcing only mature symptomless fruit
- post-harvest fungicide application by drenching the fruit with fungicide when delivered to the packing house and prior to cold storage or alternatively fungicides may be applied as a fogging treatment in cool rooms within 14 days of storage
- pre-export inspection post-cold storage and any consignments detected with any fungal stages or symptoms must be withdrawn from export to Australia.

All apple consignments for export to Australia must be sourced from apple orchards and packing houses undertaking pre- and post-harvest management in accordance with the systems approach for *P. washingtonensis*, *P. arbutifolia*, and *S. pyriputrescens*. All apple consignments must be inspected prior to export and after cold storage and found free of any fungal stages or symptoms of *P. washingtonensis*, *P. arbutifolia*, and *S. pyriputrescens*. Export consignments in which these pathogens or symptoms are detected must be withdrawn from export to Australia.

If *P. washingtonensis*, *P. arbutifolia* or *S. pyriputrescens* are detected during on-arrival inspections in Australia, the systems approach may be suspended, pending an investigation and an implementation of corrective action(s).

Details of the systems approach, including a minimum period of cold storage prior to pre-export inspection, will be documented in the 'Work plan for the export of fresh apples from the Pacific Northwest states of the United States of America to Australia' to be developed by USDA-APHIS as part of the operational system.

#### **Specific commercial production practices mandatory for *Dasineura mali*, *Erwinia amylovora* and *Neonectria ditissima***

For *D. mali*, *E. amylovora* and *N. ditissima*, specific existing commercial production practices are mandatory for all apples produced for export to Australia as these practices were considered in the pest risk assessments for the URE of these pests as achieving the ALOP for Australia. The existing commercial production practices in place to manage these 3 pests in the PNW-USA are comparable to those of the Integrated Pest Management program for New Zealand apples.

*Recommended mandatory commercial production practices for D. mali: In-field monitoring and controls, packing house procedures, including sorting, grading and packing house sanitation, and pre-export visual inspection and, if found, remedial action*

All PNW-USA apple growers are required to apply in-field monitoring and controls as described in Chapter 3. All apple consignments for export to Australia must undergo packing house procedures of sorting, grading and packing house sanitation, including sanitiser application (such as chlorine), high pressure washing, brushing and waxing, as described in Chapter 3. Prior to export to Australia, all apple consignments must be inspected by APHIS/US regulatory

officials and found free of *D. mali*. Export consignments found to contain this pest must be subject to remedial action, which may include withdrawing the consignments from export to Australia or applying an approved treatment such as methyl bromide fumigation to ensure that the pest is no longer viable.

*Recommended mandatory commercial production practices for E. amylovora: In-field monitoring and controls, fruit maturity testing, packing house sanitation and pre-export visual inspection and, if found, remedial action*

All PNW-USA apple growers are required to apply in-field monitoring and controls for *E. amylovora* as described in Chapter 3. Fruit must be tested for maturity using iodine solution to determine starch pattern index. Only commercially produced mature apple fruit can be exported to Australia. All apple consignments for export to Australia must undergo packing house sanitation, including sanitiser application (such as chlorine), high pressure washing, brushing and waxing, as described in Chapter 3. Prior to export to Australia, all apple consignments must be inspected by APHIS/US regulatory officials and found free of any signs of *E. amylovora*. Export consignments found to contain any signs of *E. amylovora* must be withdrawn from export to Australia.

*Recommended mandatory commercial production practices for N. ditissima: In-field monitoring and controls, packing house sanitation and pre-export visual inspection and, if found, remedial action*

All PNW-USA apple growers are required to apply in-field monitoring and controls for *N. ditissima* as described in Chapter 3. All apple consignments for export to Australia must undergo packing house sanitation, including sanitiser application (such as chlorine), high pressure washing, brushing and waxing, as described in Chapter 3. Prior to export to Australia, all apple consignments must be inspected by APHIS/US regulatory officials and found free of any signs of *N. ditissima*. Export consignments found to contain any signs of *N. ditissima* must be withdrawn from export to Australia.

### 5.1.3 Consideration of alternative measures

Consistent with the principle of equivalence detailed in ISPM 11: *Pest risk analysis for quarantine pests* (FAO 2021e), the department will consider any alternative measure proposed by USDA-APHIS, providing that it demonstrably manages the target pests to achieve the ALOP for Australia. Evaluation of any such measure will require a technical submission from USDA-APHIS that details the proposed measure, including suitable information to support the claimed efficacy, for consideration by the department.

## 5.2 Operational system for the assurance, maintenance and verification of phytosanitary status

A system of operational procedures is necessary to ensure proposed specific risk management measures (Section 5.1) are effectively applied, the phytosanitary status of apples from the PNW-USA is maintained, and these can be verified.

### 5.2.1 A system of traceability to source orchards

The objectives of this recommended procedure are to ensure that:

- apples are sourced only from orchards producing commercial export-quality fruit in the Pacific Northwest states of Idaho, Oregon and Washington in the United States of America

- orchards from which apples are sourced can be identified, so that any investigation and corrective action can be targeted in the event that pests of biosecurity concern to Australia are intercepted
- orchards are capable of applying in-field controls for specific pests as outlined in Chapter 3 and the required risk management measures such as systems approach
- where apple fruit are grown/produced in an approved PFA, PFPP or PFPS, it can be verified that all fruit were sourced from the approved area, place or site and produced and exported under the conditions for that pathway.

USDA-APHIS must establish a system to enable traceability to where apple fruit for export to Australia are sourced. USDA-APHIS must ensure that growers of apple fruit for export are aware of pests of biosecurity concern for Australia and have systems in place to produce export quality fruit that meet Australia's requirements.

Where a pest risk management measure involving pest monitoring and controls during production and at harvest (such as PFA, PFPP, PFPS or systems approach) is used, export orchards must be registered with USDA-APHIS before commencement of each harvest season. Records of registered orchards and USDA-APHIS audits must be kept by USDA-APHIS and must be made available to the department upon request.

### **5.2.2 Registration of packing houses and treatment providers, and auditing of procedures**

The objectives of this recommended procedure are to ensure that:

- commercial quality apples are sourced only from growers and packing houses that are approved by USDA-APHIS
- where applicable, treatment providers are approved by USDA-APHIS and capable of applying a treatment that suitably manages the target pests.

Export packing houses are registered with USDA-APHIS before the commencement of each harvest season. USDA-APHIS is required to ensure that the registered packing houses are suitably equipped and have a system in place to carry out the specified phytosanitary activities. The list of registered packing houses and records of USDA-APHIS audits must be kept by USDA-APHIS and must be made available to the department upon request.

In circumstances where apples undergo pre-export treatment, this process must be undertaken by treatment providers that have been registered with and audited by USDA-APHIS for that purpose. Records of USDA-APHIS's registration requirements and audits must be made available to the department upon request.

The approval of treatment providers by USDA-APHIS must include verification that suitable systems are in place to ensure compliance with the treatment requirements. This may include:

- documented procedures to ensure apples are appropriately treated and safeguarded post treatment
- staff training to ensure compliance with procedures

- record-keeping procedures
- suitability of facilities and equipment
- USDA-APHIS's system of oversight of treatment application.

### 5.2.3 Packaging, labelling and containers

The objectives of this recommended procedure are to ensure that:

- apples proposed for export to Australia, and associated packaging, are not contaminated by quarantine pests or regulated articles (as defined in ISPM 5: *Glossary of phytosanitary terms* (FAO 2021c))
- unprocessed packaging material is not imported with fresh apples from the PNW-USA as it may vector pests identified as not being on the pathway, or pests not known to be associated with apples
- all wood material associated with the consignment used in the packaging and transport of fresh apples from PNW-USA complies with the department's import conditions, as published on BICON
- secure packaging is used for export of fresh apples from PNW-USA to Australia, to prevent re-infestation during storage and transport, and prevent escape of pests during clearance procedures on arrival in Australia. Packaging must meet Australia's secure packing options published on BICON
- consignments are made insect-proof and secure, by using at least one of the following secure consignment options:
  - **integral cartons** - produce may be packed in integral (fully enclosed) cartons (packages) with boxes having no ventilation holes and lids tightly fixed to the bases
  - **ventilation holes of cartons covered** - cartons (packages) with ventilation holes must have the holes covered/sealed with a mesh/screen of no more than 1.6 mm pore size and not less than 0.16 mm strand thickness. Alternatively, the vent holes could be taped over
  - **polythene liners** - vented cartons (packages) with sealed polythene liners/bags within are acceptable (folded polythene bags are acceptable)
  - **meshed or shrink-wrapped pallets or Unit Loading Devices (ULDs)**- ULDs transporting cartons with open ventilation holes/gaps, or palletised cartons with ventilation holes/gaps must be fully covered or wrapped with polythene/plastic/foil sheet or mesh/screen of no more than 1.6 mm diameter pore size
  - **produce transported in fully enclosed containers** - cartons (packages) with holes as loose boxes or on pallets may be transported in fully enclosed containers. Enclosed containers include 6-sided container with solid sides, or ULDS with tarpaulin sides that have no holes or gaps. The container must be transported to the inspection point intact.
- packaged PNW-USA apples are labelled with sufficient identification for the purposes of traceability. This may include:
  - for treated product: the treatment facility name/number and treatment identification reference/number
  - for apples where the measures include in-field controls/orchard freedom/area freedom: the orchard's reference/number
  - for apples where phytosanitary measures are applied at the packing house: packing house reference/number.

Export packing houses and treatment providers (where applicable) must ensure packaging and labelling are suitable to maintain phytosanitary status of the export consignments.

#### 5.2.4 Specific conditions for storage and movement

The objective of this recommended procedure is to ensure that the quarantine integrity of the commodity is maintained during storage and movement.

Treated and/or inspected fresh apples for export to Australia must be kept secure and segregated at all times from any fruit for domestic or other markets, and from untreated/non pre-inspected product, to prevent mixing or cross-contamination.

#### 5.2.5 Freedom from trash

The objective of this recommended procedure is to ensure that fresh apples for export are free from trash (for example, loose stem and leaf material, seeds, soil, animal matter/parts or other extraneous material) and foreign matter. Freedom from trash must be confirmed by the inspection procedures. Export lots or consignments found to contain trash or foreign matter must be withdrawn from export unless approved remedial action such as reconditioning is available and applied to the export consignment, which is then to be re-inspected.

Freedom from trash will be confirmed by the inspection procedures. Export lots or consignments found to contain trash or foreign matter should be withdrawn from export unless approved remedial action such as reconditioning is available and applied to the export consignment and then re-inspected.

#### 5.2.6 Pre-export phytosanitary inspection and certification by USDA-APHIS

The objectives of this recommended procedure are to ensure that Australia's import conditions have been met. All apple consignments for export to Australia must be inspected by APHIS/US regulatory officials and found free of pests of biosecurity concern for Australia. Pre-export visual inspection must be undertaken by APHIS/US regulatory officials in accordance with ISPM 23: *Guidelines for inspection* (FAO 2021f) and consistent with the principles of ISPM 31: *Methodologies for sampling of consignments* (FAO 2021h). All fruit in the inspection sample which exhibit symptoms of potential infestation will be required to undergo fruit cut and examination of cut fruit samples by APHIS/US regulatory officials to detect internal-feeding life stages of this pest. In addition, all fruit in the inspection sample which exhibit symptoms of potential infection will be required to undergo further examination to identify the pathogen species.

Where the mandatory treatment option is taken, pre-export phytosanitary inspection by APHIS/US regulatory officials must be undertaken after completion of the treatment.

All consignments must be inspected prior to export in accordance with official procedures for all visually-detectable quarantine pests and regulated articles (including trash). Sampling and inspection methods should be consistent with ISPM 23 and ISPM 31 and provide a 95% level of confidence that infestation greater than 0.5% will be detected. For a consignment equal to or greater than 1,000 units (one unit being a single apple fruit), this is equivalent to a 600-unit sample randomly selected across the consignment. Any netting or artificial wrapping material must be removed during the inspection. A phytosanitary certificate must be issued for each consignment upon completion of pre-export inspection and treatment to verify that the required risk management measures have been undertaken prior to export and that the consignment meets Australia's import requirements.

Each phytosanitary certificate must include:

- a description of the consignment (including traceability information);
- details of disinfection treatments (for example, methyl bromide fumigation) which includes date, concentration, temperature, duration, and/or attached fumigation certificate (as appropriate);
- any other statements that may be required such as identification of the consignment as being sourced from a recognised pest free area.

### **5.2.7 Phytosanitary inspection by the Department of Agriculture, Fisheries and Forestry**

The objectives of this recommended procedure are to ensure that:

- consignments comply with Australian import requirements;
- consignments are as described on the phytosanitary certificate; and
- quarantine integrity has been maintained.

On arrival in Australia, the department will:

- assess documentation to verify that the consignment is as described on the phytosanitary certificate, that required phytosanitary actions have been undertaken, and that product security has been maintained
- verify that the biosecurity status of consignments of apples from PNW-USA meet Australia's import conditions. When inspecting consignments, the department will use random samples of 600 units or equivalent per phytosanitary certificate and an inspection method suitable for the commodity.

### **5.2.8 Remedial action(s) for non-compliance**

The objectives of remedial action(s) for non-compliance are to ensure that:

- any quarantine pest or regulated article, including trash, is addressed by remedial action, as appropriate
- non-compliance with import requirements is addressed, as appropriate.

Any consignment that fails to meet Australia's import conditions will be subject to a suitable remedial treatment where an effective treatment is available and biosecurity risks associated with applying the treatment can be effectively managed, or the imported consignment will be exported or destroyed.

Other actions including partial or complete suspension of the import pathway may be taken depending on the identity and/or importance of the pest intercepted; for example, fruit flies of economic importance or pests for which area freedom is established.

In the event that apple consignments from the USA are repeatedly non-compliant, the department reserves the right to suspend imports (either all imports or imports from specific pathways) and conduct an audit of the risk management systems. Imports will be allowed to recommence only when the department is satisfied that appropriate corrective action has been undertaken.

### 5.3 Uncategorized pests

If an organism that has not been categorised, including a contaminant pest, is detected on apples on arrival in Australia, it will require assessment by the department to determine its quarantine status and whether 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 the ALOP for Australia, then it may require reassessment. The detection of any pests of biosecurity 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.

### 5.4 Review of processes

#### 5.4.1 Verification of protocol

Prior to or during the first season of trade, the department will verify the implementation of the agreed import conditions and phytosanitary measures including registration, operational procedures and treatment providers, where applicable. This may involve representatives from the department visiting areas in the PNW-USA that produce apples for export to Australia.

#### 5.4.2 Review of policy

The department will review the import policy after an appropriate volume of trade has occurred. In addition, the department reserves the right to review the import policy as deemed necessary, including if there is reason to believe that the pest or phytosanitary status in PNW-USA has changed.

USDA-APHIS must inform the department immediately on detection of any new pests of apples in the PNW-USA that might be of potential biosecurity concern to Australia.

### 5.5 Meeting Australia's food laws

In addition to meeting Australia's biosecurity laws, imported food for human consumption must comply with the requirements of the *Imported Food Control Act 1992*, as well as Australian state and territory food laws. Among other things, these laws require all food, including imported food, to meet the standards set out in the Australia New Zealand Food Standards Code (the Code).

Food Standards Australia New Zealand (FSANZ) is responsible for developing and maintaining the Code. The Code is available at [foodstandards.gov.au/code/Pages/default.aspx](http://foodstandards.gov.au/code/Pages/default.aspx).

The department administers the *Imported Food Control Act 1992* which *supports the inspection and testing of imported food to verify its safety and compliance with Australia's food standards, including the Code*. This is undertaken through a risk-based border inspection program, the Imported Food Inspection Scheme. More information about this scheme is available at [awe.gov.au/biosecurity-trade/import/goods/food/inspection-compliance/inspection-scheme](http://awe.gov.au/biosecurity-trade/import/goods/food/inspection-compliance/inspection-scheme).

Standard 1.4.2 and Schedules 20, 21 and 22 of the Code set out the maximum residue limits and extraneous residue limits for agricultural or veterinary chemicals that are permitted in foods for sale, including imported food. Standard 1.1.1 of the Code specifies that a food must not have, as

an ingredient or a component, a detectable amount of an agricultural or veterinary chemical, or a metabolite or a degradation product of the agricultural or veterinary chemical, unless expressly permitted by the Code.

Certain imported food, including some minimally processed horticulture products, must be covered by a food safety management certificate to be imported into Australia. The certificate provides evidence that a food has been produced through a food safety management system. This system must have appropriate controls in place to manage food safety hazards. More information about the foods that require a food safety management certificate and how to comply is available at [awe.gov.au/biosecurity-trade/import/goods/food/safety-management-certificates](http://awe.gov.au/biosecurity-trade/import/goods/food/safety-management-certificates).

## 6 Conclusion

This risk analysis report was conducted to assess the proposal by the USDA-APHIS for market access to Australia for fresh mature apple fruit produced from the PNW-USA for human consumption.

The risk analysis was conducted in accordance with Australia's method for pest risk analysis (Appendix A), which is consistent with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for pest risk analysis* (FAO 2021a) and ISPM 11: *Pest risk analysis for quarantine pests* (FAO 2021e), and the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (WTO 1995).

In conclusion, this report recommends that the importation of commercially produced fresh apple fruit to Australia from all commercial production areas of the PNW-USA be permitted, subject to a range of biosecurity requirements outlined in Chapter 5.

The findings of this report are based on a comprehensive analysis of scientific literature and other relevant information.

The Department of Agriculture, Fisheries and Forestry considers that the risk management measures recommended in this report will provide an appropriate level of protection against the quarantine pests and regulated article identified as potentially associated with the trade of fresh apple fruit from the PNW-USA.

All fresh fruit, including fresh mature apple fruit from the PNW-USA, have been determined by the Director of Biosecurity to be conditionally non-prohibited goods under s174 of the *Biosecurity Act 2015*. Conditionally non-prohibited goods cannot be brought or imported into Australia unless they meet specific import conditions.

This report provides the basis for import conditions for fresh apple fruit from the PNW-USA for human consumption. The import conditions will be communicated on BICON. The publication of import conditions on BICON is subject to the USDA-APHIS being able to demonstrate that processes and procedures are in place to implement the required risk management measures and specific commercial production practices.

## Appendix A: Initiation and categorisation for pests of fresh apple fruit from the Pacific Northwest states of the USA

The steps in the initiation and categorisation processes are considered sequentially, with the assessment terminating at 'Yes' for column 3 (except for pests that are present, but under official control and/or pests of regional concern) or the first 'No' for columns 4, 5 or 6.

In the columns 3 and 7 of the table the acronyms 'EP', 'NT', 'RA', 'Tas.' and 'WA' are used. The acronym 'EP' (existing policy) is used in the final column (column 7) for pests that have previously been assessed by Australia and for which a policy exists. The acronym 'RA' (Regulated article) is used in the final column (column 7) for pests that are regulated articles. Refer to Section 4.14 for definition of a regulated article. The acronym of the (Australian) state and territory for which regional pests status is considered, such as 'NT' (Northern Territory), 'Tas.' (Tasmania), or 'WA' (Western Australia), is used to identify organisms that have been recorded in some regions of Australia, and, consistent with interstate quarantine regulations, are considered pests of regional concern. Similarly, acronyms of the Pacific Northwest states and other states in the United States (USA Map 2018) of relevance to a specific pest are included in column 2 of the table, such as CA (California), ID (Idaho), OR (Oregon) and WA (Washington State).

The *Final group pest risk analysis for thrips and orthotospoviruses on fresh fruit, vegetable, cut-flower and foliage imports* (DAWR 2017) and *Final group pest risk analysis for mealybugs and the viruses they transmit on fresh fruit, vegetable, cut-flower and foliage imports* (DAWR 2019) have been applied in this risk analysis. Application of group policy involves identification of up to three species of each relevant group associated with the commodity pathway. However, if any other quarantine pests or regulated articles not included in this risk analysis and/or in the relevant group policies are detected at pre-export or on arrival in Australia, the relevant group policy will also apply.

Details of the method used in this risk analysis are given in Chapter 2: Method for pest risk analysis.

For the purposes of pest categorisation, the table does not provide a comprehensive list of all pest species associated with apple production, but concentrates on pests that could be on the fresh apple fruit import pathway, and that are relevant to the proposed export areas, that is, the Pacific Northwest states of the United States of America (Idaho, Oregon and Washington). Identification of soil-borne nematodes, soil-borne pathogens, and secondary pests have not been listed, on the basis that they are not directly related to the import pathway of fresh apple fruit and would be addressed by Australia's current approach to contaminating pests.

The Pacific Northwest States of the USA (defined above) are pest free areas for all exotic fruit fly species under the Federal Regulation 7CFR301.32 (USDA-APHIS 2019) 7 CFR 301.32 with the exception of apple maggot - *Rhagoletis pomonella* Walsh, 1867. The occasional recorded presence of other fruit fly species in California is not considered to provide a justification that the pest is likely to be found on apple fruit sourced from the Pacific Northwest. For this reason, this pest categorisation does not include other fruit fly species that can elsewhere be associated with apples. However, as

discussed in Chapter 5 for Pest Risk Management, the maintenance of area freedom for all fruit flies other than *R. pomonella* will be required unless other quarantine measures are imposed.

The department is aware of the recent changes in fungal nomenclature which ended the separate naming of different states of fungi with a pleomorphic life cycle. However, as the nomenclature for these fungi is in a phase of transition and many priorities of names are still to be resolved, this report uses the generally accepted names and provides alternatively used names as synonyms, where required. As official lists of accepted and rejected fungal names become available, these accepted names will be adopted.

List of USA states: AK: Alaska, AL: Alabama, AR: Arkansas, AZ: Arizona, CA: California, CO: Colorado, CT: Connecticut, DC: District of Columbia, DE: Delaware, FL: Florida, GA: Georgia, HI: Hawaii, IA: Iowa, ID: Idaho, IL: Illinois, IN: Indiana, KS: Kansas, KY: Kentucky, LA: Louisiana, MA: Massachusetts, MD: Maryland, ME: Maine, MI: Michigan, MN: Minnesota, MO: Missouri, MS: Mississippi, MT: Montana, NC: North Carolina, ND: North Dakota, NE: Nebraska, NH: New Hampshire, NJ: New Jersey, NM: New Mexico, NV: Nevada, NY: New York, OH: Ohio, OK: Oklahoma, OR: Oregon, PA: Pennsylvania, RI: Rhode Island, SC: South Carolina, SD: South Dakota, TN: Tennessee, TX: Texas, UT: Utah, VA: Virginia, VT: Vermont, WA: Washington, WI: Wisconsin, WV: West Virginia, WY: Wyoming.

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<b>ARTHROPODS</b>						
<b>Trombidiformes</b>						
<i>Aculus malivagrans</i> (Keifer, 1946) [Eriophyidae]	Yes. Present in OR and WA (CABI 2022; Wiman & Stoven 2021b). Also present in CA (Keifer 1952)	Yes. Present in NSW, Vic and WA (APPD 2022) and Tas. (CABI 2022)	Assessment not required.	Assessment not required	Assessment not required	No
<i>Aculus schlechtendali</i>						
<i>Vasates schlechtendali</i>						
<i>Vasates malivagrans</i>						
Rust mite						

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Calepitrimerus baileyi</i> (Keifer, 1938) [Eriophyidae] Bailey's apple rust mite	No. Present in CA and SD (Briones & McDaniel 1976; Jeppson, Keifer & Baker 1975; Keifer 1952)	No. (Halliday 1998)	No. This is a foliage pest of apples (Jeppson, Keifer & Baker 1975; Keifer 1952; Vidović et al. 2014).	Assessment not required	Assessment not required	No
<i>Cenopalpus pulcher</i> (Canestrini & Fanzago, 1876) [Tenuipalpidae] Flat scarlet mite	Yes. Present in OR (Bajwa & Kogan 2001; Bajwa & Kogan 2003; USDA-APHIS 2000; Vacante 2015)	No records found	Yes. Prefers the lower leaf surface and moves to the buds for winter (Jeppson, Keifer & Baker 1975). Females deposit eggs on the striations and natural indentations of leaves and fruit, and have been observed feeding on leaves, soft twigs and fruit (Bajwa & Kogan 2003). In the west of England it was associated with quite severe russetting around the calyx and stalk ends of apples in 2006 (Green 2007).	Yes. An invasive species that is widely distributed in Europe, the Middle East, Central Asia, North Africa (CABI 2019; Vacante 2015); India (Menon, Ghai & Katiyar 1971) and Iraq (Elmosa 1971) in a variety of environments with similarities to Australia (CABI 2018).	Yes. <i>Cenopalpus pulcher</i> is an important pest in apple and other fruit crops in Asia, Europe, Africa and North America (CABI 2019; NAPPO 2008).	Yes (EP)
<i>Eotetranychus carpini borealis</i> (Ewing, 1913) [Tetranychidae] Yellow spider mite	Yes. Present in OR and WA (APHIS 2007; Wiman & Stoven 2021b)	No records found	No. Not reported on apple fruit (Baker & Tuttle 1994; Jeppson, Keifer & Baker 1975)	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Eotetranychus frosti</i> (McGregor, 1952) [Tetranychidae] Spider mite	No. Present in AZ, CA, LA, MO, ND, NY and OH (Baker & Tuttle 1994; Jeppson, Keifer & Baker 1975)	No records found	Assessment not required	Assessment not required	Assessment not required	No
<i>Eotetranychus uncatus</i> Garman, 1952 [Tetranychidae] Spider mite	No. Present in Eastern United States, UT and CA (Jeppson, Keifer & Baker 1975)	No records found	Assessment not required	Assessment not required	Assessment not required	No
<i>Eotetranychus willamettei</i> (McGregor, 1917) [Tetranychidae] Willamette spider mite	Yes. Present in OR and WA (Baker & Tuttle 1994; Hollingsworth 2018; Jeppson, Keifer & Baker 1975; Vacante 2015). Also present in CA (CABI 2022)	No records found	No. This pest feeds on apple leaves. These mites live in colonies on the upper leaf surface (Jeppson, Keifer & Baker 1975; Vacante 2015).	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Eriophyes mali</i> (Nalepa, 1926) [Eriophyidae] <i>Phytoptus mali</i> Apple blister mite	Yes. Present in OR and WA (Burts 1970). Also present in CA	No records found	No. Wiman et al. (2019) recorded that mite feeding on leaves causes reddish to yellow green blisters; blisters turn brown or black as the tissue dies later in the season; leaves may drop prematurely; loss of foliage weakens trees, reduces shoot growth, and interferes with fruit maturation and fruit bud formation. Fruit damage is caused by feeding injury to buds before bloom—mites do not reside in the blisters on fruit (Wiman & Stoven 2021).	Assessment not required	Assessment not required	No
<i>Oligonychus newcomeri</i> (McGregor, 1950) [Tetranychidae] Spider mite	Yes. Present in WA (Baker & Tuttle 1994; Vacante 2015). Also present in PA	No records found	No. This pest feeds on leaves (Jeppson, Keifer & Baker 1975; Vacante 2015).	Assessment not required	Assessment not required	No
<i>Tetranychus canadensis</i> (McGregor, 1950) [Tetranychidae] Four spotted spider-mite; Hawthorn spider mite	No. Widely distributed throughout the USA, but not reported from PNW-USA (Jeppson, Keifer & Baker 1975; Pritchard 1955)	No records found	Assessment not required	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Tetranychus mcdanieli</i> McGregor, 1931 [Tetranychidae] McDaniel spider mite	Yes. Present in ID, OR and WA (APHIS 2007; Mellott 2021)	No records found	Yes. Apple is listed as a host (Pritchard 1955). Usually stays on leaves and overwinters on tree trunk. However, they can collect around the calyx in winter (APHIS 2007).	Yes. Wide host range including deciduous tree fruit (apple ( <i>Malus</i> spp.), pear ( <i>Pyrus</i> spp.), apricot, sweet and sour cherry, peach, plum ( <i>Prunus</i> spp.) some field and vegetable crops (squash ( <i>Cucurbita</i> spp.), <i>Asparagus</i> , alfalfa ( <i>Medicago sativa</i> ), clover ( <i>Trifolium</i> spp.), and a number of weeds (mallow ( <i>Malva</i> spp.), milkweed ( <i>Asclepias</i> spp.), knotweed ( <i>Polygonum</i> spp.), ragweed ( <i>Ambrosia</i> spp.), mustard ( <i>Brassica nigra</i> ), dock ( <i>Rumex</i> spp.), wild buckwheat ( <i>Fagopyrum esculentum</i> ), wild lettuce ( <i>Lactuca</i> spp.) (Hoyt & Beers 1993). Distributed across North America in environments similar to Australia (Roy, Brodeur & Cloutier 2005)	Yes. Feeds and lays eggs on buds and fruit. An economically important pest (Roy, Brodeur & Cloutier 1999, 2005). Damage caused by this pest is significant, particularly when the hot and dry summer climatic conditions favour the development of infestations (Wiman & Stoven 2022).	Yes (EP)
<i>Tetranychus mexicanus</i> (McGregor, 1950) [Tetranychidae] Spider mite	No. Present in CA and TX (Baker & Tuttle 1994)	No records found	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Tetranychus pacificus</i> McGregor, 1919 [Tetranychidae] Pacific spider mite	Yes. Present in ID, OR and WA (APHIS 2007; Pritchard & Baker 1952)	No records found	Yes. Principally feeds on new leaf growth (APHIS 2007), with most species in this family preferring the underside of leaves as a habitat. These mites are mobile and some species in the genus are recorded in and around the stems and calyx of fruit (APHIS 2007).	Yes. Wide host range includes Australian domestic crops. Distributed in a variety of environments across North America with similarities to Australia (CABI 2019)	Yes. Damage caused by high populations feeding on leaves can adversely affect tree vitality and fruit size (CABI 2019).	Yes (EP)
<i>Tetranychus turkestanii</i> (Ugarov & Nikolskii, 1937) Synonym: <i>Tetranychus atlanticus</i> McGregor, 1941 [Tetranychidae] Strawberry spider mite	Yes. Present in ID, OR and WA (Pritchard 1955)	No records found	Yes. Apple is listed as a host (Pritchard 1955). 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.	Yes. Wide host range, primarily on a variety of low-growing hosts such as cotton ( <i>Gossypium</i> ), alfalfa ( <i>Medicago sativa</i> ), beans ( <i>Phaseolus</i> ), clover ( <i>Trifolium</i> ), and strawberry ( <i>Fragaria</i> ); vegetables such as eggplant ( <i>Solanum melongena</i> ); and ornamentals such as privet ( <i>Ligustrum</i> ), violet ( <i>Viola</i> ), and sunflower ( <i>Helianthus</i> ).	Yes. Damage caused by high populations feeding on leaves can adversely affect tree vitality and fruit size (CABI 2019). Recognized in California, Idaho, Oregon, Utah and Washington as a dominant pest (Pritchard & Baker 1952) and acknowledged as an economically important pest in temperate climates (Bailly, Migeon & Navajas 2004).	Yes (EP)

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<b>Coleoptera</b>						
<i>Anthonomus quadrigibbus</i> Say, 1831 Synonym: <i>Tachypterellus consors</i> (Dietz, 1891) [Curculionidae] Apple curculio	Yes. Present in ID, OR and WA (Burke & Anderson 1989; CABI 2021a)	No records found	Yes. It is principally an apple pest that attacks apple fruit resulting in dwarfed and misshapen fruit (CABI 2019; Metcalf, Flint & Metcalf 1962). Adults are known to feed on flower buds, blossoms and fruitlets once they have set (Burke & 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; and adults emerge and feed for a short time before seeking over-wintering sites (Burke & Anderson 1989)	Yes. Associated with a wide range of plants in the Rosaceae family although apples ( <i>Malus</i> ) and <i>Crataegus</i> species are the usual host plants. These plants occur in Australia and are distributed in a wide range of environments. Adults are strong fliers, dispersing actively in the spring, and seeking the most suitable hosts (CABI 2022)	Yes. Previously <i>A. quadrigibbus</i> was thought to be destructive to cultivated apples and pears (Brooks 1910; Hoerner & List 1952; Metcalf, Flint & Metcalf 1962). However, more recent reporting states that there is little recent information about the importance of <i>A. quadrigibbus</i> from North America, suggesting that modern control regimes have reduced it to minor pest significance (CABI 2022).	Yes
<i>Cercopedius artemisiae</i> (Pierce, 1910) Synonym: <i>Cercopaeus artemisiae</i> Pierce, 1910 [Curculionidae] Lesser sagebrush weevil	Yes. Present in ID, OR and WA (Beers 2004; Bright & Bouchard 2008; Yothers 1916)	No records found	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). It is also reported to feed on leaves (Yothers 1916).	Assessment not required	Assessment not required	No
<i>Cleonidius canescens</i> (LeConte, 1875) [Curculionidae]	Yes. Present in ID (Anderson 1987; Yothers 1916)	No records found	No. Reported destroying buds of young apple (and peach) trees in Colorado and Utah (Beers 2007b; Yothers 1916)	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Cleonidius quadrilineatus</i> (Chevrolat, 1873) [Curculionidae] Four-lined loco weevil	Yes. Present in WA (Yothers 1916)	No records found	No. Reported causing minor damage to apple buds (Beers 2007b; Yothers 1916)	Assessment not required	Assessment not required	No
<i>Conotrachelus nenuphar</i> Harris, 1841 [Curculionidae] Plum curculio	No. Present in the USA but not in PNW (CABI 2022). Although an old record exists for WA, it is not considered present in the PNW-USA. It is a pest east of Rocky mountains (Beers 2007b; EPP0 2021)	No records found	Assessment not required	Assessment not required	Assessment not required	No
<i>Evotus naso</i> (LeConte, 1857) [Curculionidae]	Yes. Present in WA (Yothers 1928)	No records found	No. Eats buds and leaves of apple trees (Yothers 1928)	Assessment not required	Assessment not required	No
<i>Lepesoma nigrescens</i> (Pierce, 1913) Synonyms: <i>Dyslobus nigrescens</i> (Pierce, 1913) <i>Melamomphus nigrescens</i> (Pierce, 1913) [Curculionidae]	Yes. Present in WA (Beers 2007b; Yothers 1914, 1916)	No records found	No. Reported destroying young buds of young apple (and peach) trees (Beers 2007b; Yothers 1914, 1916)	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Lepesoma tanneri</i> (Van Dyke, 1933) Synonym: <i>Dyslobus tanneri</i> Van Dyke, 1933 [Curculionidae]	Yes. Present in ID, OR and WA (Yothers 1916, 1941)	No records found	No. Adults reported eating or hollowing out apple buds and feeding on apple leaves (Yothers 1941)	Assessment not required	Assessment not required	No
<i>Ophryastes cinerascens</i> (Pierce, 1913) Synonym: <i>Tosastes cinerascens</i> Pierce 1913 [Curculionidae]	Yes. Present in OR and WA (Beers 2007b; O'Brien & Wibmer 1982; Yothers 1916)	No records found	No. Adults feed on the buds of 1–2 year old fruit trees (apple listed as a host) (Beers 2007b; Yothers 1916)	Assessment not required	Assessment not required	No
<i>Ophryastes geminatus</i> (Horn, 1876) Synonym: <i>Eupagoderes geminatus</i> Horn, 1876 [Curculionidae] White bud weevil	Yes. Present in ID and OR (O'Brien & Wibmer 1982)	No records found	No. Recorded attacking buds of fruit trees in early spring (Beers 2007b; Essig 1926)	Assessment not required	Assessment not required	No
<i>Otiorhynchus meridionalis</i> Gyllenhal, 1834 [Curculionidae] Lilac root weevil	Yes. Present in ID, OR and WA (O'Brien & Wibmer 1982; Warner & Negley 1976)	No records found	No. Adults recorded feeding on apple leaves in eastern Washington (Beers 2007b)	Assessment not required	Assessment not required	No
<i>Panscopus aequalis</i> (Horn, 1876) [Curculionidae] Weevil	Yes. Present in OR and WA (Beers 2004; O'Brien & Wibmer 1982; Yothers 1914, 1916)	No records found	No. Adults feed upon unfolded terminal or centre buds of 1-year-old apple trees; they also feed on sap oozing from freshly cut twigs (Beers 2007b; Yothers 1914, 1916)	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Paraptochus sellatus</i> (Boheman, 1859) [Curculionidae] Apricot leaf weevil	Yes. Present in OR and WA (Beers 2007b; Essig 1926)	No records found	No. Feeds on buds and leaves of apple (Beers 2007b; Essig 1926)	Assessment not required	Assessment not required	No
<i>Polydrusus impressifrons</i> (Gyllenhal, 1834) [Curculionidae] Leaf weevil	Yes. Present in OR and WA (O'Brien & Wibmer 1982; Parrott & Glassgow 1916; Rodstrom 2013; Sleeper 1957)	No records found	No. Adults eat foliage, especially leaf margins while some bud feeding occurs on other non-tree fruit hosts; larvae feed on tree roots (Parrott & Glassgow 1916).	Assessment not required	Assessment not required	No
<i>Rynchaenus pallicornis</i> (Say, 1831) Synonym: <i>Rhynchaenus pallicornis</i> (Say, 1831) [Curculionidae] Apple flea weevil	Yes. Present in OR and WA. Also present in CO, CT, MI, NY and PH (O'Brien & Wibmer 1982)	No records found	No. Adults eat and produce holes in newly opened 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 the leaf and extending to small blister-like cells at the leaf margin (Metcalf, Flint & Metcalf 1962).	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<b>Diptera</b>						
<i>Dasineura mali</i> Keiffer, 1904 [Cecidomyiidae] Apple leafcurling midge; apple leaf midge	Yes. Present in WA since 1994 (Antonelli & Glass 2005; LaGasa 2008)	No records found	Yes. Larvae have been recorded pupating in the calyces and stem ends of apple fruit in New Zealand (MAF Biosecurity New Zealand 2000; Smith & Chapman 1995). Larvae are known to occasionally attach their pupal cocoons to the fruit skin (Allison et al. 1995).	Yes. Host range restricted to cultivated apples (CABI 2022) and crabapples ( <i>Malus</i> 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	Yes. Apple tree shoots are damaged and tree growth is retarded resulting in decreased fruit yield in Europe and New Zealand (Smith & Chapman 1995; Tomkins et al. 1994).	Yes (EP)
<i>Drosophila suzukii</i> (Matsumura) Kamizawa, 1931 [Drosophilidae] Spotted wing drosophila (SWD), cherry drosophila, cherry fruit fly, cherry vinegar fly (CVF)	Yes. Present in OR and WA. Also present in CA, HI, UT, MI, WI, LA, NC, SC and FL (CABI 2019; Hauser 2011; USDA 2010)	No (DAFF 2013b)	No. The report by the DAFF (2013b) lists apples as non-host. There are no records of any infestation or damage on commercial apples in any area where <i>Drosophila suzukii</i> occurs. Only damaged or dropped fruit are attacked (Kanzawa 1939)	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<p><i>Rhagoletis pomonella</i> (Walsh, 1867) [Tephritidae] Apple maggot</p>	<p>Yes. Present in ID, OR and WA. Also present in CA (APHIS 2007; Beers, Antonelli &amp; LaGasa 1996; Brunner &amp; Klaus 1993; CABI 2022; EPP0 2018)</p>	<p>No records found</p>	<p>Yes. Native to North America where apple and hawthorn fruit are preferred hosts (Caprile et al. 2006b). Eggs are oviposited just below the outer skin of apple fruit. After eggs hatch, the larvae burrow in all directions within the apple flesh and emerge from the fruit once the fruit abscise (CABI 2019; Mattsson et al. 2015).</p>	<p>Yes. Since apple maggot has a wide host range including apricot, cherry, plum, (<i>Prunus</i> spp.), pear (<i>Pyrus</i>), wild rose (<i>Rosa</i> spp.), <i>Pyracantha</i> and <i>Cotoneaster</i>, and it originally fed on the fruit of wild hawthorn (<i>Crataegus</i> sp.) but has since switched to cultivated apples (<i>Malus</i>) (Weems &amp; Fasulo 2021; Yee et al. 2015), it is likely that apple maggot may be able to adapt to other host plants in the future (Beers, Antonelli &amp; LaGasa 1996). Distributed in a variety of environments across North America with similarities to Australia (CABI 2019) and adults are capable of flight (Weems &amp; Fasulo 2021).</p>	<p>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 (CABI 2019; Cornell Cooperative Extension 2000). 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, Antonelli &amp; LaGasa 1996).</p>	<p>Yes (EP)</p>

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<b>Hemiptera</b>						
<i>Acrosternum hilare</i> (Say, 1832) Synonym: <i>Chinavia hilaris</i> (Say, 1832) [Pentatomidae] Green stink bug	Yes. Present in WA (CABI 2022; McPherson & McPherson 2000). Only reported as present in North America (Plant Health Australia 2018)	No. Listed as a Declared Pest, Prohibited (section 12) (C1 Prohibited) for WA (Government of Western Australia 2020)	No. Although reported as occasionally feeding on apple fruit (Mundinger & 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. This pest is highly unlikely to be found on commercially produced and processed apples and the pest will not remain on fruit during the harvest, sorting and packing processes.	Assessment not required	Assessment not required	No
<i>Aphis gossypii</i> Glover, 1877 [Aphididae] Cotton aphid, Melon aphid	Yes. Present in ID, OR and WA (CABI 2022)	Yes. NSW, Qld, SA, NT, Tas., Vic. (Hollis & Eastop 2005). Listed as a permitted organism for WA (Government of Western Australia 2020; Plant Health Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Aphis pomi</i> DeGeer, 1773 [Aphididae] Green apple aphid	Yes. Present in ID, OR and WA (APHIS 2007; CABI 2019; Smirle et al. 2010; Wiman & Stoven 2021b)	No records found	No. Species mainly feeds on young shoots and leaves, which can result in damage to newly-formed fruit and bud clusters, leaves and stems (APHIS 2007; CABI 2022). There is no evidence that this species feeds or shelters within the calyx. Species may occasionally feed on fruit later in the season (Reding, Alston & Zimmerman 1997), but any aphids on fruit at the time of harvest would be likely to be removed during packing house processes.	Assessment not required	Assessment not required	No
<i>Aphis spiraecola</i> Patch, 1914 [Aphididae] Apple aphid, Spirea aphid	Yes. Present in ID, OR and WA (Beers, Hoyt & Willett 1993; CABI 2022; Lowery et al. 2006; Smirle et al. 2010; Wiman & Stoven 2021b)	Yes. Records found throughout Australia except NT (ALA 2018; Plant Health Australia 2018). Listed as a permitted organism for WA (Government of Western Australia 2020)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<p><i>Boisea rubrolineata</i> (Barber, 1956)  Synonym: <i>Leptocoris rubrolineatus</i> Barber, 1956  [Rhopalidae]  Western boxelder bug</p>	Yes. Present in OR and WA (Anthon 1993b; Cox 2004)	No records found	No. Primary host is boxelder, but also can attack apple fruit, causing dimples and deformations on fruit (Anthon 1993b). Considered to be present on the fruit for short feeding periods only and would be disturbed. Therefore, this pest is highly unlikely to be found on commercially produced and processed apples, as the pest will not remain on fruit during the commercial harvest, sorting and packing processes.	Assessment not required	Assessment not required	No
<p><i>Diaspidiotus perniciosus</i> (Comstock, 1881)  Synonym: <i>Quadraspidiotus perniciosus</i> (Comstock, 1881)  [Diaspididae]  San Jose scale; Californian scale</p>	Yes. Present in OR and WA (CABI 2022)	Yes. Present in WA, SA, NSW, Qld, Tas., Vic. (Plant Health Australia 2018). Previously a quarantine pest for Tasmania	Assessment not required	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Dysaphis plantaginea</i> Passerini, 1860 [Aphididae] Rosy apple aphid	Yes. Present in ID, OR and WA (APHIS 2007; CABI 2022; Wiman & Stoven 2021b)	No records found	No. Species feeds on apple leaves and young fruit in spring before migrating in summer as winged adults to alternate herbaceous hosts, such as broadleaf and narrowleaf plantain (Beers & Willett 2007). Winged adults return to apple hosts in late autumn to mate and lay overwintering eggs on the bark of twigs and branches of apple trees. Although winged adults may return to apple hosts prior to fruit harvest, there is no evidence that this species feeds on apple fruit around harvest.	Assessment not required	Assessment not required	No
<i>Edwardsiana rosae</i> (Linnaeus, 1758) [Cicadellidae] Rose leafhopper	Yes. Present in OR and WA (APHIS 2007)	No records found	No. Does not occur on fruit; leafhoppers are highly active insects that take evasive action when disturbed (APHIS 2007) 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 & Elsner 1993). This pest is highly unlikely to be found on commercially produced and processed apples, as the pest will not remain on fruit during the harvest, sorting and packing processes.	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Empoasca fabae</i> (Harris, 1841) [Cicadellidae] Potato leafhopper	Yes. Present in ID (CABI 2022)	No records found	No. Feeds on vascular tissue of growing shoot tips such as young apple tree leaves (Pfeiffer, Killian & Yoder 1999)	Assessment not required	Assessment not required	No
<i>Eriosoma lanigerum</i> (Hausmann, 1802) [Aphididae] Woolly apple aphid	Yes. Present in ID, OR and WA (APHIS 2007; CABI 2022)	Yes. Present in ACT, NSW, Tas., Vic., WA (Government of Western Australia 2020; Hollis & Eastop 2005; Plant Health Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No
<i>Eulecanium tiliae</i> (Linnaeus, 1758) [Coccidae] Nut scale, Brown gooseberry scale	Yes. Present in OR and WA (Gill 1988b)	Yes. Present in all states and territories except NT (CSIRO 2022; DPIW Tasmania 2008a; PaDIL 2018; Plant Health Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Euschistus conspersus</i> Uhler, 1897 [Pentatomidae] Stink bug	Yes. Present in WA (APHIS 2007)	No records found	No. Eggs laid in clusters on the undersides of leaves of various weed hosts. Adults migrate from herbaceous hosts to feed on tree fruit either late spring or close to harvest when hosts in uncultivated areas dry up. Adults overwinter beneath weeds or honeysuckle on the orchard floor or in brush piles or bin stacks. Adults are easily disturbed and feed on fruit for short periods only; nymphs feeding on pome fruit do not survive for any length of time (Krupke 2007; Krupke & Brunner 2008). This pest is highly unlikely to be found on commercially produced and processed apples, as damaged fruit will be discarded during the harvest, sorting and packing process.	Assessment not required	Assessment not required	No
<i>Fieberiella florii</i> (Stål, 1864) [Cicadellidae] North American leafhopper; Privet leafhopper; Cherry leafhopper	Yes. Present in OR and WA) (Oman 1969; Swenson 1974)	Yes. Present in ACT (Plant Health Australia 2018)	No. Overwinter as nymphs on crabapple and apple or as eggs on deciduous fruit trees (Van Steenwyk, Daane & Grant 2006). Not likely to be associated with the mature apple fruit pre-harvest as it prefers to feed on cherry (Van Steenwyk, Daane & Grant 2006)	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Halyomorpha halys</i> (Stål, 1855) [Pentatomidae] Brown marmorated stink bug	Yes. Present in ID, OR and WA (CABI 2022; EPPO 2018; LaBonte, Mudge & Johnson 2005; Nielsen & Hamilton 2009)	No. Intercepted but not established (Plant Health Australia 2018)	No. Eggs are laid on the undersides of leaves; adults and nymphs are sap suckers that are known to feed on apple fruit (Gyeltshen, Bernon & Hodges 2010). However, nymphs and adults are considered to be present on fruit for short periods only. They are easily disturbed, and are unlikely to remain on the fruit when disturbed during harvesting and packing processes. In addition, fruit damaged by adults and nymphs become distorted (Gyeltshen, Bernon & Hodges 2010) and would not be picked during harvest, minimising the chance of this pest in commercial apple shipment.	Assessment not required	Assessment not required	No
<i>Hyalopterus pruni</i> (Geoffroy, 1762) [Aphididae] Mealy plum aphid	Yes (Beers et al. 1993a)	Yes. Qld, SA, Vic., Tas. (Hollis & Eastop 2005; Plant Health Australia 2018), Listed as a Declared Pest, Prohibited (section 12) (C1 Prohibited) for WA (Government of Western Australia 2020)	No. Not associated with apple (Wiman & Stoven 2022). Overwintering eggs are laid in crevices on twigs. Adults and nymphs feed on the undersides of leaves, causing leaves to curl. The species migrates from tree fruit to summer hosts, which include weeds, ornamental plants and vegetables before returning to fruit hosts in spring to lay eggs (Beers et al. 1993a). However, there is no evidence that the aphids are directly associated with the fruit.	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Lygus elisus</i> Van Duzee, 1914 [Miridae] Lucerne plant bug	Yes (Anthon 1993a; Seymour et al. 2005)	No records found	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. The most important damage occurs when adults feed on flower parts or young fruit. This kills some cells in the fruit, which fail to grow, leaving the fruit deformed with deep pits. Females deposit eggs in young fruit causing shallow pitting and deformity, but the species is not as common as <i>Lygus lineolaris</i> in attacking tree fruit (Anthon 1993a).	Yes. Polyphagous bug feeding on <i>Medicago sativa</i> (alfalfa), <i>Melilotus officinalis</i> (sweet clover), <i>Verbascum</i> spp. (mullein), <i>Salsola tragus</i> (Russian thistle), <i>Bassia</i> spp. (smotherweed), <i>Conyza</i> spp. (horseweed), <i>Brassica</i> spp. (wild mustards), <i>Ambrosia psilostachya</i> (western ragweed), <i>Chrysothamnus</i> spp. (rabbitbrush) and <i>Artemisia</i> spp. (sagebrush). <i>Lygus elisus</i> will also attack apples, pears, peaches and apricots (Anthon 1993a) and move from host to host. Distributed throughout the USA and southern Canada (Anthon 1993a) in a variety of environments with similarities to parts of Australia.	Yes. Nymphs and adults suck plant juices from host plants; lygus bugs cause the most serious damage by feeding on fruit causing round pits or irregularly-shaped depressions in apple (Caprile et al. 2009a). Lygus bugs may be present in large numbers but cause no damage, but they can also attack apple fruit at any time from petal fall to harvest (Caprile et al. 2006c). Preventative treatments are costly and are not always effective, since lygus bugs are quick to develop resistance (Caprile et al. 2006c).	Yes (EP)

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<p><i>Lygus hesperus</i> Knight, 1917 [Miridae] Western tarnished plant bug</p>	<p>Yes. Present in ID, OR and WA (Anthon 1993a; CABI 2022)</p>	<p>No records found</p>	<p>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 1993a).</p>	<p>Yes. Polyphagous bug feeding on same hosts as <i>L. elisus</i> but prefers <i>Kochia scoparia</i> (Mexican fireweed) (Anthon 1993a). Distributed throughout the USA and southern Canada (Anthon 1993a) in a variety of environments with similarities to parts of Australia.</p>	<p>Yes. Nymphs and adults suck plant juices from host plants; lygus bugs cause the most serious damage by feeding on fruit causing round pits or irregularly-shaped depressions in apple (Caprile et al. 2009a). Lygus bugs may be present in large numbers but cause no damage, but they can also attack apple fruit at any time from petal fall to harvest (Caprile et al. 2006c). Preventative treatments are costly and are not always effective, since Lygus bugs are quick to develop resistance (Caprile et al. 2006c).</p>	<p>Yes (EP)</p>

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Lygus lineolaris</i> (Palisot de Beauvois, 1818) [Miridae] Tarnished plant bug	Yes. Present in ID, OR and WA (Anthon 1993a; CABI 2022)	No records found	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. The most important damage occurs when adults feed on flower parts or young fruit. This kills some cells in the fruit, which fail to grow, leaving the fruit deformed with deep pits. Females deposit eggs in young fruit causing pitting and deformity (Anthon 1993a).	Yes. A polyphagous bug with three generations a year and a partial fourth generation in the PNW (Anthon 1993a) that will also attack apples, pears, peaches and apricots and move from host to host (Anthon 1993a). Distributed throughout the USA and southern Canada (Anthon 1993a) in a variety of environments with similarities to parts of Australia.	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 1993a; Bentley & Day 2006; Caprile et al. 2009a). Known to cause economic losses in apples in Idaho (Colt et al. 2001)	Yes (EP)
<i>Myzus (Nectarosiphon) persicae</i> (Sulzer, 1776) [Aphididae] Peach green aphid	Yes. Present in ID, OR and WA (CABI 2022; Capinera 2008)	Yes. Present in NSW, NT, Qld, Vic., Tas. (Plant Health Australia 2018). One record indicates its presence in the ACT (Plant Health Australia 2018). Listed as a permitted organism for WA (Government of Western Australia 2020)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Parlatoria pergandii</i> Comstock, 1881 [Diaspididae] Chaff scale	Yes. Present in WA (Davidson & Miller 1990). Also present in AL, CA, CT, DC, FL, GA, HI, IL, IN, KS, LA, MD, MA, MS, MO, NJ, NY, NC, OH, OK, PA, SC, TX and VA (Miller & Gimpel 2009)	Yes. Qld (Plant Health Australia 2018); Listed as a Declared Pest, Prohibited (section 12) (C1 Prohibited) for WA (Government of Western Australia 2020). One record each for Vic. and NT (Plant Health Australia 2018)	Yes. Apple is listed as a minor host (CABI 2022). Found mainly on leaves, but sometimes also on bark, twigs and fruit (Watson 2022). It is primarily a citrus pest and has a decided shade preference, commonly being found on fruit often in the inner, shady part of the canopy (Watson 2022)	Yes. Restricted host range, most commonly found on <i>Citrus</i> (Williams & Watson 1988) and already established in Queensland (Smith, Beattie & Broadley 1997); easily dispersed by wind and plant material (Williams & Watson 1988)	Yes. Causes green spots on fruit, making them unsuitable for the fresh fruit market (Cartwright & Browning 2008). Listed as a serious and widespread pest (Miller & Davidson 1990).	Yes (WA)
<i>Parthenolecanium corni</i> (Bouché, 1844) [Coccidae] European fruit lecanium scale; brown scale; plum scale	Yes. Present in WA (Smith 2001)	Yes. Minimal records for Vic. and Tas. (Plant Health Australia 2018). Listed as a Declared Pest, Prohibited (section 12) (C1 Prohibited) for WA (Government of Western Australia 2020)	No. Crawlers feed on leaves and return to twigs and branches before autumn (Gill 1988a). 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).	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Phenacoccus aceris</i> (Signoret, 1875) [Pseudococcidae] Apple mealybug	Yes. Present in OR and WA (Beers 2007a, 2008; CABI 2022)	No records found	Yes. Eggs are found on the trunk, twigs or leaves of apple; crawlers disperse to leaves, twigs, leaf axils and fruit to feed, and can also feed on fruit often around the calyx (Beers 2007a, 2008). Second instar nymphs overwinter in cocoons under bark or in bark cracks in colder northern regions (Beers 2007a).	Yes. A very broad host range, including deciduous fruit and nut trees such as apple ( <i>Malus</i> ), pear ( <i>Pyrus</i> ), apricot, cherry, plum ( <i>Prunus</i> spp.), hazelnut ( <i>Corylus</i> ), grape ( <i>Vitis vinifera</i> ), currant, gooseberry ( <i>Ribes</i> spp.), blueberry ( <i>Vaccinium</i> ), many shade trees, maple ( <i>Acer</i> ), oak ( <i>Quercus</i> ), birch ( <i>Betula</i> ), willow ( <i>Salix</i> ), ash ( <i>Fraxinus</i> ), linden ( <i>Tilia</i> ), elm ( <i>Ulmus</i> ), rowan ( <i>Sorbus</i> ) and various ornamentals ( <i>Cotoneaster</i> , <i>Pyracantha</i> , <i>Spirea</i> , hawthorn ( <i>Crataegus</i> ) and quince ( <i>Cydonia oblonga</i> ) (Beers 2007a). All of these plants are widely distributed in Australia. It is present in USA states where climatic conditions similar to those in Australia exist. It is likely that this species could establish in Australia.	Yes. Apple mealybug is a known vector of <i>Little cherry virus</i> (Beers 2008; Raine, McMullen & Forbes 1986), which is regulated in British Columbia. The virus has been widespread and devastating in Kootenay (British Columbia) cherry growing region (Beers 2007a; Rott & Jelkmann 2001). It is also a known vector of <i>Grapevine leafroll-associated virus-1</i> and <i>-3</i> (GLRaV-1 and -3) in France and Italy where it is considered as becoming a serious pest (Sforza, Boudon-Padieu & Greif 2003).	Yes. Mealybug group PRA applied (DAWR 2019)

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Pseudococcus calceolariae</i> (Maskell, 1879) [Pseudococcidae] Citrophilus mealybug; Scarlet mealybug	No. Present in CA and LA (CABI 2022; García Morales et al. 2016)	Yes. Qld, NSW, SA, Tas, Vic. (Plant Health Australia 2018); Listed as a Declared Pest, Prohibited (section 12) (C1 Prohibited) organism for WA (Government of Western Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pseudococcus comstocki</i> (Kuwana, 1902) [Pseudococcidae] Comstock's mealybug	No. Present in USA in AL, CA, CT, DE, DC, GA, IL, IN, LA, ME, MD, MA, MI, MO, NH, NJ, NY, OH, PA, SC, TX, VA and WV (CABI 2022; García Morales et al. 2016)	No records found	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Pseudococcus maritimus</i> (Ehrhorn, 1900) [Pseudococcidae] Grape mealybug	Yes. Present in ID, OR and WA (APHIS 2007; García Morales et al. 2016)	No records found. (Williams 1985) states that <i>P. maritimus</i> is not known to occur in Australia but is a misidentification for <i>P. affinis</i> , <i>P. calceolariae</i> and <i>P. longispinus</i> . However, (Williams & Granara de Willink 1992) state that <i>P. maritimus</i> is common in Australia and the USA. According to Gimpel (1996), there are no correct records of <i>P. maritimus</i> outside the New World. Listed as a Declared Pest, Prohibited (section 12) (C1 Prohibited) for WA (Government of Western Australia 2017).	Yes. Feeding occurs primarily on the leaves, but adult females migrate to the trunk for oviposition (García Morales et al. 2016). Recognised as a sporadic pest of minor importance, the second generation of this pest may be associated with fruit (Burts & 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).	Yes. Wide host range on many cultivated and ornamental plants from 44 families (García Morales et al. 2016), most of which occur throughout Australia. Present in Idaho, Oregon and Washington (APHIS 2007; García Morales et al. 2016), where climatic conditions are similar to those in parts of Australia. 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. Mealybug group PRA applied (DAWR 2019)

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<b>Hymenoptera</b>						
<i>Ametastegia glabrata</i> (Fallén, 1808) [Tenthredinidae] Dock sawfly	Yes. Present in OR and WA (APHIS 2007)	Yes. Vic. (Malipatil, Naumann & Williams 1995) – recent introduction probably widespread in Victoria. Listed as a Declared Pest, Prohibited (section 12) (C1 Prohibited) for WA (Government of Western Australia 2017)	No. After feeding, larvae seek out hollow stems, soft wood or fruit, including fruit of apple to form pupal cells (Malipatil, Naumann & Williams 1995). However, according to APHIS (2007), commercial fruit are unlikely to be a pathway as the pest will not remain in apples due to the commercial production and processing practices in place.	Assessment not required	Assessment not required	No
<i>Caliroa cerasi</i> (Linnaeus, 1758) [Tenthredinidae] Pear and cherry slugworm	Yes. Present in ID, OR and WA (CABI 2019)	Yes. NSW, Tas., Vic., SA (Plant Health Australia 2018). Listed as a permitted organism for WA (Government of Western Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No
<i>Hoplocampa testudinea</i> (Klug, 1816) [Tenthredinidae] (European apple sawfly)	No. Not present in PNW-USA (Graf, Höpli & Höhn 2001; Looney & LaGasa 2013)	No records found	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<b>Lepidoptera</b>						
<i>Acleris holmiana</i> (Linnaeus, 1758) Synonym: <i>Croesia holmiana</i> (Linnaeus, 1758) [Tortricidae] Golden leafroller	Yes. Present in WA (LaGasa 1996)	No records found	No. Larvae feed on leaves (LaGasa 1996). The larva spins several leaves together from which it feeds on. It lives on a range of rosaceous trees including apple ( <i>Malus</i> ) (de Prins & Steeman 2008; Kimber 2009).	Assessment not required	Assessment not required	No
<i>Archips argyrospila</i> (Walker, 1863) [Tortricidae] Fruit tree leafroller	Yes. Present in OR and WA (APHIS 2007)	No records found	Yes. A native American species whose larvae primarily feed on the lower surface of leaves, usually in groups (APHIS 2007; Brunner 1993). Larvae can damage fruit throughout the growing season causing fruit drop or deep scarring and severe deformation (Brunner 1993; Wiman & Stoven 2022).	Yes. Wide host range including apricot, cherry, plum ( <i>Prunus</i> spp.), pear ( <i>Pyrus</i> ), apple ( <i>Malus</i> ), quince ( <i>Cydonia</i> ), raspberry, loganberry, blackberry ( <i>Rubus</i> ), currant, gooseberry ( <i>Ribes</i> spp.), English walnut ( <i>Juglans regia</i> ), ash ( <i>Fraxinus</i> ), box elder ( <i>Acer negundo</i> ), elm ( <i>Ulmus</i> ), locust ( <i>Robinia</i> ), oak ( <i>Quercus</i> ), poplar ( <i>Populus</i> ), willow ( <i>Salix</i> ) and rose ( <i>Rosa</i> ), and distributed across North America in environments similar to those found in Australia (Bentley & Day 2006; Caprile et al. 2006c; Deland et al. 1993; Pickel et al. 2017).	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 & Day 2006; Berry 1998c; Pickel et al. 2017) or shallow cavities or deep bronze-coloured scars with roughened, netlike surfaces on apple fruit (Caprile et al. 2006d).	Yes (EP)

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Archips fuscocupreanus</i> Walsingham, 1900 [Tortricidae] Apple tortrix	Yes. Present in WA (Maier 2007a)	No records found	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 graze young fruit (Maier 2003, 2007a). It is not a pest of mature fruit (CABI 2019). Therefore, this pest is highly unlikely to be found on commercially produced apples.	Assessment not required	Assessment not required	No
<i>Archips podana</i> (Scopoli, 1763) [Tortricidae] Great brown twist moth, Large fruit tree tortrix	Yes. Present in WA (CABI 2022)	No records found	Yes. An introduced European species. Attacks leaves and buds early in the season; later in the season, early instar larvae can cause skin damage to mature fruit (Dickler 1991). Eggs are laid in batches on the upper surface of leaves and larvae continue to feed on the fruit (Cuthbertson & Murchie 2005). Third instar larvae hibernate in a cocoon at the base of the leaves or at a branch axil on rolled leaves (Wiman & Stoven 2022).	Yes. Wide host range feeding on the foliage, flowers and fruit of a wide variety of deciduous trees, including apple ( <i>Malus</i> ), pear ( <i>Pyrus</i> ), plum, cherry, apricot ( <i>Prunus</i> spp.), blackthorn ( <i>Prunus spinosa</i> ), black currant ( <i>Ribes nigrum</i> ), raspberry ( <i>Rubus</i> ), hop ( <i>Humulus lupulus</i> ), rhododendron ( <i>Rhododendron</i> ), rose ( <i>Rosa</i> ) and occasionally conifers (BugGuide 2022; Kimber 2022).  It is an introduced species widely distributed across Europe, Canada, and USA with environments similar to those found in parts of Australia (CABI 2019; Safonkin & Triseleva 2005).	Yes. Larval feeding on fruit reduces marketability (CABI 2019). It is considered one of the most harmful leafroller moths on apples and other fruit trees (Tesanovic & Spasic 2013).	Yes (EP)

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Archips rosana</i> (Linnaeus, 1758) Synonym: <i>Archips rosanus</i> (Linnaeus, 1758) [Tortricidae] European leafroller	Yes. Present in OR and WA (APHIS 2007; Berry 1998b; Hollingsworth 2008)	No records found	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 & Ulenberg 2000). Early instar larvae cause skin damage to mature fruit (Dickler 1991) and fruit in contact with leaves are nibbled quite deeply in spring in Europe.	Yes. Wide host range, the primary hosts being apple ( <i>Malus</i> ), pear ( <i>Pyrus</i> ), hawthorn ( <i>Crataegus</i> ), cherry, plum ( <i>Prunus</i> spp.) currant ( <i>Ribes</i> ) as well as privet ( <i>Ligustrum</i> ), and widely distributed across Europe and localised areas in North America with environments similar to those in parts of Australia (Brunner 1993; CABI 2019).	Yes. Larvae feed on buds resulting in fruit loss (Brunner 1993; CABI 2019). 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 fruit (Wiman & Stoven 2022). Larvae also feed on leaves and roll them.	Yes (EP)
<i>Argyresthia conjugella</i> (Zeller, 1839) [Yponomeutidae] Apple fruit moth	Yes. Present in WA (LaGasa 2008)	No records found	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).	Yes. Principal hosts are apple ( <i>Malus</i> ) and rowan ( <i>Sorbus aucuparia</i> ) which are present throughout temperate Australia, (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) leading to crop losses or reduced marketability and subsequent economic loss to growers.	Yes (EP)

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<p><i>Argyrotaenia franciscana</i> (Walsingham, 1879)  Synonyms: <i>Argyrotaenia citrana</i> (Fernald, 1889); <i>Eulia citrana</i> (Fernald, 1889); <i>Argyrotaenia kearfotti</i> Obraztsov, 1961  [Tortricidae]  Orange tortrix, Tortrix citrana</p>	<p>Yes. Present in OR and WA (Berry 1998d; CABI 2022)</p>	<p>No records found</p>	<p>Yes. Larvae are known as apple skinworms because of their surface feeding habit which causes fruit scarring (Zalom &amp; 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. 2006c).</p>	<p>Yes. Wide host range including raspberry, blackberry, boysenberry, loganberry, youngberry, blueberry, salmonberry (<i>Rubus</i> spp.), apple (<i>Malus</i>), peach, apricot (<i>Prunus</i> spp.), grape (<i>Vitis vinifera</i>) and weeds such as pigweed (<i>Portulaca oleracea</i>) and lambsquarter (<i>Chenopodium album</i>) and localised to PNW states with similar environments being found in parts of Australia (Berry 1998d; Caprile et al. 2006c; Heppner 2004).</p>	<p>Yes. Larvae of this leafroller feed on developing buds and leaves of cane fruit, tree fruit, 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 1998d). Orange tortrix is an important pest on apples as well as many other fruit crops, for example avocado, in the western United States (Phillips et al. 2009; Walker 2004; Zalom &amp; Pickel 1988). In apple orchards even fairly low population densities can result in significant fruit damage making the fruit unmarketable (Walker &amp; Welter 2001).</p>	<p>Yes (EP)</p>

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Choreutis pariana</i> (Clerck, 1759) Synonym: <i>Eutromula pariana</i> (Clerck, 1759) [Choreutidae] Apple-and-thorn skeletonizer	Yes. Present in OR and WA (APHIS 2007)	No records found	No. Eggs are laid in small batches on the undersides of leaves. Larvae feed on the undersides of leaves before moving to feed on the upper leaf surface, often tying the sides together creating a 'rolled' effect. Feeding results in the leaves being skeletonized. Larvae pupate in the leaf rolls, which eventually drop to the ground (Hollingsworth 2008).	Assessment not required	Assessment not required	No
<i>Choristoneura rosaceana</i> (Harris, 1841) [Tortricidae] Oblique-banded leafroller	Yes. Present in OR and WA (APHIS 2007; CABI 2022; EPPO 2018)	No records found	Yes. A native North American species that usually feeds on the lower surface of leaves, and usually in groups (APHIS 2007; Fadamiro 2004). Occasionally, larvae may eat portions of young fruit, causing damaged fruit to abort or be deeply scarred and severely deformed (Brunner 1993). First instar larvae crawl to protected locations including under the calyx of a fruit after hatching (Gilligan & Epstein 2014b).	Yes. Wide host range and distributed across North America in similar environments to parts of Australia (Bentley & Day 2006; CABI 2019; Caprile et al. 2006c; Coates et al. 2009; Pickel et al. 2017; Wilkinson, Landis & Gut 2004)	Yes. Major pest of apple worldwide (CABI 2019); larval feeding results in scarring and distorted fruit reducing marketability and severe attack can result in young fruit aborting (Bentley & Day 2006; Brunner 1993; Caprile et al. 2006c; Coates et al. 2009; Pickel et al. 2017; Wilkinson, Landis & Gut 2004). Not previously considered an important pest as cover sprays provided effective control, but insecticide resistance has dictated a need for specific control measures (Fadamiro 2004).	Yes (EP)

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Cydia pomonella</i> (Linnaeus, 1758) [Tortricidae] Codling moth	Yes. Present in ID, OR and WA (APHIS 2007; Brunner 2018; CABI 2019)	Yes. Present in all states and territories except WA (Nielsen, Edwards & Rangsi 1996). Listed as a Declared Pest, Prohibited (section 12) (C1 Prohibited) for WA (Government of Western Australia 2020)	Yes. This is a pest of apples (Caprile et al. 2006a). Larvae bore internally in apple fruit (APHIS 2007).	Yes. Main hosts are apples and pears. Larvae are known to be polyphagous and feed on apple ( <i>Malus</i> ), pear ( <i>Pyrus</i> ), plum ( <i>Prunus</i> ) and walnut ( <i>Juglans regia</i> ) (CABI 2019). Suitable hosts are widespread in Western Australia. Several outbreaks have occurred in Western Australia and have been successfully eradicated (Government of Western Australia 2017), 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 2019). Larvae damage developing shoots and fruit. Severe damage can occur causing a reduction in marketability of fruit (Caprile et al. 2006c; Lacey et al. 2006).	Yes (EP, WA)
<i>Datana ministra</i> (Drury, 1773) [Notodontidae] Yellow-necked caterpillar	Yes. Present in OR and WA (APHIS 2007)	No records found	No. Feeds on leaves, (APHIS 2007) and is not known to occur on apple fruit. Major host is round leaf service berry ( <i>Amelanchier sanguinea</i> ) (APHIS 2007).	Assessment not required	Assessment not required	No
<i>Graphiphora augur</i> (Fabricius, 1775) [Noctuidae] Double dart moth	Yes. Present in WA (Loggers & Shepard 2010); reported to be rare in the interior dry regions of WA, OR and ID (Crabo et al. 2021; Fauske 2007)	No records found	No. Larvae feed on leaves of many host species (BugGuide 2021). There is no evidence that the species feeds on apple fruit (Mazzei, Reggianti & Pimpinelli 2008)	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<p><i>Grapholita (Aspila) molesta</i> (Busck, 1916). Synonym: <i>Cydia molesta</i> Busck, 1916 [Tortricidae] Oriental fruit moth</p>	Yes. Present in WA (Botha et al. 2006; CABI 2022)	Yes. Present in NSW, Qld, SA, Tas., Vic. (EPPO 2018; Nielsen, Edwards & Rangsi 1996). Listed as a Declared Pest, Prohibited (section 12) (C1 Prohibited) for WA (Government of Western Australia 2020)	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, Hull & Krawczyk 2006a, b, c, 2007).	Yes. Wide host range, distributed globally, present in all Australian states except WA and NT (Barcenas, Unruh & Neven 2005; Bentley & Day 2006; CABI 2019; Gencsoylu et al. 2006)	Yes. Serious international pest especially of peaches, nectarines and apricots (CABI 2019; Rothschild & Vickers 1991) and in recent years its incidence on apples has increased (Botha et al. 2006). Attacks on fruit considerably reduce their quality and; therefore, their market value (Botha et al. 2006). Oriental fruit moth can cause economic damage at relatively low population densities (Botha et al. 2006) and it could have significant consequences if it was introduced into Western Australia.	Yes (EP, WA)
<p><i>Grapholita packardi</i> Zeller, 1875 Synonym: <i>Cydia packardi</i> (Walsh, 1868) [Tortricidae] Cherry fruitworm</p>	Yes. Present in OR and WA (Barcenas, Unruh & Neven 2005; CABI 2022)	No records found	Yes. Larvae are internal fruit feeders of apples and pears in North America (Barcenas, Unruh & Neven 2005).	Yes. Wide host range, distributed across the USA and localised in Canada in environments similar to parts of Australia (Barcenas, Unruh & Neven 2005; CABI 2019)	Yes. A pest in PNW-USA blueberry fields that can cause up to 25% of the berries to be destroyed or rendered unmarketable (DeFrancesco 2004).	Yes (EP)

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<p><i>Grapholita prunivora</i> (Walsh, 1868)  Synonym: <i>Cydia prunivora</i> (Walsh, 1868)  [Tortricidae]  Lesser appleworm or plum moth</p>	<p>Yes. Present in OR and WA (APHIS 2007; CABI 2022)</p>	<p>No records found</p>	<p>Yes. Larvae bore internally in apple fruit which may result in some fruit drop; larvae pupate in the ground (APHIS 2007).</p>	<p>Yes. Hosts include apple (<i>Malus</i>), stone fruit (<i>Prunus</i> spp.), service berries (<i>Amelanchier</i>), pears (<i>Pyrus</i>), roses (<i>Rosa</i>), hawthorns (<i>Crataegus</i>) and elms (<i>Ulmus</i>), all of which are widespread in Australia; distributed across USA and Canada in environments similar to parts of Australia (Barcenas, Unruh &amp; Neven 2005; CABI 2019).</p>	<p>Yes. Larvae eat fruit by hollowing out superficial galleries under the skin, which remain intact at first, but then wrinkle, turn brown and pest excrement accumulates in the calyx end of the fruit, but they may also be found near the peduncle or around the apple (CABI 2019). This results in the fruit being unmarketable.</p>	<p>Yes (EP)</p>

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Hedya nubiferana</i> (Haworth, 1811) Synonym: <i>Hedya dimidioalba</i> (Retzius, 1783) [Tortricidae] Green budworm	Yes. Present in WA (LaGasa 1996).	No records found	No. 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 and rarely on fruit, which are seldom damaged by larval feeding (Ovsyannikova & Grichanov 2005a). The caterpillar hibernates in bud axils or cracks in tree bark, and it pupates inside a cocoon in a rolled-up leaf (Kimber 2022). Young larvae may feed on fruitlets causing deformation and scarring (Wiman & Stoven 2022) and may nibble the skin of late apples. This pest is highly unlikely to be found on commercially produced apples, as the pest will not remain on fruit during the harvest, sorting and packing process.	Assessment not required	Assessment not required	No
<i>Hemithea aestivaria</i> (Hübner, 1799) [Geometridae] European common emerald	Yes. Present in WA (LaGasa 1996; Schuble 2013)	No records found	No. Larvae feed on apple leaves (Duncan 2006; Kimber 2009; LaGasa 1996)	Assessment not required	Assessment not required	No
<i>Hyalophora cecropia</i> (Linnaeus, 1758) [Saturniidae] Cecropia silkworm	Yes. Present in WA (Opler, Lotts & Naberhaus 2009)	No records found	No. Eggs are laid on both sides of the leaves of small host trees or shrubs; larvae feed on the leaves of various trees and shrubs including apples ( <i>Malus</i> ) (Gallice 2017; Opler, Lotts & Naberhaus 2009)	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Hyphantria cunea</i> (Drury, 1770) [Arctiidae] Fall webworm	Yes. Present in ID, OR and WA (APHIS 2007; CABI 2019; EPPO 2018)	No records found	No. Larvae spin webs on branches and are primarily foliage feeders, but may also feed on fruit enclosed in webs (Brunner & Zack 1993). Eggs are laid on both sides of leaves (Brunner & Zack 1993) and pupation occurs in bark crevices, leaf litter or just beneath the soil surface (Schowalter & Ring 2017). This pest is highly unlikely to be found on commercially produced apples. Damaged parts of trees are highly visible due to the presence of webbing and, as a result, damaged or infested fruit would likely be excluded from harvest. Any larvae on harvested fruit would likely be removed during packing house processes.	Assessment not required	Assessment not required	No
<i>Lacanobia subjuncta</i> (Grote & Robinson, 1868) [Noctuidae] Lacanobia fruitworm	Yes. Present in ID, OR and WA (APHIS 2007; Colt et al. 2001; Doerr, Brunner & Jones 2005)	No records found	Yes. Larvae feed directly on apple fruit by excavating holes (Doerr & Brunner 2007). Young larvae feed on the shoots, sometimes resulting in defoliation, while older larvae also feed on fruit (APHIS 2007; Bell, Antonelli & Daniels 2007; Riedl & Hilton 2007).	Yes. Wide host range feeding on a variety of plants including row crops, shrubs, trees and several weed species including dandelion ( <i>Taraxacum</i> ), bindweed ( <i>Convolvulus</i> ) and mallow ( <i>Malva</i> ) (Doerr, Brunner & Jones 2005; Landolt 1998). Occurs in North America in environments similar to parts of Australia	Yes. Although fruit injury is incidental to foliage feeding, it can be quite severe in orchards where the densities are high (Doerr & Brunner 2007) resulting in loss of production and reduction in fruit marketability.	Yes

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Lithophane antennata</i> (Walker, 1858) [Noctuidae] Green fruitworm	Yes. Present in WA (APHIS 2007)	No records found	No. Larvae feed on leaves and fruit (APHIS 2007; Riedl & Hilton 2007). This species overwinters as adults and lays eggs in the spring, with fruit feeding restricted to the later instars. Larvae drop to the soil in the first weeks of summer to pupate (Rings 1973). Mature larvae can cause slight injury to apples, causing scars to form when the apple fruit matures, and may completely eat an apple and cause premature fruit-drop (Rings 1973). This pest is highly unlikely to be found on commercially produced apples, as infested fruit will be discarded during the harvest, sorting and packing process.	Assessment not required	Assessment not required	No
<i>Lyonetia prunifoliella</i> Hübner, 1796 Synonym: <i>Lyonetia speculella</i> Clemens, 1862 [Lyonetiidae] Apple leaf miner	Yes. Present in WA (Schmitt, Brown & Davis 1996)	No records found	No. Larvae mine the leaves of various rosaceous trees including apple ( <i>Malus</i> ), forming blotch mines (Kimber 2009; Schmitt, Brown & Davis 1996).	Assessment not required	Assessment not required	No
<i>Malacosoma disstria</i> Hübner, 1822 [Lasiocampidae] Forest tent caterpillar	Yes. Present in OR and WA (APHIS 2007)	No records found	No. Feeds on leaves and does not overwinter on fruit (APHIS 2007; Meeker 2020)	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Mamestra configurata</i> Walker, 1856 [Noctuidae] Bertha armyworm	Yes. Present in ID, OR and WA (APHIS 2007; CABI 2019)	No records found	No. Eggs are laid in masses on the underside of leaves of crop plants and weeds (Berry 1998a; Hollingsworth 2008). Larvae feed on buds and leaves, chewing holes in buds and ragged holes in leaves, and also feed on growing tips, particularly on small apple trees or on the lower branches of large apple trees (Berry 1998a).	Assessment not required	Assessment not required	No
<i>Operophtera brumata</i> (Linnaeus, 1758) [Geometridae] Winter moth	Yes. Present in OR and WA (Childs, Swanson & Elkinton 2007; Kimberling, Miler & Penrose 1986; LaGasa 1996)	No records found	No. Eggs are laid in clusters on tree trunks and branches, in bark crevices, under bark scales and loose lichen. Larvae feed on leaves, buds (by tunnelling into apple buds just before or at bud break), expanding leaf clusters and fruit (Kimber 2022) from early spring. Damage to blossoms and developing fruit produces a high percentage of distorted fruit; larvae leave fruit to pupate underground before fruit reaches maturity (Childs, Swanson & Elkinton 2007; LaGasa 1996). This pest is highly unlikely to be found on commercially produced and processed apples, as infested fruit will be discarded during the harvest, sorting and packing process.	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Orgyia antiqua</i> (Linnaeus, 1758) [Lymantriidae] Rusty (European) tussock moth	Yes. Present in OR and WA (APHIS 2007)	No records found	No. Larvae feed externally on leaves, sometimes causing complete defoliation of shrubs and trees; larvae change to pupae by mid-winter and cocoons are spun on twigs, branches, crevices in bark amongst leaves, or in crevices in walls (CABI 2019; NRC 2009). Flightless females lay their eggs, in a foamy white mass, on or near empty cocoons (NRC 2009). Rarely feeds on fruit and does not overwinter on fruit (APHIS 2007).	Assessment not required	Assessment not required	No
<i>Orthosia hibisci</i> (Guenée, 1852) [Noctuidae] Speckled green fruitworm	Yes. Present in WA (Howell 1993)	No records found	No. Eggs are laid on leaves and larvae are reported to feed at first on buds, then later on flowers, leaves and fruit. In summer, mature larvae drop to the ground to pupate in the soil (Howell 1993) and are therefore not present in fruit at harvest time.	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<p><i>Pandemis cerasana</i> (Hübner, 1786)  Synonym: <i>Pandemis ribeana</i> (Hübner, 1796)  [Tortricidae]  Barred fruit tree tortrix</p>	<p>Yes. Present in OR and WA (CABI 2022; LaGasa 1996)</p>	<p>No records found</p>	<p>No. Larvae feed on leaves (Evans 1970; Gilligan &amp; Epstein 2014a), blossoms and immature apple fruitlets (LaGasa 1996), and fruit in contact with leaves. In Russia, larvae have been reported feeding on rosaceous fruit, especially apple, causing damaged ovaries (Ovsyannikova &amp; Grichanov 2005c), which results in fruit dropping or becoming deformed or rotten. This pest is highly unlikely to be found on commercially produced apples as infested fruit will be discarded during either harvest or packing house processes.</p>	<p>Assessment not required</p>	<p>Assessment not required</p>	<p>No</p>

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Pandemis heparana</i> (Denis & Schiffermüller, 1775) [Tortricidae] Dark fruit tree tortrix	Yes. Present in WA (LaGasa 1996)	No records found	No. Eggs are laid on the upper side of the leaves (Ovsyannikova & Grichanov 2005b). Larvae mostly feed on leaves, but flower and fruit feeding can cause fruit loss or blemished fruit (LaGasa 1996). Although this moth species was assessed as on the fruit pathway for Fuji apples from Japan (AQIS 1998a) and ya pear from China (AQIS 1998b), the China apple risk analysis considered that the larvae are unlikely to be on the pathway of mature apple fruit because they mainly feed on leaves. The young larvae live in small webbings, usually against a vein on the leaf underside. The older larvae spin several leaves together and feed on fruit superficially, causing shallow irregular russet marks (CABI 2022).	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Pandemis pyrusana</i> Kearfott, 1907 [Tortricidae] Pandemis leafroller	Yes. Present in ID, OR and WA (APHIS 2007; Unruh et al. 2012)	No records found	Yes. A historical pest of apples and reported from various stone fruit. Principally a leaf feeder, that also causes damage to fruit (Berry 1998c). Some larvae may eat portions of young fruit causing damaged fruit to abort or become deeply scarred and severely deformed (Brunner 1993). Eggs are laid in masses on the upper surfaces of leaves and on fruit, and economic damage is caused by feeding between clusters of fruit (Gilligan & Epstein 2014a).	Yes. Wide host range including wild plants such as cottonwood ( <i>Populus</i> spp.), rose ( <i>Rosa</i> ), willow ( <i>Salix</i> ), dogwood ( <i>Cornus</i> ), hawthorn ( <i>Crataegus</i> ), antelope brush ( <i>Purshia glandulosa</i> ), big-leaf maple ( <i>Acer macrophyllum</i> ), chokecherry ( <i>Prunus virginiana</i> ), lupine ( <i>Lupinus</i> ) and alder ( <i>Alnus</i> ), as well as apple ( <i>Malus</i> ) and cherry ( <i>Prunus</i> spp.) (Brunner 1993). Widely distributed across North America in environments similar to parts of Australia (Caprile et al. 2006c; Jones et al. 2005).	Yes. Larvae eat fruit leaving holes in fruit and leaves, causing reduction in fruit marketability. It is a key pest of apple (Caprile et al. 2006c; Dunley et al. 2006; Jones et al. 2005).	Yes (EP)
<i>Pasiphila rectangulata</i> (Linnaeus, 1758) Synonym: <i>Chloroclystis rectangulata</i> (Linnaeus, 1758) [Geometridae] Green pug moth	Yes. Present in WA (Ferguson & Mello 1996; LaGasa 1996, 2008)	No records found	No. Larvae eat buds, flowers and leaves of apple in spring. Damage to blossoms causes considerable deformation of fruit (Ferguson & Mello 1996; LaGasa 1996; Maier 2007b). This pest is highly unlikely to be found on commercially produced and processed apples, as infested fruit will be discarded during the harvest, sorting and packing process.	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Peridroma saucia</i> (Hübner, 1808) Synonym: <i>Lycophotia saucia</i> Hübner, 1808 [Noctuidae] Pearly underwing moth; variegated cutworm	Yes. Present in OR and WA (CABI 2019; Rock 1975; West & Miller 1989)	No records found	No. Eggs are laid on foliage and on stems of plants or tree trunks. Larvae are inactive during the day and remain under surface debris or loose dirt at the base of host plants and pupate (Mau & Martin Kessing 2007). Larvae have been reported feeding on apple fruit (Rock 1975); however, they are one of the few cutworm species that are known to climb the host plant to feed only during the night (Mau & Martin Kessing 2007; NCSU 1982). Therefore, this pest will not be present on fruit when they are harvested during the day.	Assessment not required	Assessment not required	No
<i>Phyllonorycter blancardella</i> (Fabricius, 1781) Synonym: <i>Lithocolletis blancardella</i> (Fabricius, 1781) [Gracillariidae] Spotted tentiform leafminer	Yes. Present in OR and WA (Landry & Wagner 1995)	No records found	No. Larvae are leaf miners of apple ( <i>Malus</i> spp.) (Landry & Wagner 1995). The eggs are laid on the underside of leaves and the larvae feed on leaves (BugGuide 2022). The pest may also feed on fruit causing premature drop (CABI 2022).	Assessment not required	Assessment not required	No
<i>Phyllonorycter elmaella</i> Doganlar & Mutuura, 1980 [Gracillariidae] Western tentiform leafminer	Yes. Present in ID, OR and WA (APHIS 2007; Beers, Brunner & Barrett 2007; Landry & Wagner 1995)	No records found	No. Eggs are laid on the undersides of leaves; larvae mine apple leaves and pupate in fallen leaves (Beers, Brunner & Barrett 2007; Simone 2004). Larvae do not feed on apple fruit (APHIS 2007).	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Phyllonorycter mespilella</i> (Hübner, 1805) [Gracillariidae] Apple leafmining moth	Yes. Present in OR and WA (Landry & Wagner 1995; Varela et al. 1997)	No records found	No. Larvae mine the leaves of various apple cultivars and crabapples ( <i>Malus</i> spp.) (Meristem Land and Science 2002) and other rosaceous plants (Borden, Lange & Madsen 1953; Landry & Wagner 1995).	Assessment not required	Assessment not required	No
<i>Platynota stultana</i> Walsingham, 1884 [Tortricidae] Omnivorous leafroller	No. Present in CA, AZ, AR, FL, HI, IL, MD, MA, MI, PA, TX and VA (CABI 2019; Flaherty et al. 1992; Gilligan, Brown & Hoddle 2011; Korycinska & Eyre 2013)	No records found	Assessment not required	Assessment not required	Assessment not required	No
<i>Recurvaria nanella</i> (Denis & Schiffermüller, 1775) [Gelechiidae] Lesser bud moth	Yes. Present in WA (LaGasa 1996)	No records found	No. Larvae of this pest feed on leaves and blossoms of apple ( <i>Malus</i> ) in early spring (Kimber 2009; LaGasa 1996).	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<p><i>Rhopobota naevana</i> (Hübner, 1814)  Synonym: <i>Rhopobota unipunctana</i> (Haworth, 1811)  [Tortricidae]  Blackheaded fireworm moth;  Holly bud moth</p>	Yes. Present in OR (Rosetta & Young 2007)	No records found	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; and larvae pupate in a cocoon spun in a folded leaf or amongst dead leaves or debris on the ground (Meijerman & Ulenberg 2000). No evidence found to suggest that this pest is associated with apple fruit in the PNW-USA.	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Spilonota ocellana</i> (Denis & Schiffermüller, 1775) [Tortricidae] Eyespotted bud moth	Yes. Present in OR and WA (APHIS 2007)	No records found	No. Moths oviposit on leaves and young shoots; larvae bore into leaves and fruit buds; and high populations may cause fruit drop or scarring due to fruit feeding, but damage is considered superficial and unimportant (CABI 2019; Swain 2016). A silken feeding tube may be spun to the surface of apple fruit (APHIS 2007) so the larvae may also feed on the fruit surface producing shallow feeding excavations (Swain 2016). This pest was assessed as associated with fruit in the IRAs for Fuji apples from Japan (AQIS 1998a) and pears from China (AQIS 1998b). However, the China apple IRA considered that this species is unlikely to be on the pathway.	Assessment not required	Assessment not required	No
<i>Spodoptera frugiperda</i> (J.E. Smith, 1797) Synonym: <i>Laphygma frugiperda</i> (J.E. Smith, 1797) [Noctuidae] Fall armyworm	No. Present in all states except AK, HI, ID, NV, OR, UT, VT, WA (CABI 2019; EPPO 2018)	Yes. Present in all the states and territories (CABI 2022)	Assessment not required	Assessment not required	Assessment not required	No
<i>Swammerdamia pyrella</i> (Villers, 1789) Synonym: <i>Swammerdamia pelicaria</i> (Retzius, 1783) [Yponomeutidae]	Yes. Present in WA (LaGasa 1996, 2008)	No records found	No. Larvae feed on the upper surface of apple and hawthorn leaves during early to late summer (Kimber 2009; LaGasa 1996).	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Tischeria malifoliella</i> Clemens, 1860 [Tischeriidae] Appleleaf trumpeter miner	No. Present in eastern USA (Byers 2006)	No records found	Assessment not required.	Assessment not required	Assessment not required	No
<i>Xestia c-nigrum</i> (Linnaeus, 1758) Synonym: <i>Amathes c-nigrum</i> (Linnaeus, 1758) [Noctuidae] Spotted cutworm; Setaceous Hebrew character	Yes. Present in ID, OR and WA (CABI 2019; Howell 1979; Howell & George 1979; Landolt 2000; Landolt & Hammond 2001)	No records found	No. Larvae feed on buds and leaves, chewing holes in buds and ragged holes in leaves as well as the growing tips on small trees or in high density plantings (Hollingsworth 2008). Larvae graze on the surface of fruit in the growing season (Howell & George 1979). Larvae feed at night, and then descend to the ground to hide during the day (CABI 2019). Therefore, this pest will not be present on fruit when they are harvested during the day.	Assessment not required	Assessment not required	No
<i>Yponomeuta malinellus</i> (Zeller, 1838) Synonym: <i>Hyponomeuta malinellus</i> (Zeller, 1838) [Yponomeutidae] Apple ermine moth	Yes. Present in OR and WA (LaGasa 1996, 2008; Unruh et al. 2003)	No records found	No. Eggs are laid on the bark of apple trees (Antonelli, LaGasa & Bay 1989). The web spinning larvae feed on apple leaves in spring, and fruit may also be deformed where they come in contact with larval webs (Kimber 2009; LaGasa 1996). Pupal cocoons are arranged in a web beneath a leaf or twig (Kimber 2009). Infested or damaged fruit will be discarded during the harvest, sorting and packing process.	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Yponomeuta padella</i> (Linnaeus, 1758) [Yponomeutidae] Cherry ermine moth; Orchard ermine	Yes. Present in WA (LaGasa 1996)	No records found	No. This species is univoltine (Noma et al. 2010; Purdue University 2013). Adults, eggs and overwintering first instar larvae are the only life stages that would be present in apple orchards at the time of harvest, but none of these life stages would be likely to be present on fruit. Female moths lay eggs in autumn on twigs and branches of hosts, which hatch into the overwintering first instar larval stage. Between spring and early summer, larvae feed gregariously under loose webs on buds, leaves and sometimes developing fruit. Pupation occurs in cocoons within the webbing and adults emerge in summer.	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<b>Thysanoptera</b>						
<p><i>Frankliniella occidentalis</i> (Pergande, 1895) Synonyms: <i>Euthrips tritici californicus</i> Moulton, 1911; <i>Frankliniella tritici maculata</i> Priesner, 1925; <i>Frankliniella tritici moultoni</i> Hood, 1914. [Thripidae] Western flower thrips</p>	Yes. Present in ID, OR and WA (CABI 2022)	Yes. Occurs in every state and ACT (Government of Western Australia 2020; Mound 2008) but absent from NT (DRDPIFR NT 2008) and under official control in Tasmania (DPIW Tasmania 2008b)	Yes. Affects leaves, and inflorescences of the plants (Frantz & Fasulo 2008a). It is associated with apple and can be associated with fruit (CABI 2020b).	Yes. A very broad host range including apple ( <i>Malus</i> ), <i>Geranium</i> (Geraniaceae), <i>Chrysanthemum</i> , cotton ( <i>Gossypium</i> ), grapes ( <i>Vitis vinifera</i> ) and citrus (CABI 2022; Frantz & Fasulo 2008a). High reproductive rate with more than one generation per year (McDonald, Bale & Walters 1998) and capable of unassisted flight (Pearsall 2002)	Yes. A pest of several economically important crop species and a known vector of <i>Tomato spotted wilt virus</i> (TSWV) (CABI 2022; Frantz & Fasulo 2008a).	Yes. Thrips group PRA applied (RA) (DAWR 2017)
<p><i>Frankliniella tritici</i> (Fitch, 1855) [Thripidae] Eastern flower thrips</p>	Yes. Present in ID, OR and WA (APHIS 2007) Also present in CA (University of California 2012) (APHIS)	No records found	Yes. Feeds on flowers (Frantz & Fasulo 2008b) and young fruit (APHIS 2007). 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 insect's mouthparts, which is necessary for transmission (de Assis Filho et al. 2005).	Yes. Wide host range including grasses, legumes, composites, crucifers as well as rose ( <i>Rosa</i> ) (Frantz & Fasulo 2008b) and distributed across North America in environments similar to parts of Australia (Stavisky et al. 2002; University of Illinois 2004).	Yes. Major pest of several fruit crops and flowers, especially roses ( <i>Rosa</i> spp.) in eastern United States (Nakahara 1997)	Yes. Thrips group PRA applied (DAWR 2017)

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<b>BACTERIA</b>						
<i>Erwinia amylovora</i> (Burrill 1882) Winslow et al. 1920, emend. Hauben et al. 1998 [Enterobacteriales: Enterobacteriaceae] Fire blight	Yes. Present in ID, OR and WA (Bonn & Van der Zwet 2000)	No. <i>Erwinia amylovora</i> was detected on <i>Cotoneaster</i> in the Melbourne Royal Botanic Garden in 1997 and its eradication was confirmed by national survey (Jock et al. 2000; Rodoni et al. 1999)	Yes. Fruit sourced from infected orchards have the potential to carry epiphytic bacteria (Hale, McRae & Thomson 1987) but endophytic infections in fruit are rare (Van der Zwet et al. 1990).	Yes. Fruit sourced from infected orchards have the potential to carry epiphytic bacteria (Hale, McRae & Thomson 1987). The bacterium is disseminated by rain or insects (Beer 1990). Suitable hosts, including apple and pear, are present in Australia. Fire blight was first 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 (Bonn 1999; Vanneste 2000). A single severe outbreak can disrupt orchard production for several years (Vanneste 2000).	Yes (EP)
<i>Gluconobacter oxydans</i> (Henneberg 1897) De Ley 1961 [Rhodospirillales: Acetobacteraceae]	No. Not present in PNW (Pscheidt & Ocamb 2019)	Yes. SA (Mateo et al. 2014)	Assessment not required	Assessment not required	Assessment not required	No
<b>CHROMALVEOLATA</b>						
<i>Phytophthora megasperma</i> Drechsler [Peronosporales: Peronosporaceae] Phytophthora root rot	Yes. Present in OR (CABI 2022)	Yes. WA (Burgess et al. 2009), Qld, SA, NSW, Vic., Tas. (Plant Health Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Phytophthora ramorum</i> Werres, De Cock & Man in't Veld [Peronosporales: Peronosporaceae] Sudden oak death (SOD)	Yes. Present in OR and WA (APHIS 2011; CABI 2022; Goheen et al. 2006)	No records found	No. The pathogen can cause leaf blight, spots, blotches and scorches as well as branch dieback and cankers; however, the fungus does not appear on fruit (Cave, Randall-Schadel & Redline 2008; Plant Health Australia 2018).	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Phytophthora syringae</i> (Berk Kleb.) Kleb. [Peronosporales: Peronosporaceae] Phytophthora fruit rot	Yes (Pscheidt & Ocamb 2019)	Yes. Vic. (Cunnington, de Alwis & Priest 2009) Records from SA (Cook & Dubé 1989) and Vic. (Washington & Nancarrow 1983) are considered to be unreliable (Cunnington, de Alwis & Priest 2009). A record from NSW was found to be <i>Phytophthora</i> <i>multivesiculata</i> (Cunnington, de Alwis & Priest 2009). Listed as a declared Pest, Prohibited (section 12) (C1 Prohibited) for WA (Government of Western Australia 2020)	No. It is a soilborne fungus affecting mostly roots and collar (Pscheidt & Ocamb 2019).	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<b>FUNGI</b>						
<i>Alternaria pomicola</i> A.S. Horne [Pleosporales: Pleosporaceae]	Yes. Present in WA (Shaw 1973)	No records found	No. Although <i>Alternaria pomicola</i> was reported to cause spots on apple fruit in Great Britain (Horne & Horne 1920), all of the reports of <i>A. pomicola</i> on apple in the USA are based on a report of this pathogen on <i>Malus sylvestris</i> in Washington (Shaw 1973). It appeared that Shaw (1973) used the name <i>M. sylvestris</i> for both domestic apple and crabapple. There have been no records of this pest on apple in the USA since 1973. Lack of recent records and the lack of information suggests that this pathogen is not an important pest of apple in the USA.	Assessment not required	Assessment not required	No
<i>Aspergillus sclerotiorum</i> G.A. Huber [Eurotiales: Trichocomaceae] Fruit rot	Yes. Present in WA (Farr & Rossman 2022)	No records found	No. Limited information available. This fungus has been isolated from the surface of apple fruit (Huber 1933). Under experimental conditions, Jonathan apples inoculated with <i>A. sclerotiorum</i> developed lesions both at ambient and cold storage temperatures (Huber 1933). However, all reports of <i>A. sclerotiorum</i> on apple in the USA are based on reports prior to 1974 (Huber 1933; Shaw 1973).	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Botrytis mali</i> Rühle [Helotiales: Sclerotiniaceae]	Yes. Present in WA (Ruehle 1931)	No records found	No. Although <i>B. mali</i> has been reported to cause fruit rot, all of the reports of <i>B. mali</i> on apple in the USA are based on only one report from Ruehle (1931).	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<p><i>Butlerellia eustacei</i> Weresub &amp; Illman</p> <p>Synonym: <i>Corticium centrifugum</i> (Lév.) Bres.</p> <p>[Atheliales: Atheliaceae]</p> <p>Fisheye rot</p>	<p>Yes. Present in WA (Farr &amp; Rossman 2018; Shaw 1973), based on a single record of the fungus on <i>Malus sylvestris</i>. Also present in eastern and northwestern states, IL, NY and VA (Farr &amp; Rossman 2018), based on an anonymous report in 1960 on <i>Malus sylvestris</i>.</p>	<p>No. A record of <i>Corticium centrifugum</i> on <i>Delphinium</i> sp. in Vic. (Chambers 1982) is probably a misidentification.</p>	<p>No. The record for <i>Butlerellia eustacei</i> on <i>Malus sylvestris</i> in the PNW-USA (Shaw (1973) is an isolated record and no recent records are available. <i>Butlerellia eustacei</i> or its teleomorphic stage <i>Corticium centrifugum</i> is not listed in the PNW Diseases Handbook and has not been recorded in recent postharvest rot surveys (Amiri &amp; Ali 2016; Kim &amp; Xiao 2008; Xiao 2007). It is primarily a saprophytic fungus that optimally grows at 18°C to 25°C (Rosenberger 1990a). The fungus lives on dead or dying apple tissue, but has also been isolated from stems of healthy apples after harvest. Overmature apples are at risk of infection in the field through wounds and lenticels, and visible decay and white mycelia develop (Rosenberger 1990a). Causes fisheye rot of apples in storage (Bielenin 1986; Rosenberger 1990a; Weresub &amp; Illman 1980). Evidence indicates this fungus is extremely rare or absent in commercially produced apples in the PNW-USA.</p>	<p>Assessment not required</p>	<p>Assessment not required</p>	<p>No</p>

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Cadophora malorum</i> (Kidd & Beaumont) W. Gams Synonym: <i>Phialophora malorum</i> (Kidd & Beaumont) McColloch [Helotiales: <i>Incertae sedis</i> ] Side rot	Yes. Present in OR and WA (Glawe 2009; WSU 2018). Also present in CA, IN, PA, VA and WV (Farr & Rossman 2018)	Yes. Tas. (ALA 2021) and (Plant Health Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No
<i>Cephalosporium carpogenum</i> Rühle [Hypocreales: <i>Incertae sedis</i> ]	Yes., Present in WA. Also present in PA (Farr & Rossman 2018; Glawe 2009)	No records found	No. Causes decay of apple fruit in storage (Fink 1958; Rosenberger 1990b; Rühle 1931). The only known hosts are species of <i>Malus</i> and <i>Pyrus</i> (Glawe 2009). <i>Cephalosporium carpogenum</i> is considered a weak pathogen of apple fruit that is found bordering insect marks or punctures and are likely to be removed during export inspection. The fungus develops slowly and appears as small shallow spots around the damaged area (Rühle 1931).	Assessment not required	Assessment not required	No
<i>Ceratobasidium ochroleucum</i> (F. Noack) Ginns & M.N.L. Lefebvre Synonyms: <i>Pellicularia koleroga</i> Cooke; <i>Corticium koleroga</i> (Cooke) Höhn. [Cantharellales: Ceratobasidiaceae] Thread blight	No (CABI 2022; Hartman 1990). Present in southeastern USA (Farr & Rossman 2018)	No records found	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<p><i>Chalastospora gossypii</i> (Jacz.) U. Braun &amp; Crous Synonyms: <i>Alternaria malorum</i> (Rühle) U. Braun, Crous &amp; Dugan; <i>Cladosporium malorum</i> Rühle [Pleosporales: Pleosporaceae]</p>	Yes. Present in WA (Farr & Rossman 2018; Glawe 2009)	No records found	No. Limited information available. All reports of this pest on apple in the USA appear to be based on an original description (Goetz & Dugan 2006). This pest (as the name <i>Cladosporium malorum</i> ) was among the 1,118 isolations from the lesions of stored Washington apples which were studied by Ruehle (1931). Inoculation tests indicated that <i>Cladosporium malorum</i> was capable of causing decay in apple (Ruehle 1931). Lack of recent records and the lack of information suggests that this pathogen is not an important pest of apple in the USA.	Assessment not required	Assessment not required	No
<p><i>Colletotrichum acutatum</i> J.H. Simmonds [Glomerellales: Glomerellaceae] Anthracnose</p>	Yes. Present in WA. Also present in AL, AR, CA, CT, FL, GA, KY, LA, MD, MA, MI, MS, MO, NC, NM, NY, OH, OK, PA, RI, SC, TN and VA (CABI 2019; EPPO 2018; Farr & Rossman 2018)	Yes. NSW, Qld, SA, Vic., WA (Plant Health Australia 2018), Tas. (Yuan 2017)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Colletotrichum gloeosporioides</i> (Penz.) Penz. & Sacc. [Glomerellales: Glomerellaceae] Anthracnose; bitter rot	Yes. Present in OR. Also present in AR, KY, NC and RI (Farr & Rossman 2021)	Yes. ACT, NSW, NT, Qld, SA, Tas, Vic., WA (Plant Health Australia 2018; Sampson & Walker 1982)	Assessment not required	Assessment not required	Assessment not required	No
<i>Coniothyrium convolutum</i> W.T. Horne [Pleosporales: Coniothyriaceae]	Yes. Present in WA (Shaw 1973)	No records found	No. Although <i>Coniothyrium convolutum</i> was reported to be associated with apple fruit in Great Britain (Horne & Horne 1920), there is only one record of this pest in the USA on <i>Malus sylvestris</i> in Washington (Shaw 1973). This report did not specify if this pest was found on apple fruit. It appeared that Shaw (1973) used the name <i>M. sylvestris</i> for both domestic apple and crabapple. There is no record of this pest on apple in the USA after 1973.	Assessment not required	Assessment not required	No
<i>Coprinopsis psychromorbida</i> (Redhead & Traquair) Redhead, Vilgalys & Moncalvo Synonym: <i>Coprinus psychromorbidus</i> Redhead & Traquair [Agaricales: Psathyrellaceae] Coprinus rot	Yes. Present in OR (Pscheidt & Ocamb 2021; Traquair 1987)	No records found	Yes. Causes post-harvest fruit rot of apple (Spotts 1990b)	Yes. It is a low temperature tolerant basidiomycete causing post-harvest rot of apple and pear (Traquair 1987). Also infects cereals, grasses and legumes causing snow mould (Spotts 1990b). Hosts are available in Australia. The fungus grows best at 15°C, but also readily grows at 2°C (Gaudet, Kokko & Sholberg 1990).	Yes. It has the potential to be a serious problem, causing significant losses (Sholberg & Gaudet 1992).	Yes

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Cryptosporiopsis corticola</i> (Edgerton) Nannf. Synonym: <i>Myxosporium corticola</i> Edgerton [Helotiales: Dermateaceae]	Yes. Present in OR and WA. Also present in IL, MI, NC, northeastern states, OK and SD (Farr & Rossman 2018; Glawe 2009)	No records found	No. A superficial bark canker (Farr & Rossman 2018; Zeller 1924) found more often on pear than apple (Zeller 1924). Not known to cause decay of fruit even when artificially inoculated (Zeller 1924)	Assessment not required	Assessment not required	No
<i>Cylindrocarpon angustum</i> Wollenw. [Hypocreales: Nectriaceae]	Yes. Present in OR (Shaw 1958, 1973; USDA 1960)	No records found	No. Found on bark (Farr et al. 1989; USDA 1960)	Assessment not required	Assessment not required	No
<i>Cylindrocarpon candidum</i> (Link) Wollenw. [Hypocreales: Nectriaceae]	Yes. Present in OR and WA (Shaw 1973)	No records found	No. All reports of this pest on apple in the USA are based on only one report of this pest (as <i>Nectria coccinea</i> ) on <i>Malus sylvestris</i> in Oregon (Shaw 1973). This report did not specify whether the pest was found on apple fruit. It appeared that Shaw (1973) used the name <i>M. sylvestris</i> for both domestic apple and crabapple. There have been no records of this pest on apple in the USA since 1973. Also, according to Booth (1977), <i>Cylindrocarpon candidum</i> is a pathogen of <i>Fagus sylvatica</i> (beech) causing beech bark disease.	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Cyphella marginata</i> McAlpine Synonym: <i>Maireina marginata</i> (McAlpine) W.B. Cooke [Agaricales: Cyphellaceae]	Yes. Present in OR and WA (Farr & Rossman 2018; Glawe 2009)	No records found	No. This fungus is known to occur on dead twigs and is not associated with the mature fresh harvested fruit of its hosts (Farr & Rossman 2018; Ginns & Lefebvre 1993).	Assessment not required	Assessment not required	No
<i>Diplodia mutila</i> (Fr.) Mont. Synonyms: <i>Botryosphaeria stevensii</i> Shoemaker; <i>Physalospora mutila</i> (Fr.) N.E. Stevens; <i>Sphaeropsis malorum</i> (Berk.) Berk. [Botryosphaeriales: Botryosphaeriaceae] Diplodia canker	Yes. Present in OR and WA. Also present in CA and MT (Farr et al. 1989; Farr & Rossman 2018; Glawe 2009)	Yes. ACT, NSW, SA, Vic., WA (Plant Health Australia 2018). Already established widely in Australia	Assessment not required	Assessment not required	Assessment not required	No
<i>Discula pyri</i> (Fuckel) Höhn. Synonym: <i>Phacidiopycnis piri</i> (Fuckel) Weindlm [Helotiales: Potebniamyces] Phacidiopycnis rot	Yes. Present in WA (Kim & Xiao 2006; Xiao et al. 2005) and OR (Pscheidt & Ocamb 2021e)	No records found	Yes. Causes fruit rot on pears, but has also been observed on apples in WA (Kim & Xiao 2006; Xiao et al. 2005; Xiao 2006). It is also associated with twig dieback and canker disease of apple and pear (DiCosmo, Nag Raj & Kendrick 1984; Xiao & Boal 2005c).	Yes. Infection of fruit with <i>Discula pyri</i> occurs in the orchard, and rot symptoms develop in storage (Xiao & Boal 2004b, a). Infection can also spread from fruit to fruit in storage (Xiao & Boal 2004b). 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 post-harvest fruit rots in d'Anjou pears in Washington State causing economic losses due to fruit rotting in storage (Xiao & Boal 2004b, a). It is much less common in apple (Kim & Xiao 2006; Xiao et al. 2005). <i>Discula pyri</i> causes twig dieback and canker disease of apple and pear (DiCosmo, Nag Raj & Kendrick 1984; Xiao & Boal 2005c).	Yes

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Dothichiza</i> sp. [Dothideales: Dothioraceae]	Yes. Present in WA (Shaw 1973)	No records found	No. All of the reports of <i>Dothichiza</i> sp. on apple in the USA are based on only one report of this pest on <i>Malus sylvestris</i> (Shaw 1973). This report does not specify whether <i>Dothichiza</i> sp. was found on apple fruit. It appeared that Shaw (1973) used the name <i>Malus sylvestris</i> for both domestic apple and crabapple. There have been no records of this pest on apple in the USA since 1973. <i>Dothichiza</i> spp. are not known as pests of apple fruit.	Assessment not required	Assessment not required	No
<i>Dothiorella sarmentorum</i> (Fr.) A.J.L. Phillips, A. Alves & J. Luque Synonym: <i>Diplodia sarmentorum</i> (Fr.:Fr.) [Botryosphaeriales: Botryosphaeriaceae]	Yes. Present in OR and WA (Farr & Rossman 2018; Glawe 2009)	Yes. SA, NSW, Vic. (Plant Health Australia 2018). Listed as a Declared Pest, Prohibited (section 12) (C1 Prohibited) for WA (Government of Western Australia 2020)	No. Found on limbs of apple (Farr et al. 1989)	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Elsinoë piri</i> (Woron.) Jenkins Variant spelling: <i>Elsinoë pyri</i> (Woron.) Jenkins [Myriangiales: Elsinoaceae] Elsinoe spot	Yes. Present in OR and WA (Shaw 1973)	Yes. NSW, Qld (Plant Health Australia 2018). Not listed as a Declared Organism for WA (Government of Western Australia 2017)	Assessment not required	Assessment not required	Assessment not required	No
<i>Epicoccum granulatum</i> Penz. [Pleosporales: Didymellaceae]	Yes. Present in WA. Also present in WV (Adams & Tamburo 1957; Shaw 1973; USDA 1960)	No records found	No. Reported to cause fruit rot (Adams & Tamburo 1957; Heald & Ruehle 1931). However, all reports of <i>E. granulatum</i> on apple in the USA are based on reports prior to 1974 (Adams & Tamburo 1957; Shaw 1973; USDA 1960). There have been no records of this pest on apple in the USA since 1973.	Assessment not required	Assessment not required	No
<i>Eutypa lata</i> (Pers.) Tul. & C.Tul. Synonyms: <i>Eutypa armeniacae</i> Hansf. & M.V. Carter; <i>Libertella blepharis</i> A.L. Sm. [Xylariales: Diatrypaceae] Eutypa dieback	No. Reported on apple in WA in 1982, but no further reports from this region (Carter 1991). Present in California, in crabapple (Gubler et al. 2009).	Yes. NSW, Qld, SA, Tas., Vic. (Plant Health Australia 2018). Listed as a Declared Pest, Prohibited (section 12) (C1 Prohibited) for WA (Government of Western Australia 2017)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Eutypella prunastri</i> (Pers.) Sacc. [Xylariales: Diatrypaceae]	Yes. Present in OR (Shaw 1973)	No records found	No. Has been reported on winter-injured apple bark in Oregon in 1925 (Zeller 1927). All reports of <i>E. prunastri</i> on apple in the USA are based on a report of this pest on <i>Malus sylvestris</i> in Washington (Shaw 1973). This report did not specify if this pest was found on apple fruit. It appeared that Shaw (1973) used the name <i>M. sylvestris</i> for both domestic apple and crabapple. Lack of recent records and the lack of information suggest that this pathogen is not an important pest of apple.	Assessment not required	Assessment not required	No
<i>Fusarium roseum</i> Link [Hypocreales: Nectriaceae]	Yes. Present in WA (Shaw 1973)	Yes. NSW, Qld, NT, Vic., WA (Plant Health Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No
<i>Fusicoccum pyrorum</i> Chupp & Clapp [Botryosphaeriales: Botryosphaeriaceae]	Yes. Present in OR (Shaw 1973; Zeller 1929)	No records found	No. Found on dieback 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 & Clapp 1923)	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Gymnosporangium clavipes</i> Cooke & Peck [Pucciniales: Pucciniaceae] Quince rust	Yes. Present in WA. Also present in AR, eastern states, MI and MS (Farr & Rossman 2018).	No. One report on <i>Crataegus monogyna</i> (English hawthorn) in Vic. (Chambers 1982), but no herbarium specimen and no record in Australia since 1982	Yes. Infects fruit of apple (Aldwinckle 1990c; Sinclair & Lyon 2005). Has been reported on <i>Crataegus douglasii</i> (black hawthorn) and <i>Juniperus communis</i> (common juniper) in Washington State (Farr & Rossman 2018)	Yes. Is heteroecious with apple as aecial host (Farr & Rossman 2018). Requires <i>Juniperus communis</i> L. (common juniper) or <i>J. virginiana</i> L. (eastern red-cedar) as an alternate host to complete its life cycle (Aldwinckle 1990c). Juniper hosts are grown as ornamentals in Australia (ABC 2008). It is dispersed by wind (Sinclair & Lyon 2005).	Yes. Quince rust is an important disease of apple in eastern North America (Aldwinckle 1990c). It is the most damaging of the <i>Gymnosporangium</i> rusts to rosaceous species (Sinclair & Lyon 2005).	Yes
<i>Gymnosporangium juniperi-virginiana</i> Schwein. [Pucciniales: Pucciniaceae] Cedar apple rust	Yes. Present in WA (Sinclair & Lyon 2005). Also present in AL, CT, eastern states, GA, IA, IN, MA, ME, MS, NH, OK, PA, RI, SD, VA, VT and CA (Farr & Rossman 2018; Sinclair & Lyon 2005)	No records found	Yes. Infects leaves, petioles and fruit (Aldwinckle 1990a). Is widespread in the USA east of the Rocky Mountains, also in California (Laundon 1977)	Yes. It is heteroecious with apple as aecial host (Farr et al. 1989). Requires eastern red cedar ( <i>Juniperus virginiana</i> L.) as an alternate host to complete its life cycle (Aldwinckle 1990a). Juniper hosts are grown as ornamentals in Australia (ABC 2008). It is dispersed by wind (Sinclair & 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 & Lyon 2005).	Yes. Cedar apple rust is the most economically important of the <i>Gymnosporangium</i> rusts (Aldwinckle 1990a; Sinclair & Lyon 2005). 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 & Lyon 2005).	Yes

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Gymnosporangium libocedri</i> (Henn.) F. Kern [Pucciniales: Pucciniaceae] Pacific Coast pear rust	Yes. Present in OR and WA. Also present in CA (Aldwinckle 1990b; Farr & Rossman 2018; PNW Handbooks 2019a; Sinclair & Lyon 2005)	No records found	Yes. Causes malformation and premature drop of fruit (Aldwinckle 1990b). Is most severe on pear, but also attacks apple (Aldwinckle 1990b)	Yes. It is heteroecious with apple as the aecial host (Farr et al. 1989). Requires incense cedar ( <i>Calocedrus decurrens</i> (Torr.) Florin) as an alternate host to complete its life cycle (Aldwinckle 1990b). <i>Calocedrus decurrens</i> , although not widespread, is grown as an ornamental in Australia (ABC 2008). Spores are dispersed by wind (Sinclair & Lyon 2005). Rosaceous hosts can become infected at distances as great as 12–16 km from infected incense cedars (Sinclair & Lyon 2005).	Yes. Has occasionally caused severe infections of pear and quince fruit in orchards in the Northwest of the USA where incense cedar was growing nearby (Sinclair & 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 1990b).	Yes
<i>Helminthosporium papulosum</i> Anth. Berg [Pleosporales: Massarinaceae] Black pox	Yes. Present in OR. Also present in southeastern USA (Glawe 2008; Grove et al. 2003; Taylor 1963)	No records found	No. This is a minor fungal disease which can affect apple bark, fruit, and foliage and causes lesions on the surface of apple fruit (Yoder 2009). The disease is more common from southern Virginia southward (Yoder 2009). If it appeared in orchards, fruit symptoms will be visible and infected fruit will be discarded during commercial harvest, sorting and packing processes.	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Hyphoderma litschaueri</i> (Burt) J. Erikss. & Å. Strid Synonym: <i>Corticium litschaueri</i> Burt [Polyporales: Meruliaceae]	Yes. Present in OR. Also present in ND (Farr & Rossman 2018; Glawe 2009)	No records found	No. It is associated with bark and wood (Ginns & Lefebvre 1993).	Assessment not required	Assessment not required	No
<i>Hysteropatella</i> sp. [Hysteriales: Hysteriaceae]	Yes. Present in ID and WA (Farr & Rossman 2018; Shaw 1973)	No records found	No. All of the reports of <i>Hysteropatella</i> sp. on apple in the USA are based on only one report of this pest on <i>Malus sylvestris</i> in Washington (Shaw 1973). This report did not specify whether this pest was found on apple fruit. It appeared that Shaw (1973) used the name <i>M. sylvestris</i> for both domestic apple and crabapple. There have been no records of this pest on apple in the USA since 1973.	Assessment not required	Assessment not required	No
<i>Lambertella cornimaris</i> Höhn. 1918 [Rutstroemiaceae] Lambertella rot/yellow rot	Yes. Present in WA (Amiri 2020; Pscheidt & Ocamb 2021c; Wiseman, Dugan & Xiao 2016). First confirmed in 2015 (Wiseman et al. 2015)	No. Two reports in Tarra Bulga National park, Victoria (ALA 2021). Host not listed. No record in Australia since 1958	No. Causes post-harvest Lambertella rot or yellow rot of stored apples, but requires a wound to infect apples (Amiri & Ali 2018; Pscheidt & Ocamb 2021c; Wiseman et al. 2015), which is not likely to occur in commercially produced apples. Amiri (2020b) indicated that they could not rule out other means of infection.	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Microsphaeropsis olivacea</i> (Bonord.) Höhn. Synonym: <i>Coniothyrium olivaceum</i> Bonord. [Pleosporales: Montagnulaceae]	Yes (Farr & Rossman 2018; Glawe 2009)	Yes. Australia (Taylor & Hyde 2003); WA (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
<i>Mucor mucedo</i> Fresen. [Hysteriales: Mucoraceae] Mucor rot	Yes. Present in WA (Shaw 1973)	No records found	No. <i>Mucor mucedo</i> has been reported to cause decay in apple fruit in Northern Ireland (Colhoun 1938), and in strawberry, raspberry, blackberry (Dennis & Mountford 1975) and tomato (Moline & Kuti 1984). Michailides (1990) reported that Mucor rot of apples in the PNW is caused only by <i>M. piriformis</i> . All reports of <i>Mucor mucedo</i> associated with apples in the USA are based on a report of this pest on <i>Malus sylvestris</i> in Washington (Shaw 1973).	Assessment not required	Assessment not required	No
<i>Mycosphaerella pomi</i> (Pass.) Lindau Synonym: <i>Cylindrosporium pomi</i> C. Brooks [Capnodiales: Mycosphaerellaceae] Brooks fruit spot	No. Present in AR, eastern states, IA, MO and NC (Farr & Rossman 2018).	Yes. NSW (CABI 2022)	Assessment not required	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Nectria cinnabarina</i> (Tode) Fr. Synonym: <i>Tubercularia vulgaris</i> Tode [Hypocreales: Nectriaceae] Nectria twig blight	Yes. Present in ID, OR and WA. Also present in AK, MI and NC (APHIS 2007; Farr & Rossman 2018; Glawe 2009)	Yes. Qld, NSW, Vic., Tas. (Plant Health Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No
<i>Nectria sanguinea</i> Fr. [Hypocreales: Nectriaceae]	No. Was once reported in OR (Shaw 1973). However, no type specimen exists for <i>N. sanguinea</i> . Most specimens identified as this species have been reidentified as other <i>Nectria</i> species (Farr & Rossman 2018).	No records found	Assessment not required	Assessment not required	Assessment not required	No
<i>Neofabraea kienholzii</i> (Seifert, Spotts & Lévesque) Spotts, Lévesque & Seifert Synonym: <i>Cryptosporiopsis kienholzii</i> Seifert, Spotts & Lévesque [Helotiales: Dermateaceae] Bull's-eye rot	Yes. Present in OR and WA (Spotts et al. 2009)	Yes. NSW, WA (Cunnington 2004). <i>Cryptosporiopsis kienholzii</i> is linked to the "undescribed <i>Neofabraea</i> spp." found by de Jong (2001)	Assessment not required	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<p><i>Neofabraea malicorticis</i> (Cordley) H.S. Jacks. Synonyms: <i>Cryptosporiopsis curvispora</i> (Peck) Gremmen; <i>Pezicula malicorticis</i> (H. Jacks.) Nannf. [Helotiales; Dermateaceae] Anthracnose canker and bull's-eye rot</p>	<p>Yes. Present in ID, OR and WA. Also present in CA, IL, MA, ME, MT and OK (APHIS 2007; Farr &amp; Rossman 2018). Prevalent in the PNW-USA (Grove 1990a), particularly in wet areas west of the Cascades (Dugan, Grove &amp; Rogers 1993)</p>	<p>No records found</p>	<p>Yes. Can infect fruit and cause fruit to rot in storage (Grove 1990a; Jones &amp; Sutton 1996). This pathogen causes Bull's eye rot of stored apple fruit (Dugan 1993; Verkley 1999).</p>	<p>Yes. Fungal spores produced in the canker are spread by rain and wind. Infection occurs in autumn. 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 &amp; Ocamb 2021d). Suitable hosts, particularly apple and pear, are grown in Australia.</p>	<p>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 &amp; Ocamb 2021d). Severe outbreaks of bull's eye rot occurred in Washington in 1985, 1987 and 1988 (Grove, Dugan &amp; Boal 1992). This fungus rarely kills trees as the cankers are generally confined to small branches and twigs. Losses occur due to fruit rot after fruit have 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).</p>	<p>Yes (EP)</p>

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<p><i>Neofabraea perennans</i> Kienholz Synonyms: <i>Cryptosporiopsis perennans</i> (Zeller &amp; Childs) Wollenw.; <i>Pezicula perennans</i> (Kienholz) Dugan, R.G. Roberts &amp; G.G. Grove [Helotiales: Dermateaceae] Perennial canker and bull's-eye rot</p>	<p>Yes. Present in ID, OR and WA. Also present in ME and MT (Farr &amp; Rossman 2018; Glawe 2009). Prevalent in the PNW-USA (Grove 1990a), particularly east of the Cascades where winters are cold and summers are dry and hot (Dugan, Grove &amp; Rogers 1993)</p>	<p>Yes. Vic. (Cunnington 2004; Plant Health Australia 2018), Tas. (de Jong 1998). Absent from WA (Government of Western Australia 2018)</p>	<p>Assessment not required</p>	<p>Assessment not required</p>	<p>Assessment not required</p>	<p>No</p>
<p><i>Neonectria ditissima</i> (Tul. &amp; C. Tul.) Samuels &amp; Rossman Synonym: <i>Nectria galligena</i> Bres [Hypocreales: Nectriaceae] European canker</p>	<p>Yes. Present in ID, OR and WA (APHIS 2007; Grove 1990b). Also present in eastern, central and western states, CA, MI, MS and NC (Farr &amp; Rossman 2018; Glawe 2009)</p>	<p>No records found. Has been eradicated from Tasmania (Ransom 1997)</p>	<p>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).</p>	<p>Yes. Suitable hosts are present in Australia. Rain and wind disperse the fungus, suggesting potential for spread (Grove 1990c).</p>	<p>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 1990c). Losses can also occur due to storage rot (Swinburne 1970, 1971).</p>	<p>Yes (EP)</p>

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<i>Nigrospora oryzae</i> (Berk. & Broome) Petch Synonym: <i>Khuskia oryzae</i> H.J. Hudson [Unassigned: <i>Incertae sedis</i> ] X-spot	Yes (Farr & Rossman 2021; Pscheidt & Ocamb 2018)	Yes. ACT, NSW, NT, Qld, SA, Vic., WA (Plant Health Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No
<i>Oospora otophila</i> Harz [Erysiphales: Erysiphaceae]	Yes. Present in WA (Shaw 1973)	No records found	No. All of the reports of <i>O. otophila</i> on apple in the USA are based on only one report of this pest on <i>Malus sylvestris</i> (Shaw 1973). This report does not specify whether this pest was found on apple fruit. It appeared that Shaw (1973) used the name <i>Malus sylvestris</i> for both domestic apple and crabapple.	Assessment not required	Assessment not required	No
<i>Oothia amica</i> Sacc., E. Bommer & M. Rousseau [Unassigned: <i>Incertae sedis</i> ]	Yes. Present in WA (Shaw 1973)	No records found	No. All of the reports of <i>O. amica</i> on apple in the USA are based on only one report of this pest on <i>Malus sylvestris</i> (Shaw 1973). This report does not specify whether this pest was found on apple fruit. It appeared that Shaw (1973) used the name <i>Malus sylvestris</i> for both domestic apple and crabapple.	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Penicillium aurantiogriseum</i> Dierckx Synonyms: <i>Penicillium martensi</i> Biourge; <i>Penicillium puberulum</i> Bainier [Eurotiales: Trichocomaceae]	Yes. Present in WA (Farr & Rossman 2018; Glawe 2009)	Yes. NSW (Plant Health Australia 2018). Listed as a permitted organism for WA (Government of Western Australia 2020)	Assessment not required	Assessment not required	Assessment not required	No
<i>Penicillium aurantiogriseum</i> var. <i>viridicatum</i> (Westling) Frisvad & Filt. Synonyms: <i>Penicillium olivinoviride</i> Biourge; <i>Penicillium viridicatum</i> Westling [Eurotiales: Trichocomaceae]	Yes. Present in ID, OR and WA. Also present in CA and WV (Farr & Rossman 2018; Glawe 2009)	Yes. Vic. As <i>P. viridicatum</i> (Plant Health Australia 2018). Not listed as a Declared Organism for WA (Government of Western Australia 2020)	Assessment not required	Assessment not required	Assessment not required	No
<i>Pestalotia concentrica</i> Berk. & Broome Synonym: <i>Monochaetia concentrica</i> (Berk. & Broome) Sacc. [Amphisphaeriales: Amphisphaereaceae] Leaf spot	Yes. Present in ID. Also present in IN and southeastern states (Farr & Rossman 2018; Glawe 2009)	No records found	No. Found on dead leaves of hardwoods (Farr et al. 1989)	Assessment not required	Assessment not required	No
<i>Pezicula pruinosa</i> Farl. [Helotiales: Dermateaceae]	Yes. Present in OR and WA (Farr & Rossman 2018; Glawe 2009)	No records found	No. Found on twigs (Farr & Rossman 2018)	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
Phaciidiopycnis washingtonensis C.L. Xiao & J.D. Rogers [Helotiales: Bulgariaceae] Speck rot	Yes. Present in WA (Ali et al. 2018; Kim & Xiao 2006; Washington State University Extension 2020; Xiao et al. 2005; Xiao 2011, 2013a; Xiao & Boal 2005c; Xiao & Kim 2013) and OR (Elliott et al. 2014)	No records found	Yes. Causes fruit rot but a weak pathogen on apple fruit (Xiao 2013a). Primarily causes 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 & Xiao 2006). This pathogen has been detected in China on apple fruit from three packing houses in Washington State (USDA 2009).	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 & Xiao 2006). The fungus forms spores on the surface of decayed fruit after an extended period in storage (Kim & 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 & Xiao 2006).	Yes
<i>Phacidium lacerum</i> Fr. Synonym: <i>Ceuthospora pinastri</i> (Fr.) Höhn [Phacidiales: Phacidiaceae] Phacidium rot	Yes. Present in ID and WA (Wiseman et al. 2016)	Yes. Victoria and Tasmania (ALA 2020)	No	No	No	No
<i>Phlyctema vagabunda</i> Desm. Synonyms: <i>Neofabraea alba</i> (E.J. Guthrie) Verkley; <i>Pezicula alba</i> E.J. Guthrie [Helotiales: Dermateaceae] Ripe spot	Yes. Present in OR and WA (Farr & Rossman 2018; Garipey et al. 2005; Glawe 2009)	Yes. Tas., Vic., WA (Plant Health Australia 2018; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Phoma bismarckii</i> Kidd & Beaumont [Pleosporales: Didymellaceae]	Yes. Present in WA (Farr & Rossman 2018; Glawe 2009)	No records found	No. Found on dead branches and leaves (Farr & Rossman 2018). Has occasionally been recorded on dead branches of apple trees (Boerema et al. 2004)	Assessment not required	Assessment not required	No
<i>Phoma fuliginea</i> Kidd & Beaumont [Pleosporales: Didymellaceae]	Yes. Present in WA (Shaw 1973)	No records found	No. There is only one record of <i>Phoma fuliginea</i> in the US. The pest was reported to be on <i>Malus sylvestris</i> in Washington (Shaw 1973). This report did not specify whether this pest was found on apple fruit. It appeared that Shaw (1973) used the name <i>M. sylvestris</i> for both domestic apple and crabapple.	Assessment not required	Assessment not required	No
<i>Phyllactinia guttata</i> (Wallr.:Fr.) Lév. [Erysiphales: Erysiphaceae]	Yes. Present in WA (Shaw 1958)	No records found	No. Only reported on crabapple in 1958 with no later records on apple. No records found for <i>Malus domestica</i> (Farr & Rossman 2018)	Assessment not required	Assessment not required	No
<i>Phyllosticta arbutifolia</i> Ellis & G. Martin Synonym: <i>Phyllosticta solitaria</i> Ellis & Everh. [Botryosphaeriales: Botryosphaeriaceae] Apple blotch	Yes. Present in WA (Yoder 1990). Also present in central and western states including AL, FL, IA, LA, MS, NC, OK and TX (Farr & Rossman 2018; Glawe 2009)	No records found	Yes. Can be present on leaves, buds, twigs and fruit (Gardner 1923; Yoder 1990). This pathogen can survive for nine months on apple seedlings stored at 1°C to 2°C (McClintock 1930).	Yes. The hosts of <i>P. arbutifolia</i> are restricted to <i>Crataegus</i> , <i>Malus</i> and <i>Pyrus</i> species (Farr et al. 1989). These hosts are widely available in Australia. The fungus is disseminated by water splash (Gardner 1923).	Yes. Formerly a major disease in the eastern USA but today it 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 1990).	Yes (EP)

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<i>Phyllosticta clypeata</i> Ellis & Everh. [Anamorphic] [Botryosphaeriales: Botryosphaeriaceae]	Yes. Present in OR (Farr & Rossman 2018; Glawe 2009)	No records found	No. Found on leaves, petioles and twigs (Farr et al. 1989)	Assessment not required	Assessment not required	No
<i>Podosphaera clandestina</i> var. <i>clandestina</i> (Wallr.) Lév. Synonyms: <i>Oidium crataegi</i> Grognot; <i>Podosphaera oxycanthae</i> (DC.) de Bary [Erysiphales: Erysiphaceae] Hawthorn powdery mildew	Yes. Present in ID and WA. Also present in CA, FL, MS and SD (Farr et al. 1989; Farr & Rossman 2018; Glawe 2009)	No. North American strain not present in Australia. Listed as a Declared Pest, Prohibited (section 12) (C1 Prohibited) for WA (Government of Western Australia 2018). Reported in WA on <i>Malus sylvestris</i> and <i>Pyrus communis</i> under the synonym <i>P. oxycanthae</i> (Shivas 1989)	No. Infects leaves, shoots and fruit of cherry (Grove 1995). However, <i>Malus</i> spp. are not a main-host (CABI 2019).	Assessment not required	Assessment not required	No
<i>Ramularia magnusiana</i> (Sacc.) Lindau [Capnodiales: Mycosphaerellaceae]	Yes. Present in WA. Also present in northwestern states (Farr & Rossman 2018; Glawe 2009)	No records found	No. Found on leaves causing leaf spot (Farr & Rossman 2018)	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Schizothyrium pomi</i> (Mont. & Fr.) Arx Synonyms: <i>Leptothyrium pomi</i> (Mont. & Fr.) Sacc.; <i>Microthyriella rubi</i> Pter.; <i>Botryodiplodia pomi</i> (Mont. & Fr.) Cif. [Unassigned: Schizothyriaceae] Flyspeck	Yes. Present in ID and WA. Also present in CA, FL, MS, NC and OK (Farr & Rossman 2018; Shaw 1973)	Yes. Present in NSW and WA as <i>Leptothyrium pomi</i> (Plant Health Australia 2018; Shivas 1989), and Qld (Simmonds 1966). Not a regulated pest for Tas. (DPIPWE 2020)	Assessment not required	Assessment not required	Assessment not required	No
<i>Scytinostroma galactinum</i> (Fr.) Donk [Russulales: Lachnocladiaceae] Eastern white root rot	Yes. Present in ID, OR and WA. Also present in AK, AL, AR, DE, IL, IN, KY, MD, MO, NC, OK, TN, VA and WV (Farr & Rossman 2018)	No records found	No. This fungus is known as a root pathogen and is not associated with the mature fruit of its hosts (Jones & Sutton 1996). Causes a root and butt rot of woody plants (Ginns & Lefebvre 1993).	Assessment not required	Assessment not required	No
<i>Seimatosporium lichenicola</i> (Corda) Shoemaker & E. Müll. Synonym: <i>Sporocadus lichenicola</i> Corda [Amphisphaeriales: Discosiaceae]	Yes. Present in WA. Also present in AK (Farr & Rossman 2018; Glawe 2009; Shaw 1958)	Yes. SA, NSW, Vic., Tas. (Plant Health Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No
<i>Seiridium unicorne</i> (Cooke & Ellis) B. Sutton [Amphisphaeriales: Pestalotiopsidaceae] Monochaetia twig canker	No. Present in CA, IL, MO, NJ and WV (Farr & Rossman 2018)	Yes. Qld, NSW, Tas. (Plant Health Australia 2018)	Assessment not required.	Assessment not required	Assessment not required	No

Pest	Present in PNW-USA	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
<i>Sphaeropsis pyriputrescens</i> C.L. Xiao & J.D. Rogers [Anamorphic] [Botryosphaerales: Botryosphaeriaceae] Sphaeropsis rot	Yes. Present in WA (Kim, Curry & Xiao 2014; Kim & Xiao 2008; WSU 2020; Xiao & Boal 2005b; Xiao 2013b; Xiao & Kim 2013; Xiao, Kim & Boal 2011)	No records found	Yes. First reported on apple in Washington packing houses causing post-harvest fruit rot (Xiao, Rogers & Boal 2004). Sphaeropsis rot shows three types of symptoms: stem-end rot, calyx-end rot and more rarely skin rot (Kim & Xiao 2008). <i>Sphaeropsis pyriputrescens</i> also causes canker and twig dieback disease on apple and crabapple (Xiao & Boal 2005b).	Yes. Infection seems to occur in the orchard leading to fruit rot during storage (Kim & Xiao 2008; Xiao, Rogers & Boal 2004). The fungus can form spores on the surface of decayed fruit (Xiao & Rogers 2004). If left unmanaged, this post-harvest disease can result in significant economic losses of apple fruit in storage, during transit, or in the market (Xiao, Kim & Boal 2011). Suitable hosts are grown in Australia.	Yes. Sphaeropsis rot can cause economic losses due to fruit rotting in storage. It is an important post-harvest disease in apple in Washington State and is widely distributed in all major apple growing regions in this state (Kim & Xiao 2008).	Yes
<i>Stachybotrys albipes</i> (Berk. & Broome) S.C. Jong & Davis Synonym: <i>Melanopsamma pomiformis</i> (Pers.:Fr.) Sacc. [Hypocreales: Niessliaceae]	Yes. Present in OR as <i>Melanopsamma pomiformis</i> (Farr & Rossman 2018)	No records found	No. Has been reported on winter injured apple bark in Oregon in 1925 (Zeller 1927). Not recorded on apple fruit	Assessment not required	Assessment not required	No
<i>Stemphylium congestum</i> G.A. Newton [Pleosporales: Pleosporaceae] Stemphylium rot	Yes. Present in WA. Also present in CA (Farr & Rossman 2018)	No records found	No. Causes decay of apples in the PNW-USA (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 <i>S. congestum</i> on apples. Lack of recent records suggests that this pathogen is not an important pest of apple.	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Stemphylium graminis</i> (Corda) Bonord. [Pleosporales: Pleosporaceae]	Yes. Present in WA (Shaw 1958, 1973). According to Simmons (pers. comm.) the report from WA on apple is probably a <i>Ulocladium</i> sp. (Farr & Rossman 2018)	No records found	No. Although <i>S. graminis</i> was reported to cause rot of apples (Ruehle 1930), all of the reports of <i>S. graminis</i> on apple in the USA are based on reports of this pest on <i>Malus sylvestris</i> in Washington prior to 1974 (Shaw 1958, 1973). It appeared that Shaw (1958) and Shaw (1973) used the name <i>M. sylvestris</i> for both domestic apple and crabapple.	Assessment not required	Assessment not required	No
<i>Taphrina bullata</i> (Berk.) Tul. [Taphrinales: Taphrinaceae]	Yes. Present in WA (Farr & Rossman 2018; Glawe 2009; Shaw 1958, 1973)	No. Historical records from Vic. (Plant Health Australia 2018), but no other record in Australia in more than 100 years (Cunnington & Mann 2004)	No. It is a pathogen of pear causing leaf blister and is not of economic significance (Cunnington & Mann 2004).	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Trichoderma</i> sp. [Hypocreales: Hypocreaceae]	Yes. Present in OR and WA (Farr & Rossman 2018; Shaw 1958, 1973)	Yes. <i>T. harzianum</i> is present in Qld, NSW, Vic., SA, Tas. (Plant Health Australia 2018). <i>Trichoderma harzianum</i> and <i>Trichoderma viride</i> are listed as permitted organisms for WA (Government of Western Australia 2020)	Assessment not required	Assessment not required	Assessment not required	No
<i>Trichosporum</i> sp. [Capnodiales: Piedraiaceae]	Yes. Present in WA (Shaw 1958, 1973)	No records found	No. All of the reports of <i>Trichosporum</i> sp. on apple in the USA are based on reports from Shaw (1958) and Shaw (1973). These reports did not specify whether it was found on apple fruit. It appeared that Shaw (1958) and Shaw (1973) used the name <i>Malus sylvestris</i> for both domestic apple and crabapple.	Assessment not required	Assessment not required	No
<i>Truncatella hartigii</i> (Tubeu) Steyaert Synonym: <i>Pestalotia hartigii</i> Tubeuf [Amphisphaeriales: Bartaliniaceae] Leaf spot	Yes. Present in WA (Farr & Rossman 2018; Shaw 1958, 1973; USDA 1960)	No records found	Yes. Reported to cause rotting of stored apple fruit in Washington (USDA 1960). It is considered to cause an apple rot of minor or very minor importance (Pierson, Ceponis & McColloch 1971).	Yes. Suitable hosts, including apple and conifer, are present in Australia. It has been reported to be a seedborne pathogen of apple (Chaudhary, Puttoo & Ashraf 1987).	Yes. <i>Truncatella hartigii</i> is a significant pathogen of conifers (Vujanovic, St-Arnaud & Neumann 2000)	Yes (EP)

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Ulocladium consortiale</i> (Thüm.) E.G. Simmons Synonym: <i>Alternaria consortialis</i> (Thüm.) J.W. Groves & S. Hughes [Pleosporales: Pleosporaceae]	Yes. Present in WA (Shaw 1973)	Yes. NSW as <i>Alternaria consortialis</i> (Plant Health Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No
<i>Valsa ambiens</i> (Pers.: Fr.) Fr. Synonym: <i>Cytospora ambiens</i> Sacc. [Diaporthales: Valsaceae]	Yes. Present in OR and WA. Also present in north central, northeastern and western states, IA and OK (Farr & Rossman 2018; Glawe 2009; Zeller 1927)	Yes. SA, NSW, Vic., Tas. (Plant Health Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No
<i>Valsa ceratosperma</i> (Tode) Maire Synonym: <i>Cytospora ceratosperma</i> (Tode) G.C. Adams & Rossman <i>Cytospora ceratophora</i> Sacc. <i>Valsa ceratophora</i> Tul. & C. Tul. [Diaporthales: Valsaceae] Valsa canker/dieback of apple	Yes. Present in WA. Also present in GA and NJ (CABI 2020b; EPPO 2004; Farr & Rossman 2018)	Yes. ACT, NSW, Tas. (Plant Health Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Valsa cincta</i> (Fr.) Fr. Synonyms: <i>Cytospora cincta</i> Sacc.; <i>Leucostoma cinctum</i> (Fr.) Höhn. (variant spelling: <i>Leucostoma cincta</i> (Fr.) Höhn.) [Diaporthales: Valsaceae] Leucostoma canker and dieback	No. Present in MI and WI, as <i>Leucostoma cinctum</i> (Farr & Rossman 2018)	No records found	Assessment not required	Assessment not required	Assessment not required	No
<i>Valsa leucostoma</i> (Pers.: Fr.) Fr. Synonyms: <i>Cytospora leucostoma</i> Sacc.; <i>Leucostoma persoonii</i> (Nitschke) Höhn. [Diaporthales: Valsaceae] Leucostoma canker	Yes. Present in ID and WA. Also present in north central states, northeastern states, western states, MI and OK (Farr & Rossman 2018; Glawe 2009)	Yes. SA, NSW, Vic. as <i>Cytospora leucostoma</i> (Plant Health Australia 2018)	No. Causes a wilt and dieback of scaffold limbs and the central leader. Cankers form on limbs and trunk (Jones 1990).	Assessment not required	Assessment not required	No
<i>Valsa papyriferae</i> (Schwein.) Cooke [Diaporthales: Valsaceae]	Yes. Present in OR (Farr & Rossman 2018; Glawe 2009)	No records found	No. Found on winter injured bark of apple in OR (Farr et al. 1989; Zeller 1927)	Assessment not required	Assessment not required	No
<i>Valsella melastoma</i> (Fr.) Sacc. Synonym: <i>Valsa melastoma</i> Fr. [Diaporthales: Valsaceae]	Yes. Present in WA. Also present in IA and MI (Farr & Rossman 2018; Glawe 2009)	No records found	No. Found on limbs of apple tree (Farr et al. 1989)	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Venturia inaequalis</i> (Cooke) G. Winter Synonym: <i>Fusicladium pomi</i> (Fr.) Lind [Venturiales: Venturiaceae] Apple scab	Yes. Present in ID, OR and WA. Also present in AK, AL, CA, CT, FL, GA, MS, MT, NC, OK, SD and TN (APHIS 2007; Farr & Rossman 2018)	Yes. NSW, Qld, SA, Tas., Vic., WA (Plant Health Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No
<b>PHYTOPLASMA</b>						
Apple chat fruit phytoplasma Apple chat fruit; apple small fruit	No. Present in other parts of the USA (Pscheidt & Ocamb 2019)	No records found	Assessment not required	Assessment not required	Assessment not required	No
<b>VIROIDS</b>						
<i>Apple hammerhead viroid</i> (AhVd) [Avsunviroidae: Pelamoviroid]	Yes. Present in WA (Szostek, Wright & Harper 2018) and OR (Pscheidt & Ocamb 2022a)	No records found	No. Apple is a host for AHVd (Hadidi et al. 2011). Fruit infection has not been recorded (Szostek, Wright & Harper 2018).	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Apple scar skin viroid</i> [Pospiviroidae: Apscaviroid] ASSVd; Apple scar skin Synonyms: <i>Dapple</i> <i>apple viroid</i> ; <i>Pear rusty</i> <i>skin viroid</i>	Yes. Present in WA (CABI 2022; Hadidi et al. 1991)	No records found	Yes. This viroid can be found in the fruit pulp (Hurt & Podleckis 1995; Koganezawa et al. 2003) and seeds (Hadidi et al. 1991; Han et al. 2003).	Yes. ASSVd is present in a number of Asian countries, Europe and North America. The climatic conditions in many parts of Australia are similar to these countries. It is generally agreed that the means of transmission of ASSVd is by grafting and contaminated pruning equipment (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 per cent transmission rate (Kim et al. 2006).	Yes. Apple scar skin caused by ASSVd 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 per cent of apple trees were affected with this viroid (Han et al. 2003). In the US, this disease was first described in 1956 (Millikan & Marting 1956; Smith, Barrat & Rich 1956). The disease decreases the market value of the fruit (Nemeth 1986b). The entire crop from affected trees becomes unmarketable (Koganezawa 2001).	Yes (EP)
<b>VIRUSES</b>						
<i>Apple chlorotic leaf spot virus</i> [Betaflexiviridae: Trichovirus] ACLSV	Yes. Present in OR and WA (Oregon Department of Agriculture 2007; USDA-APHIS 2007c)	Yes. NSW, Qld, SA, Tas., Vic., WA (Constable, Joyce & Rodoni 2007; Plant Health Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Apple mosaic virus</i> [Bromoviridae: Ilavirus] ApMV	Yes. Present in ID, OR and WA. Also widespread elsewhere in the USA. (CABI 2019; USDA-APHIS 2007a, c, b)	Yes. Qld, SA, Vic., Tas., WA (CABI 2019; McLean & Price 1984; Plant Health Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No
<i>Apple rubbery wood associated virus 1</i> (ARWaV1) Syn.: Apple rubodvirus 1 [Phenuiviridae: Rubodvirus]	Yes. Present in WA (CABI 2022; Pscheidt & Ocamb 2022b)	No records found. However, apple rubbery wood disease is reported from Tasmania (Sampson & Walker 1982; Wright et al. 2018)	Assessment not required	Assessment not required	Assessment not required	No
<i>Apple rubbery wood associated virus 2</i> (ARWaV1) Syn.: Apple rubodvirus 2 [Phenuiviridae: Rubodvirus]	Yes. Present in WA (CABI 2022; Pscheidt & Ocamb 2022b)	No records found. However, apple rubbery wood disease is reported from Tasmania (Sampson & Walker 1982; Wright et al. 2018)	Assessment not required	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Apple stem grooving virus</i> [Betaflexiviridae: Capillovirus] ASGV	Yes. Present in WA. Also present in CA (USDA-APHIS 2007c)	Yes. NSW, Qld, SA, Tas., Vic., WA (Constable, Joyce & Rodoni 2007; Plant Health Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No
<i>Apple stem pitting virus</i> [Flexiviridae: Foveavirus] ASPV	Yes. Present in WA (USDA-APHIS 2007c)	Yes. Qld, SA, Tas., Vic., WA (Constable, Joyce & Rodoni 2007; Plant Health Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No
<i>Cherry rasp leaf virus</i> [Comoviridae: Cheravirus] CRLV or Flat apple virus	Yes. Present in ID, OR, WA. Also present in a number of other states (CABI 2019)	No. Absent from Australia as previous records for NSW, Vic., WA, SA and Tas. are deemed unreliable (IPPC 2016a)	No. May occur on both foliage and fruit with visible flat apple symptoms (CABI 2019; Grove et al. 2003). Spread is slow and transmission is mainly by nematode vectors and infected propagating material (Grove et al. 2003; Hadidi et al. 2011). Commercially produced fruit will not provide a pathway as this affects fruit development or fruit develop flat apple symptoms, which will be discarded.	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
Citrus concave gum associated virus (CCGaV) [Pheniviridae: Phlebovirus]	Yes. Present in WA (Pscheidt & Ocamb 2022a)	Yes. There are uncertain records of samples collected from apple trees tested positive for CCGaV (Wright et al. 2018)	No. Less likely to be on fruit pathway as the disease is currently known to be graft transmissible (Navarro et al. 2018)	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Tobacco necrosis viruses</i> [Tombusviridae: Necrovirus]	Yes. Present in OR. Also present in CA (APHIS 2007)	Yes. Viruses likely to be strains of tobacco necrosis viruses A and D have been recorded in Vic. and Qld (CABI 2022; Finlay & Teakle 1969; Teakle 1988). <i>Tobacco necrosis virus</i> 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 (Cardoso et al. 2005; NCBI 2009; Tomlinson et al. 1983; Zhang, French & Langenberg 1993).	Yes. Tobacco necrosis viruses (TNVs) have been isolated from apple fruit flesh (Uyemoto & Gilmer 1972). Known to infect apple (CABI 2019). Virus particles released from plant debris and acquired in soil by zoospores of chytrid fungi ( <i>Olpidium</i> spp.) may be transmitted to suitable hosts (CABI 2018; Spence 2001; Uyemoto 1981). Necroviruses may also be transmitted in soil water without a vector (Lommel et al. 2005).	Yes. <i>Tobacco necrosis virus</i> strains are established in Australia (Teakle 1988). TNVs infect common vegetable crop plants, ornamental plants and tree species (Brunt & Teakle 1996; CABI 2019; Zitikaite & Staniulis 2009). TNVs are transmitted by <i>Olpidium</i> spp. (Rochon et al. 2004; Sasaya & Koganezawa 2006) and these vectors occur in Australia (Maccarone et al. 2008; McDougall 2006).	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 (Smith et al. 1988; Uyemoto 1981; Xi et al. 2008; Zitikaite & Staniulis 2009).	Yes (EP)

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Tobacco ringspot virus</i> [Secoviridae: Nepovirus] TRSV	Yes. Present in OR on <i>Vaccinium</i> spp. Also present in eastern and central USA states. (CABI & EPPO 1997b)	Yes. Qld, SA, WA (CABI & EPPO 1997b; CMI 1984)	Assessment not required	Assessment not required	Assessment not required	No
<i>Tomato ringspot virus</i> [Secoviridae: Nepovirus] TmRSV, Apple union necrosis and decline	Yes. Present in OR. Also present on east coast USA and MI (APHIS 2007; Pscheidt & Ocamb 2018; Stouffer & Powell 1989)	No. Eradicated from Australia, previously present in SA (CABI 2019)	No. This virus is not directly associated with apple fruit. However, it is strongly associated with apple union necrosis which results in pitting of the stem at the graft union, productivity declines and apple trees may die (CABI 2019). Transmission occurs primarily through infected rootstock and vectoring nematodes (Gonsalves 1990).	Assessment not required	Assessment not required	No
<i>Tulare apple mosaic virus</i> [Bromoviridae: Ilarvirus] TAMV	No. A single record for Tulare County, California (Howell, Parish & Mink 1990)	No records found	Assessment not required	Assessment not required	Assessment not required	No
<b>DISEASES OF UNKNOWN AETIOLOGY</b>						
Apple freckle scurf	Yes (Nemeth 1986b)	No records found	No. Symptoms occur on bark (Parish & Hansen 1990). The disorder is transmitted by grafting and spread occurs through infected budwood (Parish & Hansen 1990).	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
<i>Apple green mottle virus</i>	No. Present in eastern USA (Nemeth 1986b)	No records found	Assessment not required	Assessment not required	Assessment not required	No
<i>Apple pucker leaf virus</i>	Yes. US, no particular region specified (Nemeth 1986b)	No records found	No. Symptoms on fruit (Hansen & Parish 1990; Nemeth 1986b). No report of transmission through seeds or from fruit was found.	Assessment not required	Assessment not required	No
<i>Apple McIntosh depression virus</i>	No. Present in eastern USA (Nemeth 1986b; Zawadzka & Millikan 1989).	No records found	Assessment not required	Assessment not required	Assessment not required	No
Apple pustule canker	Yes. Western USA (Nemeth 1986b)	No records found	No. Symptoms occur on woody parts of the plant (Nemeth 1986b). The disorder is spread by infected budwood (Parish & Hansen 1990). Transmission by budding and grafting (Nemeth 1986b)	Assessment not required	Assessment not required	No
Apple rough skin	Yes. No particular region specified. Apple is the only known host (Nemeth 1986b)	No records found	No. Symptoms appear on fruit (Hansen & Parish 1990). No report of transmission through seeds or from fruit was found.	Assessment not required	Assessment not required	No

<b>Pest</b>	<b>Present in PNW-USA</b>	<b>Present within Australia</b>	<b>Potential to be on pathway</b>	<b>Potential for establishment and spread</b>	<b>Potential for economic consequences</b>	<b>Pest risk assessment required</b>
Apple russet ring and associated disorders Apple russet ring; leaf pucker and fruit russet; leaf fleck; blister bark, green crinkle and fruit distortion	Yes (Pierson, Ceponis & McColloch 1971)	Yes. Tas. (Sampson & Walker 1982); NSW (Letham 1995)	No. Symptoms appear on fruit (Hansen & Parish 1990). Russet ring is considered to be a graft-transmissible fruit disorder (Hansen & Parish 1990). Affected fruit are not expected to pass initial fruit quality inspection. No report of transmission through seeds or from fruit was found.	Assessment not required	Assessment not required	No
Apple star crack agent <i>Apple star crack virus</i>	Yes. Present in WA (Blodgett & Aichele 1961; CABI 2021a; Pscheidt & Ocamb 2018)	Yes. NSW (Letham 1995)	No. Symptoms appear on fruit (Hansen & Parish 1990). No report of transmission through seeds or from fruit was found. Transmitted through budding or grafting (CABI 2019). Is considered to be a graft-transmissible fruit disorder (Hansen & Parish 1990)	Assessment not required	Assessment not required	No
Dead spur of apple	Yes. Present in ID, OR and WA (Parish 1990)	No records found	No. Kills the fruiting spurs in the centres of 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 vectors are known. Spread by grafting (Parish 1990)	Assessment not required	Assessment not required	No

## Appendix B: Issues raised in stakeholder comments

This section summarises key technical issues raised by stakeholders during consultation on the draft report, and the department's responses. Additional information on other issues commonly raised by stakeholders, which may be outside the scope of this technical report, is available on the department's website.

### Comment 1: Clarification on adoption of existing policies for some pests

Consistent with the department's method for pest risk analysis, outlined in Chapter 2, the report adopts existing policy in full or partially as appropriate. This is outlined in Section 2.2.6 and is summarised below.

The adoption of previous risk assessment ratings for the likelihoods of importation and of distribution are considered on a case-by-case basis by comparing factors relevant to the current commodity/country pathway with those assessed previously. After comparing these factors and reviewing the latest literature, previously determined ratings may be adopted if the department considers the likelihoods to be comparable to those assigned in the previous assessment(s), otherwise assessment for the currently assessed pathway is required. The likelihoods of establishment and of spread of a pest in Australia relate specifically to conditions and events that occur in Australia, and are independent of the import pathway through which the pest enters. Similarly, the estimate of potential consequences associated with a pest is also independent of the import pathway. Therefore, if there is no new information available that would significantly change the ratings for the likelihoods of establishment and of spread, or the consequences the pests may cause, the ratings assigned in previous assessments for these components are adopted.

The department has revised individual pest risk assessments in the report to make it clearer how existing policy has been adopted and the justification for adoption of that policy.

### Comment 2: Concern that the assessment is constrained by the World Trade Organization (WTO) ruling in 2010, which should be re-examined with reference to contemporary science.

As a signatory member of the WTO, Australia has an obligation to consider findings from the Panel and Appellate Body reports of the WTO in relation to New Zealand apples (DS367) when undertaking any pest risk assessments relevant to the findings. While Australia has the right to incorporate new information that becomes available in the pest risk assessments, any changes to the WTO findings (DS367) will need to be technically justified. The department has considered all available new evidence since the WTO ruling and has found no new information or scientific evidence to justify refuting the WTO findings.

**Comment 3: Pests have unrestricted risk estimates that are too low or too high and require reassessment.**

Australia's method for pest risk analysis, outlined in Chapter 2, was followed in all pest risk assessments. This method for pest risk analysis is consistent with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for pest risk analysis* and ISPM 11: *Pest risk analysis for quarantine pests*, and the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (WTO-SPS Agreement).

It is important to note that biosecurity risk of a pest consists of 2 major components: the likelihood of a pest entering, establishing and spreading in Australia for a defined import pathway and the consequences should this happen. These 2 components are combined to give an overall unrestricted risk estimate (URE) of the pest for the defined import pathway.

In response to criticisms from stakeholders, the department has reviewed and revised all individual pest risk assessments to clarify the evidence and arguments supporting ratings for likelihoods and consequences that were combined to provide unrestricted risk estimates. A summary of key changes is as follows:

- The likelihood of importation for *Cenopalpus pulcher* was specifically assessed for the PNW-USA apple pathway, instead of adopting from the existing policy, and has been reduced from High to Low due to the pest's limited distribution in the PNW-USA. The URE remains at Low, which does not achieve ALOP and therefore measures are still required.
- The likelihood of importation for the three *Tetranychus* species was assessed for the PNW-USA apples pathway, instead of adopting from the existing policy, and the rating for the likelihood of importation for *T. mcdanieli* has been increased from Moderate to High to reflect the species' greater prevalence on apples relative to the other two species. As a result, the URE has increased to Low for *T. mcdanieli*, which does not achieve ALOP and therefore measures are required. Ratings for *T. pacificus* and *T. turkestanii* have been maintained.
- The likelihood of importation for the three *Grapholita* species, *G. molesta*, *G. prunivora* and *G. packardii*, was assessed for the PNW-USA apples pathway, instead of adopting from the existing policy. The rating for likelihood of importation for *G. prunivora* and *G. packardii* has been decreased from Low to Very Low, reflecting their rareness and/or effective control in commercial PNW-USA apple orchards. As a result, the URE has decreased to Very Low for *G. prunivora* and *G. packardii*, which achieves ALOP and therefore no measures are required. For *G. molesta*, the URE of Very Low, which achieves the ALOP for Australia, has not changed.

**Comment 4: The risk associated with the potential presence of fire blight (*Erwinia amylovora*) in the calyx, epiphytically on the fruit, and asymptotically within the fruit; and potentially being vectored by endemic insects such as Mediterranean fruit fly (*Ceratitidis capitata*) is underestimated and needs to be reviewed.**

The department acknowledges that fire blight is one of the Australian apple industry's high priority pests and it is also a national plant priority pest for Australia. The department has reviewed all relevant literature relating to presence of fire blight in the PNW-USA and the presence of fire blight in the calyx, epiphytically on the fruit and asymptotically within the fruit, and revised the risk assessment to ensure that it is rigorous and clearly supported by

scientific evidence. The risk assessment determined that *E. amylovora* can be present in host plants in all production areas of the PNW-USA and that all apple varieties can be infected. However, the number of fruit containing inoculum and the level of inoculum per fruit are likely to be low. As a result, the risk rating for likelihood of importation was determined as Moderate, which aligns with the rating determined in the New Zealand apple policy.

A question was asked about the risk of insects such as fruit flies potentially vectoring and distributing *E. amylovora* present on an infected fruit to new hosts. The department notes that, under laboratory conditions, freshly cultured *E. amylovora* from artificially inoculated wounded apples can be transferred by Mediterranean fruit fly (Medfly) to detached pear shoots, pear seedlings and wounded apple fruits (Ordax et al. 2015). However, transmission of *E. amylovora* by Medfly under natural conditions would be very unlikely to occur. Firstly, any bacteria are likely to be within the calyx and present in low numbers. To spread the bacterium, fruit flies would need to enter the calyx of infected apple fruit waste, acquire an infection level of inoculum on their legs, mouthparts or body, and transfer the inoculum to a susceptible host and result in infection.

The experiment of Ordax et al. (2015) is more closely aligned to the vector transfer of *E. amylovora* from oozing cankers on plant material, a method of dispersal that is already well known in the epidemiology of fire blight. As outlined in Section 4.15, bees are the main agents responsible for spreading inoculum at the time of flowering.

**Comment 5: Impacts of climate change on pest risk profiles have not been assessed.**

The potential impacts of climate change are complex to address as there is not sufficient evidence to determine whether the prevalence of specific pests has been impacted by climate change or may be in the future. Under climate change, temperatures in the PNW-USA are projected to increase although the magnitude of increases is less certain (Dalton, Mote & Snover 2013). The effect of climate change on rainfall in the PNW-USA is also less certain in terms of changes in annual rainfall and timing and pattern of rainfall events. Climate variability and extreme weather conditions are also projected to increase due to climate change. Further, changes in temperature and rainfall are not likely to be consistent across a large geographical area such as the PNW-USA.

As outlined in Section 3.4.3, PNW-USA apple growers monitor and control pests and diseases to reduce their incidence and damage caused to fruit. For several pests and diseases assessed in the report, monitoring and/or management practices are recommended as part of the risk management measures or mandatory commercial production practices. Monitoring is a key means by which shifts in the abundance and/or distribution of pests and diseases will be detected in the PNW-USA, whether the cause may be climate change or other factors.

Section 5.4.2 states that the department reserves the right to review the import policy should there be a reason to believe there has been a change in the pest or phytosanitary status in the PNW-USA. USDA-APHIS must inform the department immediately on changes in pest status in the PNW-USA, including detection of any new pests of apples, that might be of potential biosecurity concern to Australia.

Comment 6: There is lack of supporting data for risk management measures and a presumption that management measures for *Dasineura mali*, *E. amylovora* and *Neonectria ditissima* on PNW-USA apples will be equally effective as equivalent measures applied to the New Zealand apples pathway. Import requirements for PNW-USA apples appear to be less than for New Zealand apples and are inconsistent with those imposed by other trading partners.

When industry commercial production practices are taken into consideration, the UREs for *D. mali*, *E. amylovora* and *N. ditissima* on apples from the PNW-USA achieve the ALOP for Australia. Therefore, no additional risk management measures are required for these 3 pests on the apples from PNW-USA pathway. However, existing commercial production practices will be mandatory for management of these pests, as these practices were considered in assessing the UREs of these pests as achieving the ALOP for Australia.

The existing commercial production practices in place to manage these 3 pests on PNW-USA apples are comparable to those of the integrated pest management program for New Zealand apples. For example, the practices in both New Zealand and PNW-USA for the 3 pests include in-field monitoring and controls, packing house procedures (sorting, grading and packing house sanitation), and pre-export visual inspection and, if found, remedial action. Additionally, for fire blight, temperature risk modelling for disease event prediction as well as maturity testing to ensure only mature fruit are harvested are used in both New Zealand and PNW-USA. Further, these 3 pests were considered in the New Zealand apple WTO dispute where it was determined that existing commercial orchard and packing house practices, combined with pre-export phytosanitary inspection and certification, manage the risk of these pests on New Zealand apples to achieve the ALOP for Australia. Therefore, any additional risk management measures imposed on either New Zealand apples or PNW-USA apples would be considered more trade-restrictive than required. This is not consistent with either the WTO-SPS Agreement or the *Biosecurity Act 2015*.

The department notes that China's import requirements for US apples (<https://www.aqsiq.net/us-apples.htm>) list similar orchard and packing house management requirements, including disease forecasting and monitoring, chemical and biological control, and fruit washing. However, there are no specific requirements listed in relation to fruit maturity testing, which may indicate that China has less stringent import requirements for US apples with respect to risk management of fire blight. The department also notes that Japan's import requirements for apples from both the USA and New Zealand only require mature symptomless fruit.

Comment 7: Clarity is needed as to what constitutes a systems approach, and how it will be underpinned with rigorous scientific data showing efficacy.

The systems approach for post-harvest fungal rots comprises orchard monitoring, pre- and post-harvest fungal control, and sourcing only of mature fresh symptomless fruit, coupled with pre-export inspection of fruit after cold storage. Any consignments detected with any of these post-harvest fungi must be withdrawn from export to Australia. This is consistent with the ISPM 14 definition of a systems approach, that is, a pest risk management option that integrates different measures, at least two of which act independently, with a cumulative effect. The framework of

van Klinken et al. (2020) for assessing systems approaches notes that definitive quantitative evidence supporting the efficacy of measures in a systems approach is rarely available, and that addressing this gap is a priority. The department agrees with this assessment, and is working with researchers to develop guidance on how to demonstrate and assess efficacy of systems approaches overall, and on the basis of their constituent measures individually.

The systems approach recommended in the report is developed and evaluated in a qualitative manner using expert judgement on the effects of individual components in reducing the risk. This approach is consistent with ISPM14, which states:

‘systems approaches may be developed or evaluated in either a quantitative or qualitative manner or a combination of both. Where suitable data are not available to support a quantitative assessment, a qualitative approach based on expert judgement should be considered more appropriate’.

In addition, prior to trade commencement, the USDA-APHIS must be able to demonstrate to the department that processes and procedures are in place to implement the agreed risk management measures, including the systems approach. If and when trade commences, the efficacy of the systems approach will be monitored and, if necessary, amended as appropriate.

**Comment 8: Mitigation measures for codling moth and fruit moths are inconsistent with those that exist for domestic interstate fruit movements into Western Australia.**

Specific risk management measures recommended in the report for codling moth (*Cydia pomonella*) on the PNW-USA apple pathway include: pest free areas, pest free places of production or pest free production sites; a systems approach approved by the department; or an appropriate pre-export phytosanitary treatment (such as methyl bromide fumigation) approved by the department. These measures are comparable with existing measures for codling moth on the New Zealand apple and the China apple import pathways, which have resulted in no detections of codling moth on any apple imports since trade commenced for both pathways.

There are no risk management measures recommended for fruit moths (*Grapholita* spp.) as the unrestricted risk estimate of Very Low for these pests achieves the ALOP for Australia. This outcome is consistent with the unrestricted risk estimate of Very Low for Oriental fruit moth (*Grapholita molesta*) on the New Zealand and China apple pathways.

As stated in the report, the Australian Government is responsible for regulating the movement of goods such as plants and plant products into and out of Australia. However, the state and territory governments are responsible for plant health controls within their individual jurisdictions. After imported plant and plant products have been cleared by Australian Government biosecurity officers, they may be subject to interstate movement regulations/arrangements.

The state of Western Australia is free from codling moth and as a result interstate consignments of fresh apple fruit and other recognised fruit hosts of the pest must be fumigated with methyl bromide prior to being permitted entry into the state. Western Australia permits apple imports from both New Zealand and China, subject to a range of conditions. To address the risk of codling moth, apples from New Zealand must be fumigated with methyl bromide before they are

allowed entry into Western Australia. Apples from approved provinces of China do not require fumigation prior to entry into Western Australia provided they remain in their original packaging, are accompanied by a phytosanitary certificate, and no pests are detected at the on-arrival inspection in Western Australia. The systems approach for codling moth and other pests carried out in Chinese apple orchards, comprising individual bagging of fruit combined with pest monitoring, trapping and management, is recognised as an effective mitigation measure for codling moth by Western Australia.

Western Australia is also free from Oriental fruit moth, but there are no mitigation measures in place for this pest on fresh apple fruit from other states into Western Australia. However, interstate consignments of fresh apricot, nectarine, peach and plum fruit, which are major hosts for Oriental fruit moth, require a mitigation measure such as methyl bromide fumigation or irradiation for this pest before they are permitted entry into Western Australia. Western Australia's import requirements for apples and other commodities can be found at <https://www.agric.wa.gov.au/iaquarantine/>.

<p><b>Comment 9: It is not clear how inspections will be carried out and how non-compliance will be managed.</b></p>
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Section 5.2.6 of the report outlines details of the pre-export phytosanitary inspection and certification carried out by USDA-APHIS. All apple consignments for export to Australia must be inspected, using random samples of 600 fruit per consignment. Any consignment showing signs of infestation or infection will require further examination, and remedial action (removing from export or applying an approved treatment) must be undertaken if a pest is found. Additional information has been added to this section to enhance clarity of the requirements; for example, to specify that sampling and inspection methods should provide a 95% level of confidence that infestation of or above 0.5% will be detected. Interception of any quarantine pest or regulated article, including trash, must be addressed by remedial action, as appropriate.

In addition, an on-arrival phytosanitary inspection by the department will be conducted to verify that all consignments of PNW-USA apples comply with Australian import requirements, that consignments are as described on the phytosanitary certificate, and that quarantine integrity has been maintained (Section 5.2.7). Section 5.2.8 outlines remedial actions for non-compliance, which can include remedial treatment, export or destruction of non-compliant consignments, or suspension of imports should repeated non-compliance occur. The department reserves the right to suspend imports, either across the entire import pathway or a specific subset of the import pathway that causes non-compliance, such as specific export orchards, packing houses and/or treatment facilities. The USDA-APHIS must conduct an investigation and implement corrective actions. Imports will be allowed to recommence only when the department is satisfied that appropriate corrective action has been undertaken and may involve the department conducting an audit and/or site visit, where required.

**Comment 10: Concerns how the risk of asymptomatic infected fruit will be managed at the border.**

The report recognises asymptomatic infection by some pathogens can occur, that asymptomatic fruit could escape detection in the PNW-USA and be packed for export, and that fruit may remain asymptomatic on arrival in Australia. This risk is greatest if apples are exported soon after harvest. This risk would be reduced by periods of cold storage (including during transport which is likely to be via sea freight, taking around 5 weeks), when visible symptoms can develop on infected fruit, such that fruit with symptoms can be detected during packing, pre-export inspection and/or on-arrival inspection processes. It is important to note that pre-export inspection post-cold storage is one of the components of a systems approach for post-harvest pathogens that require risk management measures. Harvested apples in the PNW-USA are usually cold stored prior to export, however the period of cold storage varies from 1 day to more than 11 months. The required minimum period of cold storage will be specified in the operational work plan to be developed by USDA-APHIS.

**Comment 11: Clarify why a number of pests that are absent from Australia were deemed to not warrant further risk analysis.**

The risk analysis has been conducted in accordance with Australia's method for pest risk analysis (Chapter 2), which is consistent with ISPM 2: *Framework for pest risk analysis* and ISPM 11: *Pest risk analysis for quarantine pests*. A key step in pest risk analysis is pest categorisation, which can be found at Appendix A in the report.

ISPM 11 states that '*The opportunity to eliminate an organism or organisms from consideration before in-depth examination is undertaken is a valuable characteristic of the categorisation process. An advantage of pest categorisation is that it can be done with relatively little information; however, information should be sufficient to adequately carry out the categorisation*'. In line with ISPM 11, the department utilises the pest categorisation step to screen out some pests from further consideration where appropriate for the PNW-USA apple pathway. For each pest that is not present in Australia, or is present but under official control, the department assesses its potential to enter Australia on the PNW-USA apple pathway and, if having potential to enter, its potential to establish and spread in Australia. For a pest to cause economic consequences, the pest will need to enter, establish and spread in the PRA area. Therefore, pests that do not have potential to enter on the PNW-USA apple pathway or have potential to enter but do not have potential to establish and spread in Australia, are not considered further. The potential for economic consequences is then assessed for pests that have potential to enter, establish and spread in Australia. Further pest risk assessments are then undertaken for pests that have potential to cause economic consequences, i.e., pests that meet the criteria for a quarantine pest.

It is important to note that a number of the pests assessed only at the pest categorisation stage remain quarantine pests for Australia. Remedial action will be undertaken if these quarantine pests are detected on arrival. As outlined in Section 5.3, if a pest species categorised as not likely to be on the import pathway is detected at on-arrival inspection, it will require re-assessment and appropriate management.

**Comment 12: Clarify how the risk of Brown Marmorated Stink Bug will be addressed.**

Brown Marmorated Stink Bug (BMSB) is an important quarantine pest for Australia that hitchhikes on a range of imported goods. Brown marmorated stink bug was considered in the pest categorisation (Appendix A) where it was determined that, while BMSB occurs in the PNW-USA and feeds on apple fruit, the pest does not have potential to be on the pathway because eggs are laid on the undersides of leaves and adults and nymphs would not remain on harvested fruit. Although the result of the pest categorisation means that BMSB was not assessed further, the report does provide further information at Section 1.2.4 on how risks of contaminating pests such as hitchhikers will be addressed.

Section 5.2 provides details on how fruit destined for Australia will be packaged and segregated and the conditions for storage and transport to ensure quarantine integrity is maintained. Consignments will be packed such that they are insect-proof and secure, using one of the options outlined in Section 5.2.3. Consignments will be segregated at all times and during storage and transport to maintain the quarantine integrity of the consignment.

Hitchhiker pests such as BMSB can arrive in Australia on cargo and containers and may be more common at particular times of the year. While the on-arrival phytosanitary inspection by the department will focus on apples, it will also verify that pallets and containers carrying produce, including packaging materials such as trays and cartons, are free of BMSB and other pests.

Further information on BMSB can be found at

<https://www.agriculture.gov.au/import/arrival/pests/brown-marmorated-stink-bugs-factsheet>

**Comment 13: Concerns that higher maximum residue limits (MRLs) for some chemicals in the USA will lead to food safety issues on imported apples or compromise efficacy of existing pest and disease controls.**

The MRLs for some agrochemicals that may be used in PNW-USA apple orchards are higher than in Australia. Despite the higher MRLs in the USA, any imports of PNW-USA apples will need to meet Australia's stricter MRL requirements for these agrochemicals. All food sold in Australia must meet Australian food standards, which includes the Australia New Zealand Food Standards Code. This risk analysis focuses on biosecurity risk associated with apples commercially produced in the PNW-USA for export. The assessment of risk associated with MRLs is outside the scope of this risk analysis. However, Section 5.5 of the report states that the PNW-USA apples for export to Australia must meet Australia's food laws. For example, Section 5.5 states, in addition to meeting Australia's biosecurity laws, imported food for human consumption must comply with the requirements of the *Imported Food Control Act 1992*, as well as Australian state and territory food laws. Among other things, these laws require all food, including imported food, to meet the standards set out in the Australia New Zealand Food Standards Code (the Code).

The department checks imported food at the border for safety and compliance with Australia's food standards, through the risk-based inspection program, the Imported Food Inspection Scheme. Post-border checks are made by state and territory food safety regulatory agencies.

The MRL merely denotes the maximum allowable concentration of a chemical on fruit. This does not mean that existing pest management practices in the PNW-USA result in chemical residue levels on fruit close to or in excess of the MRL. The MRL differences for some agrochemicals also do not mean that existing commercial production practices in the PNW-USA would need to change or become less effective to meet Australia's stricter MRL requirements.

**Comment 14: Concerns with antibiotic use to manage fire blight and potential antimicrobial resistance (AMR) effects**

Although antibiotics such as streptomycin or kasugamycin are one of the key management tools to manage fire blight in the PNW-USA, this use is estimated at around 0.1% of total antibiotic use in US agriculture (Stockwell & Duffy 2012). The report clearly states that resistance can occur and antimicrobial resistance (AMR) management strategies, including the judicious use of antibiotics and alternatives such as biological control agents, are important in managing AMR risks.

The risk assessment carried out by Food Standards Australia New Zealand (FSANZ 2011) on the use of antibiotics in New Zealand apples concluded there was negligible food safety concern of antibiotic-treated apples to Australian consumers. This view was confirmed by internationally recognised experts in the field of AMR, who peer-reviewed the FSANZ assessment. AMR is considered a serious issue by Australian government agencies, and accepted management strategies require appropriate and responsible use of all antimicrobials, including antibiotics.

## Glossary

Term or abbreviation	Definition
Anamorph	An asexual reproductive and often mold-like stage of a fungus.
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).
Appropriate level of protection (ALOP) for Australia	The <i>Biosecurity Act 2015</i> defines the appropriate level of protection (or ALOP) for Australia as a high level of sanitary and phytosanitary protection aimed at reducing biosecurity risks to very low, but not to zero.
Area	An officially defined country, part of a country or all or parts of several countries (FAO 2021c).
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 2021c).
Arthropod	The largest phylum of animals, including the insects, arachnids and crustaceans.
Ascigerous	Stage producing ascocarps containing ascus (plural: asci) as the sexual spore-bearing structures produced in ascomycete fungi. Each ascus usually contains eight ascospores (or octad), produced by meiosis followed, in most species, by a mitotic cell division.
Ascocarp	Also known as an ascoma (plural: ascomata), is the fruiting body (sporocarp) of an Ascomycetes fungus. It consists of very tightly interwoven hyphae and may contain millions of asci, each of which typically contains four to eight ascospores.
Ascospores	A type of sexually produced fungal spore unique to the ascomycetes
Asexual reproduction	The development of new individual from a single cell or group of cells in the absence of meiosis.
Australian territory	Australian territory as referenced in the <i>Biosecurity Act 2015</i> refers to Australia, Christmas Island and Cocos (Keeling) Islands.
Biosecurity	The prevention of the entry, establishment or spread of unwanted pests and infectious disease agents to protect human, animal or plant health or life, and the environment.
Biosecurity measures	The <i>Biosecurity Act 2015</i> defines biosecurity measures as measures to manage any of the following: biosecurity risk, the risk of contagion of a listed human disease, the risk of listed human diseases entering, emerging, establishing themselves or spreading in Australian territory, and biosecurity emergencies and human biosecurity emergencies.
Biosecurity import risk analysis (BIRA)	The <i>Biosecurity Act 2015</i> defines a BIRA as an evaluation of the level of biosecurity risk associated with particular goods, or a particular class of goods, that may be imported, or proposed to be imported, into Australian territory, including, if necessary, the identification of conditions that must be met to manage the level of biosecurity risk associated with the goods, or the class of goods, to a level that achieves the ALOP for Australia. The risk analysis process is regulated under legislation.
Biosecurity risk	The <i>Biosecurity Act 2015</i> refers to biosecurity risk as the likelihood of a disease or pest entering, establishing or spreading in Australian territory, and the potential for the disease or pest causing harm to human, animal or plant health, the environment, economic or community activities.
Calyx	A collective term referring to all of the sepals in a flower.
Consignment	A quantity of plants, plant products 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 2021c).

<b>Term or abbreviation</b>	<b>Definition</b>
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO 2015).
Conidia	An asexually produced fungal spore.
Diapause	Period of suspended development/growth occurring in some insects, in which metabolism is decreased.
Endemic	Belonging to, native to, or prevalent in a particular geography, area or environment.
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 2021c).
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO 2021c).
Fresh	Living; not dried, deep-frozen or otherwise conserved (FAO 2021c).
Fumigation	A method of pest control that completely fills an area with gaseous pesticides to suffocate or poison the pests within.
Genus	A taxonomic category ranking below a family and above a species and generally consisting of a group of species exhibiting similar characteristics. In taxonomic nomenclature the genus name is used, either alone or followed by a Latin adjective or epithet, to form the name of a species.
Goods	The <i>Biosecurity Act 2015</i> defines goods as an animal, a plant (whether moveable or not), a sample or specimen of a disease agent, a pest, mail or any other article, substance or thing (including, but not limited to, any kind of moveable property).
Host	An organism that harbours a parasite, mutual partner, or commensal partner, typically providing nourishment and shelter.
Host range	Species capable, under natural conditions, of sustaining a specific pest or other organism (FAO 2021c).
Import permit	Official document authorising importation of a commodity in accordance with specified phytosanitary import requirements (FAO 2021c).
Infection	The internal 'endophytic' colonisation of a plant, or plant organ, and is generally associated with the development of disease symptoms as the integrity of cells and/or biological processes are disrupted.
Infestation (of a commodity)	Presence in a commodity of a living pest of the plant or plant product concerned. Infestation includes infection (FAO 2021c).
Inspection	Official visual examination of plants, plant products or other regulated articles to determine if pests are present or to determine compliance with phytosanitary regulations (FAO 2021c).
Intended use	Declared purpose for which plants, plant products, or other regulated articles are imported, produced or used (FAO 2021c).
Interception (of a pest)	The detection of a pest during inspection or testing of an imported consignment (FAO 2021c).
International Plant Protection Convention (IPPC)	The IPPC is an international plant health agreement, established in 1952, that aims to protect cultivated and wild plants by preventing the introduction and spread of pests. The IPPC provides an international framework for plant protection that includes developing International Standards for Phytosanitary Measures (ISPMs) for safeguarding plant resources.
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 IPPC (FAO 2021c).
Introduction (of a pest)	The entry of a pest resulting in its establishment (FAO 2021c).
Larva	A juvenile form of animal (plural: larvae) with indirect development, undergoing metamorphosis (for example, insects or amphibians).

<b>Term or abbreviation</b>	<b>Definition</b>
Lenticel	A small porous spot on the epiderm of the apple
Lot	A number of units of a single commodity, identifiable by its homogeneity of composition, origin et cetera, forming part of a consignment (FAO 2015). Within this report a 'lot' refers to a quantity of fruit of a single variety, harvested from a single production site during a single pick and packed at one time.
Mature fruit	Commercial maturity is the start of the ripening process. The ripening process will then continue and provide a product that is consumer-acceptable. Maturity assessments include colour, starch pattern index, soluble solids content, flesh firmness, acidity, and ethylene production rate.
National Plant Protection Organization (NPPO)	Official service established by a government to discharge the functions specified by the IPPC (FAO 2021c).
Non-regulated risk analysis	Refers to the process for conducting a risk analysis that is not regulated under legislation (Biosecurity import risk analysis guidelines 2016).
Nymph	The immature form of some insect species that undergoes incomplete metamorphosis. It is not to be confused with larva, as its overall form is already that of the adult.
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 2015).
Orchard	A contiguous area of apple trees operated as a single entity. Within this report a single orchard is covered under one registration and is issued a unique identifying number.
Pacific Northwest (PNW)	The Pacific Northwest States of the United States (Idaho, Oregon and Washington)
Pathogen	A biological agent that can cause disease to its host.
Pathway	Any means that allows the entry or spread of a pest (FAO 2021c).
Pedicel	The stem of the apple
Perithecium	A spherical, cylindrical, or flask-shaped hollow fruiting body in various ascomycetous fungi that contains the asci, usually opens by a terminal pore; plural: perithecia.
Pest	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2021c).
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 2021c)
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 2021c).
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 2021c).
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 condition 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 2021c).
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 2021c).
Pest risk assessment (for quarantine pests)	Evaluation of the probability of the introduction and spread of a pest and of the magnitude of the associated potential economic consequences (FAO 2021c).

<b>Term or abbreviation</b>	<b>Definition</b>
Pest risk assessment (for regulated non-quarantine pests)	Evaluation of the probability that a pest in plants for planting affects the intended use of those plants with an economically unacceptable impact.
Pest risk management (for quarantine pests)	Evaluation and selection of options to reduce the risk of introduction and spread of a pest (FAO 2021c).
Pest risk management (for regulated non-quarantine pests)	Evaluation and selection of options to reduce the risk that a pest in plants for planting causes an economically unacceptable impact on the intended use of those plants (FAO 2021c).
Pest status (in an area)	Presence or absence, at the present time, of a pest in an area, including where appropriate its distribution, as officially determined using expert judgement on the basis of current and historical pest records and other information (FAO 2021c).
Phytosanitary certificate	An official paper document or its official electronic equivalent, consistent with the model of certificates of the IPPC, attesting that a consignment meets phytosanitary import requirements (FAO 2021c).
Phytosanitary certification	Use of phytosanitary procedures leading to the issue of a phytosanitary certificate (FAO 2021c).
Phytosanitary measure	Phytosanitary relates to the health of plants. 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 2021c). In this risk analysis the term 'phytosanitary measure' and 'risk management measure' may be used interchangeably.
Phytosanitary procedure	Any official method for implementing phytosanitary measures including the performance of inspections, tests, surveillance or treatments in connection with regulated pests (FAO 2021c).
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 2021c).
Pleomorphic	More than one form of the fungi (usually referring to the asexual and sexual forms of fungi).
Polyphagous	Feeding on a relatively large number of hosts from different plant family and/or genera.
PRA area	Area in relation to which a pest risk analysis is conducted (FAO 2021c).
Practically free	Of a consignment, field or place of production, without pests (or a specific pests) in numbers or quantities in excess of those that can be expected to result from, and be consistent with good cultural and handling practices employed in the production and marketing of the commodity (FAO 2021c).
Production site	In this report, a production site is a continuous planting of apple trees treated as a single unit for pest management purposes. If an orchard is subdivided into one or more units for pest management purposes, then each unit is a production site. If the orchard is not subdivided, then the orchard is also the production site.
Pupa	An inactive life stage that only occurs in insects that undergo complete metamorphosis, for example butterflies and moths (Lepidoptera), beetles (Coleoptera) and bees, wasps and ants (Hymenoptera).
Pycnidia	Flask-shaped asexual reproductive structure, or fruiting body of Ascomycetes <a href="#">fungi</a> and in rust fungi. It bears <a href="#">spores</a> (conidia) variously known as pycnidiospores, oidia, or spermatia. The spores are liberated through an opening (ostiole) in the pycnidium.
Pycnosclerotia	These are overwintering pycnidia containing pseudoparenchyma of large cells surrounded by a thick wall. They are globose or subglobose, 115-274 x 107-238µm; ostiole 23-59µm thick.
Quarantine	Official confinement of regulated articles for observation and research or for further inspection, testing or treatment (FAO 2021c).

<b>Term or abbreviation</b>	<b>Definition</b>
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 2021c).
Regulated article	Any plant, plant product, storage place, packaging, 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 2021c).
Regulated non-quarantine pest	A non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing contracting party (FAO 2021c).
Regulated pest	A quarantine pest or a regulated non-quarantine pest (FAO 2021c).
Restricted risk	Restricted risk is the risk estimate when risk management measures are applied.
Risk analysis	Refers to the technical or scientific process for assessing the level of biosecurity risk associated with the goods, or the class of goods, and if necessary, the identification of conditions that must be met to manage the level of biosecurity risk associated with the goods, or class of goods to a level that achieves the ALOP for Australia.
Risk management measure	Are conditions that must be met to manage the level of biosecurity risk associated with the goods or the class of goods, to a level that achieves the ALOP for Australia. In this risk analysis, the term 'risk management measure' and 'phytosanitary measure' may be used interchangeably.
Saprophyte	An organism deriving its nourishment from dead organic matter.
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area (FAO 2021c).
SPS Agreement	WTO Agreement on the Application of Sanitary and Phytosanitary Measures.
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.
Stroma	A tissue mass of pseudoparenchyma in or on which the reproductive structures (perithecia) are formed in some sac fungi. More generally, a mass or matrix of vegetative hyphae, with or without tissue of the host or substrate, in which spores are produced.
Surveillance	An official process which collects and records data on pest occurrence or absence by surveying, monitoring or other procedures (FAO 2021c).
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.
Teleomorph	The sexual reproductive stage of a fungus, typically a fruiting body.
Trash	Soil, splinters, twigs, leaves and other plant material, other than fruit as defined in the scope of this risk analysis. For example, stem and leaf material, seeds, soil, animal matter/parts or other extraneous material
Treatment	Official procedure for the killing, inactivation or removal of pests, or for rendering pests infertile or for devitalisation (FAO 2021c).
Unrestricted risk	Unrestricted risk estimates apply in the absence of risk management measures.
Vector	An organism that does not cause disease itself, but which causes infection by conveying pathogens from one host to another.
Viable	Alive, able to germinate or capable of growth.

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