Australian Government

Biosecurity Australia

Final Report

Pest Risk Analysis for Stone Fruit from New Zealand into Western Australia

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GLOSSARY OF TERMS AND ABBREVIATIONS

Additional declaration	a statement that is required by an importing country to be entered on a Phytosanitary Certificate and which provides specific additional information pertinent to the phytosanitary condition of a consignment
ALOP	appropriate level of protection
AQIS	Australian Quarantine and Inspection Service
Area	an officially defined country, part of a country or all or parts of several countries
Biological control agent	a natural enemy, antagonist or competitor, and other self-replicating biotic entity used for pest control
Biosecurity Australia	a prescribed Agency within the Australian Government Department of Agriculture, Fisheries and Forestry
Biosecurity New Zealand	a major operating group within the New Zealand Ministry of Agriculture and Forestry
Certificate	an official document, which attests to the phytosanitary status of any consignment affected by phytosanitary regulations
Consignment	a quantity of plants, plant products and/or other articles being moved from one country to another and covered, when required, by a single phytosanitary certificate (a consignment may be composed of one or more commodities or lots)
Contaminating pest	a pest that is carried by a commodity and, in the case of plants and plant products, does not feed directly on the commodity
Control (of a pest)	suppression, containment or eradication of a pest population
DAFF	Australian Government Department of Agriculture, Fisheries and Forestry
Eastern Australia/ Eastern States	New South Wales, Victoria, Queensland, South Australia, Tasmania and Northern Territory
Endangered area	an area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss
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
Establishment	the perpetuation, for the foreseeable future, of a pest within an area after entry
Harmonisation	The establishment, recognition and application by different countries of phytosanitary measures based on common standards
Host range	species of plants capable, under natural conditions, of suiting a specific pest

Import Permit	official document authorising importation of a commodity in accordance with specified phytosanitary requirements
Inspection	official visual inspection of plant, plant products or other regulated articles to determine if pests are present and/or to determine compliance with phytosanitary regulations
Interception (of a pest)	the detection of a pest during inspection or testing of an imported consignment
Introduction	entry of a pest resulting in its establishment
IPPC	International Plant Protection Convention, as deposited with FAO in Rome in 1951 and as subsequently amended
IRA	Import Risk Analysis, an administrative process through which quarantine policy is developed or reviewed, incorporating risk assessment, risk management and risk communication
ISPM	International Standard on Phytosanitary Measures
National Plant Protection Organisation	official service established by a government to discharge the functions specified by the IPPC (DAFF is Australia's NPPO)
NZ MAF	New Zealand Ministry of Agriculture and Forestry
Official	established, authorised or performed by a National Plant Protection Organisation
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
Pathway	any means that allows the entry or spread of a pest
Pest	any species, strain or biotype of plant, animal, or pathogenic agent, injurious to plants or plant products
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
Pest-free area	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
Pest risk analysis	the process of evaluating biological or other scientific evidence to determine whether a pest should be regulated and the strength of any phytosanitary measures to be taken against it
Pest risk assessment (for quarantine pests)	evaluation of the probability of the introduction and spread of a pest and of the associated potential economic consequences
Pest risk management (for quarantine pests)	evaluation and selection of options to reduce the risk of introduction and spread of a pest
Phytosanitary Certificate	Certificate patterned after the model certificates of the IPPC

Phytosanitary measure	any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests
PIRSA	Primary Industries and Resources South Australia
PRA area	area in relation to which a pest risk analysis is conducted
Polyphagous	feeding on a relatively large number of host plants from different plant families
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
Restricted risk	'Restricted risk' estimates are those derived when risk management measures are used
Spread	expansion of the geographical distribution of a pest within an area
SIRA	State Import Risk Analysis; a process for assessing the risk and determining measures needed for the movement of plants and animals and their products between the States and Territories of Australia
SPS Agreement	WTO Agreement on the Application of Sanitary and Phytosanitary Measures
Stakeholders	Government agencies, individuals, community or industry groups or organisations, whether in Australia or overseas, including the proponent/applicant for a specific proposal
Unrestricted risk	'Unrestricted risk' estimates are those derived in the absence of risk management measures
WTO	World Trade Organization

SUMMARY

This pest risk analysis report recommends that stone fruit from New Zealand be allowed entry into Western Australia subject to phytosanitary measures for citrophilus mealybug, leafrollers, oriental fruit moth, thrips and biological control agents (phytoseiid mites). These pests will require the use of risk management measures, in addition to New Zealand's standard commercial production practices, to reduce the risk to a very low level to meet Australia's appropriate level of protection (ALOP).

A combination of risk management measures and operational systems will reduce the risk associated with the importation of stone fruit from New Zealand to meet Australia's ALOP, specifically:

- pest free area or area of low pest prevalence or methyl bromide fumigation for oriental fruit moth;
- inspection and remedial action for citrophilus mealybug, leafrollers, thrips and biological control agents (phytoseiid mites); and
- supporting operational systems to maintain and verify phytosanitary status.

New Zealand requested market access for stone fruit (apricot, cherry, nectarine, peach and plums) into Western Australia in 2000.

Biosecurity Australia has considered the importation of stone fruit into Western Australia as an extension of existing policy. This existing policy includes policy for the importation into Western Australia of cherry fruit from South Australia (completed in September 2001), from New Zealand (completed in January 2003) and from Tasmania (completed in January 2004) and subsequently apricot fruit from South Australia and Tasmania (completed in October 2004).

Detailed risk assessments were conducted for those pests that were categorised as quarantine pests for Western Australia, to determine unrestricted risk estimates for each organism. For those pests for which the unrestricted risk was estimated to be above Australia's ALOP, risk management measures were identified and selected.

Consultation with Biosecurity New Zealand and the Department of Agriculture and Food Western Australia, and input from stakeholders on the draft import conditions, has resulted in a set of final risk management measures, operational procedures and import conditions, together with their objectives.

Biosecurity Australia has made a number of changes in the risk analysis following considerations of stakeholder comments on the draft report for the Extension of Existing Policy for Stone Fruit from New Zealand into Western Australia. These changes include:

- Inclusion of pest free places of production and pest free production sites as risk mitigation measures for oriental fruit moth;
- The removal of one leafroller (*Harmologa oblongana*, native leafroller) as it is not found in orchards managed in accordance with the SummerGreen ™ program;
- Minor amendments to the pest categorisation table in light of stakeholder comments, including additional information to justify the assessments. These amendments have had no bearing on the final list of quarantine pests; and

- Inclusion of information about the stone fruit production regions in Western Australia to allow consideration of the consequences for quarantine pests.

1 INTRODUCTION

Biosecurity Australia is a prescribed Agency within the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF) responsible for developing international quarantine policy for imports and for liaising with overseas National Plant Protection Organisations (NPPOs) to determine their technical requirements for exports of Australian plants and plant products.

Quarantine policy for the importation of stone fruit from New Zealand into Australia has been in place since 1984. However, stone fruit has not been permitted into Western Australia from either New Zealand or other states and territories of Australia in the absence of suitable phytosanitary measures to mitigate the risk of the introduction into Western Australia of the brown rot diseases of stone fruit, caused by *Monilinia fructicola* and *M. laxa*.

The quarantine status of the brown rot diseases of stone fruit changed for Western Australia when the presence of both *M. fructicola* and *M. laxa* was confirmed in 1999. Following confirmation of brown rot in Western Australia, New Zealand requested access for stone fruit (apricot, cherry, nectarine, peach and plums) into Western Australia in 2000.

Following a comparison of the phytosanitary status of the commodities under consideration with those currently allowed entry into Western Australia, Biosecurity Australia determined that it was appropriate for New Zealand's market access request for stone fruit to Western Australia to be progressed as an extension of existing policy. The existing policy includes policy for the importation into Western Australia of cherry fruit from South Australia (completed in September 2001), from New Zealand (completed in January 2003) and from Tasmania (completed in January 2004) and subsequently apricot fruit from South Australia and Tasmania (completed in October 2004).

This pest risk analysis for New Zealand stone fruit to Western Australia has been prepared with the assistance of the New Zealand Ministry of Agriculture and Forestry (NZ MAF) and the Department of Agriculture Western Australia.

In the pest risk analysis (PRA) process for stone fruit from New Zealand into Western Australia, Biosecurity Australia first categorised the pests associated with stone fruit from New Zealand to identify the quarantine pests for Western Australia. The likelihood of entry, establishment or spread and associated potential consequences were then assessed to arrive at an unrestricted risk estimate for each quarantine pest.

Risk management measures, in addition to the standard commercial practices, were then identified for each quarantine pest that was above the appropriate level of protection (ALOP) for Australia and used to develop proposed import conditions.

This document includes the following sections:

- background to this pest risk analysis;
- method for pest risk analysis;
- results of pest categorisation and pest risk assessments;
- proposed pest risk management; and
- import conditions.

2 PROPOSAL TO IMPORT STONE FRUIT FROM NEW ZEALAND INTO WESTERN AUSTRALIA

2.1 Background

Importation of stone fruit from the eastern states and New Zealand into Western Australia had been prohibited due to the absence of suitable phytosanitary measures to mitigate the risk posed by the brown rot diseases of stone fruit caused by *Monilinia fructicola* and *M. laxa*. In 1999, both *Monilinia fructicola* and *M. laxa* were found to be widespread in Western Australia.

Following confirmation of brown rot in Western Australia, the New Zealand Ministry of Agriculture and Forestry (NZ MAF) requested access into Western Australia for stone fruit (apricot, cherry, nectarine, peach and plums) in 2000, with cherries being a priority. New Zealand gained access for cherries into Western Australia in January 2003, following a review of import policy conducted by Biosecurity Australia in cooperation with the Department of Agriculture Western Australia.

2.2 Administration

2.2.1 Scope

This pest risk analysis presents an assessment of biosecurity risks associated with commercially produced stone fruit (apricot, nectarine, peach and plums) from New Zealand free from regulated articles[1]. The report also proposes, as appropriate, risk management measures.

In the PRA section of this pest risk analysis, Biosecurity Australia has considered the pests associated with stone fruit in New Zealand. The PRA process forms the basis for the development of import policy with respect to the entry of stone fruit into Western Australia from New Zealand.

Stone fruit is produced commercially in New Zealand using the management system developed by Summerfruit New Zealand. This management system includes (a) appropriate field sanitation programs and (b) cultural and chemical control programs. Details of this management system are given in the SummerGreen Manual, which is only available to growers and participants in the SummerGreen™ Program.

All growers producing stone fruit in New Zealand for export to Western Australia are to comply with SummerGreen™ program requirements under a compliance agreement.

2.2.2 Biological Control Agents

A range of biological control agents are commonly used in the production of stone fruit in New Zealand. These biological control agents form part of integrated pest management programs and are available commercially to control target pests. Stone fruit imports represent a possible pathway for the entry of biological control agents into Australia. The

[1] The IPPC defines a regulated article as “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.

species not present in Australia are potentially beneficial to various production systems in Australia but they could also pose a risk to the environment.

Biosecurity Australia has included assessments of biological agents associated with stone fruit in New Zealand in this pest risk analysis.

2.2.3 Contaminating pests

In addition to the pests of stone fruit in New Zealand, there are other arthropods that may be carried by the fruit (present on the import pathway). Biosecurity Australia considers these arthropods as contaminating pests, which can pose quarantine risks. These risks are addressed for most contaminating pests by AQIS's standard inspection procedures.

2.3 Australia's Current Quarantine Policy for Stone Fruit

The Commonwealth Government is responsible for regulating the movement of plants and plant products into and out of Australia. However, the State and Territory governments are primarily responsible for plant health controls within Australia. 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.

2.3.1 International Policy

Fresh stone fruit may be imported into eastern Australia from New Zealand. General import requirements for all fruits and vegetables and specific import conditions for stone fruit from New Zealand to eastern Australia can be found in the Australian Quarantine and Inspection Service (AQIS) Import Conditions (ICON) database at http://www.aqis.gov.au/icon/.

New Zealand stone fruit can enter eastern Australia either under an AQIS pre-clearance program or with inspection upon arrival. If stone fruit is exported under the AQIS pre-clearance program, inspection for quarantine pests is carried out in New Zealand and no inspection is required on arrival in Australia. Inspection on arrival and remedial action for regulated articles, if detected, is required for New Zealand stone fruit that is not exported under the AQIS pre-clearance program.

2.3.2 Western Australia

The importation of fruit of stone fruit into Western Australia is prohibited under the *Plant Diseases Act 1914*, due to the historical absence of brown rot (*Monilinia fructicola* and *M. laxa*). Western Australia's previous freedom from brown rot had led to the prohibition into the State, as there was no effective disinfection treatment or other phytosanitary measure for this disease. Brown rot was confirmed in Western Australia in 1999 but the *Plant Diseases Regulations 1989* have not been amended to reflect this change in phytosanitary status.

Cherry fruit is permitted entry into Western Australia from South Australia, Tasmania and New Zealand in accordance with the following pest risk assessments:

> *Categorisation of Pests of Stone Fruit from Eastern Australia - Final State Import Risk Analysis of Cherry Fruit (Prunus avium) from South Australia into Western Australia.* (21 September 2001);

Final Policy Extension for the Importation of Cherry Fruit (Prunus avium) from Tasmania into Western Australia (22 December 2003); and

Extension of Existing Policy for Cherry Fruit (Prunus avium) Exported from New Zealand into Western Australia (22 January 2003).

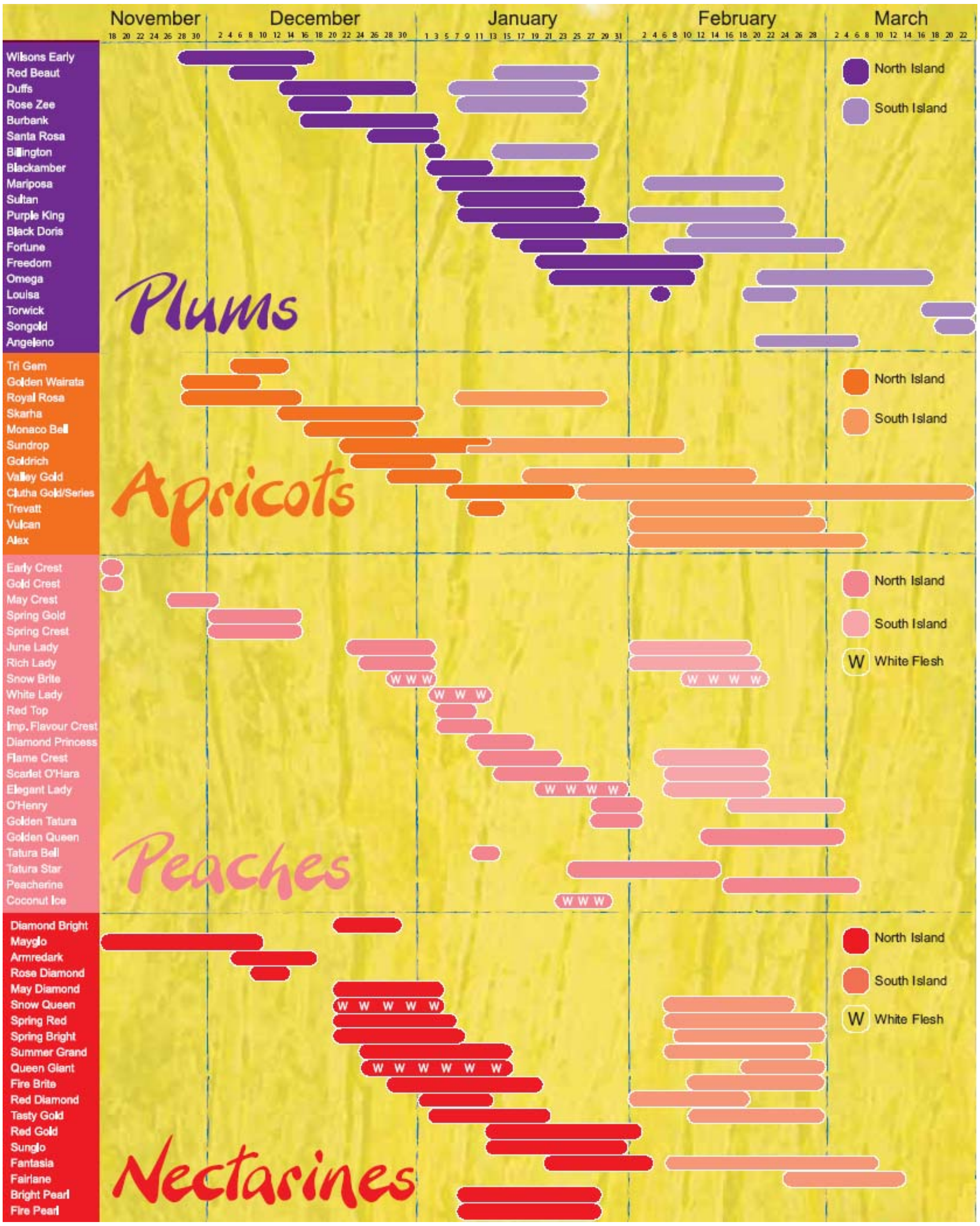
Apricot fruit is permitted entry into Western Australia from South Australia and Tasmania in accordance with the following pest risk assessment:

Final Policy Extension – Fresh Apricot (Prunus armeniaca) Fruit Imported from South Australia and Tasmania into Western Australia (5 October 2004).

2.4 Stonefruit Production in New Zealand

The New Zealand stone fruit industry is based in the Hawkes Bay; Blenhiem/Nelson and Central Otago regions and due to the climatic variation can provide fruit from late November (Hawkes Bay) through to late March (Otago). Current production covers approximately 3000 hectares and over 2300 tonnes of fruit were exported in the 2003/04 season. Cherries and apricots have historically been the most significant exports, totalling over ninety percent of all exported stone fruit. Figure 1 details the production periods for the listed varieties during the New Zealand stone fruit season (from Summerfruit New Zealand website at http://www.summerfruitnz.co.nz).

Figure 1 Production periods for stone fruit varieties in New Zealand



2.5 Stonefruit Production in Western Australia

Stone fruit production in Western Australia consists mainly of nectarines, peaches and plums. Production is concentrated in the south-west of Western Australia between Perth and Albany (Figure 2), in the major growing regions of the Perth Hills, Dwellingup, Donnybrook and Manjimup (Ward *et al*., 2006). Stone fruit is also grown in the region of Carnarvon in the north-west of Western Australia (Ward *et al*., 2006).

Figure 2 Production areas for stone fruit in Western Australia

The south-west region of Western Australia has a temperate Mediterranean climate, suitable soils and availability of good quality, irrigation water which favours the production of high quality stone fruit. Nectarines, peaches and plums are available for seven months of the year, from September to March. The peak harvest season is from December to March. Production in the Carnarvon region has extended the cropping season (Ward *et al*., 2006).

Western Australia contributed about seven per cent of the national nectarine, peach, plum and prune production of 163,000 tonnes in 2004-05 (ABS, 2006). In 1998/99, Western Australian stone fruit exports were valued at $10 m (Ward *et al*., 2006).

3 METHOD FOR PEST RISK ANALYSIS

An outline of the methodology used for pest risk analysis (PRA) is given to provide the context for the technical information that is provided later in this document. In accordance with the International Standards for Phytosanitary Measures Number 11 *Pest Risk Analysis for Quarantine Pests, including Analysis of Environmental Risks and Living Modified Organisms* (ISPM 11) (FAO, 2004), this pest risk analysis process comprises three discrete stages:

- Stage 1: initiation
- Stage 2: pest risk assessment
- Stage 3: pest risk management

Stage 1: Initiation

The aim of the *initiation* stage is to identify the pest(s) and pathway(s) (e.g. commodity imports) that are of quarantine concern and should be considered for risk analysis in relation to the identified PRA area.

Stage 2: Pest Risk Assessment

The pest risk assessment is carried out in accordance with relevant International Plant Protection Convention (IPPC) standards and reported in the following steps:

- pest categorisation;
- assessment of probability of entry, establishment and spread; and
- assessment of potential consequences (including environmental impacts).

Pest categorisation

Pest categorisation is a process to examine, for each pest, whether the criteria for a quarantine pest are satisfied. The process of pest categorisation is summarised by the IPPC in the five elements outlined below:

- identity of the pest;
- presence or absence in the endangered area;
- regulatory status;
- potential for entry, establishment and spread in the PRA area; and
- potential for economic consequences in the endangered area.

Pests are categorised according to their presence or absence, their association with commodity pathway, their potential to establish or spread, and their potential for economic consequences. Categorisation for potential of establishment or spread and potential for economic consequences was expressed using the terms ‘feasible’ / ‘not feasible’, and ‘significant’ / ‘not significant’, respectively.

Pests found to have potential for entry, establishment or spread and potential for consequences satisfy the criteria for a quarantine pest. A quarantine pest is defined as "*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, 2006).

The methodology used for the detailed risk assessments conducted on the quarantine pests is given below.

Assessment of the probability of entry, establishment or spread

Details of assessing the 'probability of entry', 'probability of establishment' and 'probability of spread' of a pest are given in ISPM 11.

Assessing the probability of entry requires an analysis of each of the pathways with which a pest may be associated, from its origin to distribution in the PRA area. The probability of entry may be divided for assessment purposes into the following components:

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

The probability of distribution: the probability that the pest will be distributed (as a result of the processing, sale or disposal of the commodity) to the endangered area, and subsequently be transferred to a suitable site on a susceptible host.

In breaking down the probability of entry into these two components, Biosecurity Australia has not altered the original meaning. The two components have been identified and separated to enable onshore and offshore pathways to be described individually.

The probability of establishment is estimated on the basis of availability, quantity and distribution of hosts in the PRA area; environmental suitability in the PRA area; potential for adaptation of the pest; reproductive strategy of the pest; method of pest survival; and cultural practices and control measures.

Similarly, the probability of spread is estimated on the basis of suitability of the natural and/or managed environment for natural spread of the pest; presence of natural barriers; the potential for movement with commodities or conveyances; intended use of the commodity; potential vectors of the pest in the PRA area; and potential natural enemies of the pest in the PRA area.

Qualitative likelihoods are assigned to the probability of entry (comprising an importation step and a distribution step), the probability of establishment and the probability of spread. Likelihoods are categorised according to a descriptive scale from 'high' to 'negligible' as shown in Table 1.

Table 1: Nomenclature for qualitative likelihoods

Likelihood	Descriptive definition
High	The event would be very likely to occur
Moderate	The event would occur with an even probability
Low	The event would be unlikely to occur
Very low	The event would be very unlikely to occur
Extremely low	The event would be extremely unlikely to occur
Negligible	The event would almost certainly not occur

The overall probability of entry is determined by combining the likelihoods of importation and of distribution using the matrix of rules for combining descriptive likelihoods (Table 2). The probability of entry, establishment and spread is then determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules for combining descriptive likelihoods (Table 2).

Table 2: Matrix of rules for combining descriptive likelihoods

	High	Moderate	Low	V. Low	E. Low	Negligible
High	High	Moderate	Low	V. Low	E. Low	Negligible
Moderate		Low	Low	V. Low	E. Low	Negligible
Low			V. Low	V. Low	E. Low	Negligible
Very low				E. Low	E. Low	Negligible
E. low					Negligible	Negligible
Negligible						Negligible

Assessment of potential consequences

The basic requirements for the assessment of consequences are described in the SPS Agreement, in particular Article 5.3 and Annex A. Further detail on assessing consequences is given in the “potential economic consequences” section of ISPM 11. This ISPM separates the consequences into “direct” and “indirect” and provides examples of factors to consider within each. In this PRA, the term “consequence” is used to reflect the “relevant economic factors”/“associated potential biological and economic consequences” and “potential economic consequences” terms as used in the SPS Agreement and ISPM 11, respectively.

The direct and indirect consequences were estimated based on four geographic levels. The terms ‘local’, ‘district’, ‘regional’ and ‘national’ are defined as:

Local: an aggregate of households or enterprises — e.g. 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, such as the ‘North West Slopes and Plains’ or ‘Far North Queensland’

Region: a geographically or geopolitically associated collection of districts — generally a state, although there may be exceptions with larger states such as Western Australia

National: Australia-wide

The consequence was described as:

- ‘*unlikely to be discernible*’ is not usually distinguishable from normal day-to-day variation in the criterion;
- ‘*minor significance*’ is not expected to threaten economic viability, but would lead to a minor increase in mortality/morbidity or a minor decrease in production. For non-commercial factors, the consequence is not expected to threaten the intrinsic ‘value’ of the criterion — though the value of the criterion would be considered as ‘disturbed’. Effects would generally be reversible.

- ‘*significant’* consequence would threaten economic viability through a moderate increase in mortality/morbidity, or a moderate decrease in production. For non-commercial factors, the intrinsic ‘value’ of the criterion would be considered as significantly diminished or threatened. Effects may not be reversible; and
- ‘*highly significant*’ would threaten economic viability through a large increase in mortality/morbidity, or a large decrease in production. For non-commercial factors, the intrinsic ‘value’ of the criterion would be considered as severely or irreversibly damaged.

The values are translated into a qualitative impact score (A–F) using the schema outlined in Table 3.

Table 3: The assessment of local, district, regional and national consequences

Impact score	Local	District	Regional	National
F	-	-	-	Highly significant
E	-	-	Highly significant	Significant
D	-	Highly significant	Significant	Minor
C	Highly significant	Significant	Minor	Unlikely to be discernible
B	Significant	Minor	Unlikely to be discernible	Unlikely to be discernible
A	Minor	Unlikely to be discernible	Unlikely to be discernible	Unlikely to be discernible

Level

The overall consequence for each pest was achieved by combining the impact scores (A–F) for each direct and indirect consequence using a series of decision rules. These rules are mutually exclusive, and are addressed in the order that they appear in the list — for example, if the first rule does not apply, the second rule is considered. If the second rule does not apply, the third rule is considered and so on until one of the rules applies:

- Where the impact score of a pest with respect to any direct or indirect criterion is ‘F’, the overall consequences are considered to be ‘extreme’.
- Where the impact scores of a pest with respect to more than one criterion are ‘E’, the overall consequences are considered to be ‘extreme’.
- Where the impact score of a pest with respect to a single criterion is ‘E’ and the impact scores of a pest with respect to each remaining criterion are ‘D’, the overall consequences are considered to be ‘extreme’.
- Where the impact score of a pest with respect to a single criterion is ‘E’ and the impact scores of a pest with respect to remaining criteria are not unanimously ‘D’, the overall consequences are considered to be ‘high’.
- Where the impact scores of a pest with respect to all criteria are ‘D’, the overall consequences are considered to be ‘high’.
- Where the impact score of a pest with respect to one or more criteria is ‘D’, the overall consequences are considered to be ‘moderate’.
- Where the impact scores of a pest with respect to all criteria are ‘C’, the overall consequences are considered to be ‘moderate’.
- Where the impact score of a pest with respect to one or more criteria is considered ‘C’, the overall consequences are considered to be ‘low’.

- Where the impact scores of a pest with respect to all criteria are 'B', the overall consequences are considered to be 'low'.
- Where the impact score of a pest with respect to one or more criteria is considered 'B', the overall consequences are considered to be 'very low'.
- Where the impact scores of a pest with respect to all criteria are 'A', the overall consequences are considered to be 'negligible'.

Method for determining the unrestricted risk estimate

The unrestricted risk estimate for each pest is determined by combining the likelihood estimates of entry, of establishment and of spread with the overall potential consequences. This is done using the risk estimation matrix shown in Table 4. The cells of this matrix describe the product of likelihood of entry, establishment or spread and consequences of entry, establishment or spread.

Table 4: Risk estimation matrix

Likelihood of entry, establishment or spread	Negligible impact	Very low	Low	Moderate	High	Extreme impact
High likelihood	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 likelihood	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk

Consequences of entry, establishment or spread

Australia's appropriate level of protection (ALOP)

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

Like many other countries, Australia expresses its ALOP in qualitative terms. Australia's ALOP, which reflects community expectations through government policy, is currently expressed as providing a high level of sanitary or phytosanitary protection aimed at reducing risk to a very low level, but not to zero. The band of cells in Table 4 marked 'very low risk' represents Australia's ALOP.

Stage 3: Pest Risk Management

Risk management describes the process of identifying and implementing measures to manage risks so as to achieve Australia's ALOP, while ensuring that any negative affects on trade are minimised.

To implement risk management appropriately, it is necessary to formalise the difference between ‘unrestricted’ and ‘restricted’ risk estimates. Unrestricted risk estimates are those derived in the absence of specific risk management measures, or following only baseline risk management procedures based on commercial production practices. By contrast, restricted or mitigated risk estimates are those derived when ‘risk management’ is applied.

The conclusions from pest risk assessment are used to decide whether risk management is required and if so, the strength of measures to be used. Where the unrestricted risk estimate exceeds Australia’s ALOP, risk management measures are required to reduce this risk to a very low level. Since zero-risk is not a reasonable option, the guiding principle for risk management is to manage risk to achieve the required degree of safety that can be justified and is feasible within the limits of available options and resources.

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

Examples given of measures commonly applied to traded commodities include:

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

Risk management measures are identified for each quarantine pest that is above Australia’s ALOP for Western Australia as required and are presented in the “Pest Risk Management” section of this document. The pests that are above the ALOP require the use of risk management measures in addition to the standard commercial practices. The proposed phytosanitary regulations based on these measures are presented in the “Draft Import Conditions” section of this document.

4 PEST RISK ANALYSIS

4.1 Stage 1: Initiation

Initiation of this PRA followed the access request in 2000 from NZ MAF for stone fruit into Western Australia.

A list of pests likely to be associated with stone fruit from New Zealand (i.e. the biosecurity risk pathway) was generated from information supplied by NZ MAF and literature and database searches. The list was used in this PRA.

The ‘PRA area’ is defined in this pest risk analysis as the State of Western Australia. The ‘endangered area’ is defined as any area within Western Australia where susceptible hosts are present and in which ecological factors favour the establishment of a pest that might be introduced in association with stone fruit from New Zealand. The pathway is considered to be fresh stone fruit for consumption from export orchards in New Zealand.

4.2 Stage 2: Pest Risk Assessment

4.2.1 Pest categorisation

The quarantine pests for stone fruit from New Zealand have been determined through a comparison of pests recorded on stone fruit in New Zealand and Western Australia (present or absent, present but with restricted/limited distribution and under official control [Appendix 1a], presence on the pathway under consideration [Appendix 1b], and potential for establishment or spread and associated consequences [Appendix 1c]). Many of the pests occur in Western Australia or are not present on the import pathway and were therefore not considered further in this PRA. Pests that do not meet the definition of a quarantine pest are not considered further in the PRA.

The quarantine pests for stone fruit from New Zealand, determined through this process of pest categorisation, are listed in Table 5. These pests require detailed risk assessment since they meet the IPPC criteria for a quarantine pest, specifically:

- the pest is known to be associated with stone fruit in New Zealand;
- the pest is absent from Western Australia, or has a limited distribution and is under official control;
- the pest has the potential for being on the pathway;
- the pest has the potential for establishment or spread in Western Australia; and
- the pest has the potential for consequences.

Table 5: Quarantine pests for stone fruit from New Zealand

Pest Type	Common name

ARTHROPODS	
Coleoptera (beetles, weevils)	
Eucolaspis brunnea (Fabricius) [Coleoptera: Chrysomelidae]	Bronze beetle
Hemiptera (aphids, leafhoppers, mealybugs, psyllids, scales, true bugs, whiteflies)	
Diaspidiotus ostreaeformis (Curtis) Borchsenius [Hemiptera: Diaspididae]	Oystershell scale
Pseudococcus calceolariae (Maskell) [Hemiptera: Pseudococcidae]	Citrophilus mealybug
Lepidoptera (leafrollers, moths, butterflies)	
Cnephasia jactatana (Walker) [Lepidoptera: Tortricidae]	Black-lyre leafroller
Coscinoptycha improbana Meyrick [Lepidoptera: Carposinidae]	Guava moth
Ctenopseustis herana (Felder & Rogenhofer) [Lepidoptera: Tortricidae]	Brownheaded leafroller
Ctenopseustis obliquana Walker [Lepidoptera: Tortricidae]	Brownheaded leafroller
Cydia pomonella Linnaeus [Lepidoptera: Tortricidae]	Codling moth
Graphania mutans (Walker) [Lepidoptera: Noctuidae]	Grey-brown cutworm
Grapholita molesta (Busck) [Lepidoptera: Tortricidae]	Oriental fruit moth
Harmologa amplexana (Zeller) [Lepidoptera: Tortricidae]	Native leafroller
Planotortrix excessana Walker [Lepidoptera: Tortricidae]	Greenheaded leafroller
Planotortrix flavescens Butler [Lepidoptera: Tortricidae]	Native leafroller
Planotortrix octo Dugdale [Lepidoptera: Tortricidae]	Greenheaded leafroller
Pyrgotis plagiatana (Walker) [Lepidoptera: Tortricidae]	Native leafroller
Thysanoptera (thrips)	
Frankliniella occidentalis (Pergande) [Thysanoptera: Thripidae]	Western flower thrips
Thrips obscuratus (J.C. Crawford) [Thysanoptera: Thripidae]	New Zealand flower thrips
BIOLOGICAL CONTROL AGNETS	
Amblyseius waltersi Schicha [Acari: Phytoseiidae]	Phytoseiid mite
Neoseiulus caudiglans Schuster [Acari: Phytoseiidae]	Phytoseiid mite
Neoseiulus fallacis (Garman) [Acari: Phytoseiidae]	Phytoseiid mite
Typhlodromus pyri Scheuten [Acari: Phytoseiidae]	Phytoseiid mite
PATHOGENS	
Bacteria	
Pseudomonas syringae pv. *persicae* Prunier *et al*.	Bacterial decline
Fungi	
Podosphaera tridactyla (Wallr.) de Bary	Powdery mildew
Taphrina pruni Tulasne	Plum pockets

4.2.2 Risk assessments for quarantine pests

Detailed risk assessments are presented in this pest risk analysis for the quarantine pests identified through the process of pest categorisation. Risk assessments are based on groups of pests (leafrollers and phytoseiid mites) where pest species share similar biological characteristics, behaviour on the host and pathway, and potential phytosanitary considerations. Individual risk assessments are presented for the balance of the pests

Each risk assessment involved the “Assessment of the probability of entry, establishment and spread” and “Assessment of consequences” as described in Section 2 – Method for Pest Risk Analysis. The unrestricted risk posed by each quarantine pest for stone fruit from

New Zealand was estimated by combining likelihood estimates of entry, of establishment and of spread with the estimate of associated potential consequences. The unrestricted risk estimates were then compared with Australia's appropriate level of protection (ALOP) to determine which quarantine pests presented an unacceptable level of risk to Western Australia requiring the further consideration of risk mitigation options.

Likelihood estimates of entry, of establishment and of spread and estimates of associated potential consequences are supported by relevant biological information. Detailed information on the biology and economic importance of each quarantine pest or pest group is provided in the data sheets in Appendix – 2.

The risk assessments were conducted on the basis that the stone fruit for export to Western Australia has been produced using the SummerGreen™ management program that includes appropriate field sanitation, cultural and chemical control programs, as well as commercial harvesting and packing activities (e.g. cleaning and hygiene during packing, and commercial quality control activities). Additionally, factors such as trade history with eastern states and interception data of stone fruit consignments from 1988 to 2002 (PDI, 2003) were also used in the risk assessments.

4.2.2.1 Arthropod pests

4.2.2.1.1 Bronze beetle

Bronze beetle is native to New Zealand, feeding primarily on the foliage of host plants. The beetle is usually only important in fruit orchards where severe defoliation may affect fruit production.

The bronze beetle examined in this pest risk analysis is:

- *Eucolaspis brunnea* (Fabricius) [Coleoptera: Chrysomelidae] – bronze beetle.

Introduction and spread probability

Probability of importation

The likelihood that bronze beetle will arrive in Western Australia with the importation of stone fruit from New Zealand: **Very low**.

- The bronze beetle is native to New Zealand and occurs throughout New Zealand (Kay, 1980).
- Bronze beetle feeds mainly on the foliage of host plants, but feeding tends to be haphazard and discontinuous. On broad-leaved plants, they chew from the lower surface of the leaf, penetrating to the upper side and producing a "shot-hole" (Kay, 1980).
- Bronze beetle adults are reported to feed on the foliage and fruit of stone fruit from October to January in New Zealand and may be present on trees at the time of harvest (McLaren *et al.*, 1999).
- Eggs are laid in the soil and larvae develop underground where they feed on grass roots (McLaren *et al.*, 1999). Although sometimes present in large numbers, the damage they do is slight.
- Fully-grown larvae are about 5 mm long whereas adults are 4-5 mm long.

- Adults feed at night, leaving holes in leaves. If disturbed, adults can jump vigorously off the plant and for this reason are sometimes called “flea beetles” (Kay, 1980).
- Bronze beetles have an activity period coinciding with the harvest of early and mid season stone fruit varieties and may be present on harvested fruit as a contaminant.
- Bronze beetle has not been intercepted in Australia on stone fruit from New Zealand during AQIS inspections from 1988 to 2002 (PDI, 2003).
- Post-harvest grading, washing and packing procedures are likely to remove this pest from the fruit.

Probability of distribution

The likelihood that bronze beetle will be distributed to the endangered area as a result of the processing, sale or disposal of stone fruit from New Zealand: **Moderate**.

- Distribution of the commodity in Western Australia could be for retail sale, as the intended use of the commodity is human consumption. Adult beetles could be distributed with imported fruit, particularly in unopened cartons.
- Adult bronze beetles are capable of flight and could directly disperse from imported cartons of stone fruit.
- When disturbed, adult bronze beetles are reported to jump vigorously (Kay, 1980). Therefore, this beetle may disperse when cartons of imported stone fruit are opened.
- Bronze beetle has a wide host range including both horticultural crops, ornamentals and native plants. Suitable hosts, including *Eucalyptus* species, are present in Western Australia.

Probability of entry (importation x distribution)

The likelihood that bronze beetle will enter Western Australia as a result of trade in stone fruit from New Zealand and be distributed in a viable state to the endangered area: **Very low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of ‘rules’ for combining descriptive likelihoods (Table 2).

Probability of establishment

The likelihood that bronze beetle will establish based on a comparative assessment of factors in the source and destination areas considered pertinent to the ability of the pest to survive and propagate: **High**.

- Bronze beetles have a wide host range including horticultural crops and ornamental species (Kay, 1980) and a number of these hosts are widespread in Western Australia.
- Adults of this species have been recorded on *Chenopodium quinoa*, *Cynodon dactylon*, stone fruit, pome fruit, berry fruits (Penman, 1984), pine (Kay, 1980), eucalyptus, acacia, hawthorn, elm, clover, geranium and rose (Lysaght, 1930).
- Bronze beetle is found throughout New Zealand and similar environments are present in Western Australia.
- Adult females lay eggs in dry soil, in batches of 3-14 eggs. Larvae emerge from the eggs after about three weeks and overwinter underground. In early spring they become active again and pupate. Pupation takes about three weeks (Kay, 1980).

- The species has several overlapping generations per year, breeding continuously without diapause.
- The distribution of bronze beetle in New Zealand indicates the species would be restricted to the lower south west of Western Australia.

Probability of spread

The likelihood that the bronze beetle will spread based on a comparative assessment of those factors in the source and destination areas considered pertinent to the expansion of the geographical distribution of the pest: **High**.

- Adult beetles are capable of independent flight and dispersal from favoured hosts, such as blackberry, are considered an important source of infestation in orchards (Tomkins, 2001).
- Long-distance dispersal is through adult flight (Kay, 1980). However, adults are relatively slow flying diurnal beetles that spend most of their time on (or under) foliage or in flowers.
- Natural physical barriers would likely prevent the unaided spread of this pest but larvae could spread undetected via the movement of nursery stock as larvae feed on roots. The limited information available indicates that larvae feed primarily on the root of a variety of grasses (McLaren *et al.*, 1999). The importance of nursery stock as a potential vector for bronze beetle larvae is unclear.
- Bronze beetle is more likely to disperse in association with host material. There are no intrastate quarantine controls in place in Western Australia on the movement of nursery stock.
- The relevance of natural enemies in Western Australia is unknown.

Probability of entry, of establishment and of spread

The overall likelihood that the bronze beetle will enter Western Australia as a result of trade in stone fruit from New Zealand, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **Very low**.

- The probability of entry, establishment or spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 2).

Consequences

Consequences (direct and indirect) of the bronze beetle: **Low**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C**— The bronze beetle is capable of causing direct harm to a wide range of hosts. Severe defoliation may affect fruit production, and the blemishes produced through beetles chewing young fruit may detract from the value of the crop at maturity (Kay, 1980). This insect is known to cause localised defoliation in young *Pinus radiata* stands, as well as on apples, stone fruit and berry fruit (Manaaki Whenua Land Care Research, 2006). High populations usually last no more than one season, and pine trees soon outgrow any affect of defoliation by this insect (Kay, 1980).
Any other aspects of the environment	**B** — There are no known direct consequences of bronze beetle on the natural or built environment. The impact of bronze beetle on native trees, such as *Eucalyptus* species, is considered to be of minor importance (Withers, 2001), but

Criterion	Estimate
	its introduction into a new environment may lead to competition for resources with native species.
Indirect consequences	
Eradication, control, etc.	**B** — Additional programs to minimise the impact of the bronze beetle on host plants could be necessary. Existing control programs may be effective for some hosts but not necessarily all.
Domestic trade	**C** — The presence of these beetles in commercial stone fruit production areas of Western Australia could result in interstate trade restrictions on a wide range of commodities. These restrictions may lead to a loss of market.
International trade	**C** — The presence of these beetles in commercial stone fruit production areas on a wide range of commodities could have a significant effect at district level due to any limitations to access to overseas markets where this pest is absent.
Environment	**A** — Additional pesticide applications or other control activities could be required to control this pest on susceptible crops although any impact on the environment is likely to be minor at the local level.

Note: Refer to Table 3 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for the bronze beetle, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 4): **Negligible**.

4.2.2.1.2 Citrophilus mealybug

Mealybugs injure plants by extracting large quantities of sap and producing honeydew that serves as a substrate for the development of sooty mould. They generally prefer warm, humid, sheltered sites away from adverse environmental conditions and natural enemies. Many mealybug species pose particularly serious problems to agriculture when introduced into new areas of the world without their specific natural enemies (Miller *et al*., 2002).

The mealybug examined in this pest risk analysis is:

- *Pseudococcus calceolariae* Maskell [Hemiptera: Pseudococcidae] – citrophilus mealybug.

Introduction and spread probability

Probability of importation

The likelihood that citrophilus mealybug will arrive in the PRA area with the importation of stone fruit from New Zealand: **High**.

- Citrophilus mealybug has been recorded on nectarines and plums in New Zealand (Charles, 1993; McLaren *et al*., 1999).
- Mealybugs feed on phloem sap from the stem and fruit. They are typically found in protected sites such as crevices on branches or in the stem end of the fruit (McLaren *et al*., 1999).
- Honeydew, the waste product of the mealybug feeding process, is a perfect growth medium for sooty mould fungi (Hely *et al*., 1982). Fruit with sooty mould may be detected during pre-export inspections.

- Post-harvest grading, washing and packing procedures may remove this pest from the fruit. However, mealybugs often favour cryptic habitats, such as the stem end of fruit, and may remain with the fruit.
- Citrophilus mealybug can survive packinghouse procedures. AQIS inspectors have intercepted citrophilus mealybug on peaches from New Zealand. Numerous other interceptions of mealybugs, including *Pseudococcus* spp., are recorded (PDI, 2003).

Probability of distribution

The likelihood that citrophilus mealybug will be distributed to the endangered area as a result of the processing, sale or disposal of stone fruit from New Zealand: **Moderate**.

- Adults or immature forms may remain on the surface of the fruit during distribution via wholesale or retail trade.
- Distribution of the commodity in Western Australia would be for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- Mealybugs are likely to survive cold storage and transportation i.e. *Pseudococcus affinis* can survive up to 42 days storage at 0°C (Hoy & Whiting, 1997).
- Disposal of waste material could occur near hosts.
- Citrophilus mealybug may enter the environment as adults discarded with fruit or as juveniles blown by wind or carried by other vectors.
- Mealybugs are mobile at all life stages. Crawlers are mobile while adults are slow-moving (Smith *et al*., 1997).
- The natural dispersal mechanism that allows the movement of mealybugs from discarded fruit waste to a suitable host is a significant limiting factor. Mealybugs have a limited ability to disperse independently from the stone fruit pathway.
- Adult females are wingless and would need to be carried onto hosts by vectors such as other insects or people. Adult females can only crawl a few metres, restricting their ability to move from discarded fruit waste to a suitable host.
- Because citrophilus mealybug is polyphagous and its life stages have limited mobility, it is possible it could be transferred to a susceptible host.

Probability of entry (importation x distribution)

The likelihood that citrophilus mealybug will enter Western Australia as a result of trade in stone fruit from New Zealand and be distributed in a viable state to the endangered area: **Moderate**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of ‘rules’ for combining descriptive likelihoods (Table 2).

Probability of establishment

The likelihood that citrophilus mealybug will establish based on a comparative assessment of factors in the source and destination areas considered pertinent to the ability of the pest to survive and propagate: **High**.

- Citrophilus mealybug is native to eastern Australia and now also occurs in the USA, South America, New Zealand, South Africa and Europe (Smith *et al*., 1997).

- Citrophilus mealybug is a highly polyphagous species that has been recorded on 40 plant families (Ben-Dov, 1994), including many commercial and nursery plants such as apple, pear, grape, stone fruit, potato, hibiscus and rose. These hosts are widespread in Western Australia.
- The rate of development of citrophilus mealybug is temperature dependent. There is a minimum threshold temperature for each particular species of mealybug, below which development either ceases totally or is slowed significantly. There is also a maximum threshold temperature, beyond which development is slowed significantly or ceases all together. If temperatures remain elevated for prolonged periods, insect mortality increases rapidly with a consequent crash in population size.
- Mild to warm conditions are most favourable with temperatures of about 25°C and a high relative humidity being optimum for mealybug development. In Australia, mealybug populations reach peaks in spring and autumn.
- Mealybugs have high reproductive rates with multiple generations in a year (Smith *et al*., 1997). Mated females commonly move to a protected site to lay eggs over a period of up to 2 weeks. Females lay approximately 500 eggs within a cottony sac. Females cease feeding before egg laying and die at the end of egg laying. A population can be started from these eggs.
- Existing control programs may be effective. Control strategies are already in place as Western Australia has several economically important mealybug species. These existing control strategies would minimise the impact of citrophilus mealybug within Western Australia. Biological control agents are available that provide control of citrophilus mealybug.

Probability of spread

The likelihood that citrophilus mealybug will spread based on a comparative assessment of those factors in the source and destination areas considered pertinent to the expansion of the geographical distribution of the pest: **High**.

- Citrophilus mealybug has limited independent dispersal capabilities. The long distance dispersal of this pest requires the movement of nymphs and adults on infested host material, such as fruit and nursery stock.
- There are no intrastate quarantine controls in place in Western Australia on the movement of nursery stock.
- Commercial fruit crop hosts of citrophilus mealybug are grown in south-western Western Australia and there are natural barriers between some districts. It would be difficult for the mealybugs to disperse from one district to another by natural means.
- Female mealybugs do not have wings and are therefore limited in their ability to disperse. However, the spread of this pest would be aided if other host plants occurred between the commercial fruit orchards in different districts of Western Australia.
- Short distance dispersal of juveniles could occur through the movement of crawlers in wind currents or as contaminants on biological or mechanical vectors (Williams, 1996).
- Adult males are winged, capable of short flights and are short lived. Male dispersal by crawling or flight is strongly affected by the location of females and their production of sex pheromones.
- Natural enemies of the citrophilus mealybug, such as *Cryptolaemus montrouzieri* and parasitoids *Tetracnemus pretisous* and *Coccophagus gurneyi*, are used to control this

pest in Australia and other countries. However, only *Cryptolaemus montrouzieri* is known to be present in Western Australia.

Probability of entry, of establishment and of spread

The overall likelihood that the citrophilus mealybug will enter Western Australia as a result of trade in stone fruit from New Zealand, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **Moderate**.

- The probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 2).

Consequences

Consequences (direct and indirect) of the citrophilus mealybug: **Low**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C**— Citrophilus mealybug is highly polyphagous and capable of causing direct harm to a wide range of hosts (Hely *et al.,* 1982; Altmann & Green, 1991). Fruit quality can be reduced by the presence of sooty mould. Existing control strategies already in place to control other mealybug species may temper the impact of citrophilus mealybug in some areas.
Any other aspects of the environment	**A**— There are no known direct consequences of citrophilus mealybug on the natural or built environment but their introduction into a new environment may lead to competition for resources with native species.
Indirect consequences	
Eradication, control, etc.	**B** — Existing control programs may be effective. Control strategies are already in place in Western Australia for several economically important mealybug species. These existing control strategies would minimise the impact of citrophilus mealybug within Western Australia. Biological control agents are available that provide control of citrophilus mealybug.
Domestic trade	**A** — The presence of citrophilus mealybug in the commercial stone fruit production areas of Western Australia is estimated to have consequences that are unlikely to be discernible at the regional level and of minor significance at the local level. It is doubtful that there would be any resulting interstate trade restrictions on the host plants and plant material as citrophilus mealybug is present in other states.
International trade	**A** — The presence of citrophilus mealybug in the commercial stone fruit production areas in Western Australia would not have a significant effect, as the mealybug is widespread in areas other than Western Australia.
Environment	**A** — Additional pesticide applications or other control activities may be required to control this pest on susceptible crops but any impact on the environment is likely to be minor at the local level.

Note: Refer to Table 3 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for citrophilus mealybug, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 4): **Low**.

4.2.2.1.3 Oystershell scale

Scale insects are sessile, small and often inconspicuous and have been spread widely on plants and plant products. A wax-based covering protects armoured scales.

The scale examined in this pest risk analysis is:

- *Diaspidiotus ostreaeformis* (Curtis) Borchsenius [Hemiptera: Diaspididae] – oystershell scale

Introduction and spread probability

Probability of importation

The likelihood that oystershell scale (OSS) will arrive in Western Australia with the importation of stone fruit from New Zealand: **Low**.

- OSS is reported on stone fruit in the southern regions of New Zealand (McLaren *et al*., 1999).
- OSS mostly infects the bark on the stems and branches of the host trees. Sometimes it can be found on fruit, where it causes red spots (CABI, 2004).
- OSS is typically found in protected sites such as crevices, which provide refuge for the scale insects from predators and pesticides (Ker & Walker, 1990).
- Eggs are laid on the stems or branches and after hatching, crawlers may settle on the bark or fruit (McLaren *et al*., 1999).
- OSS produces one generation per year and during harvesting time, all stages of the scale are present. Crawlers are the only mobile stage that could contaminate clean fruit by moving from infested fruit.
- Post-harvest grading, washing and packing procedures are likely to reduce the number of OSS on the fruit. OSS is usually found on the fruit surface near the stem-end and may not be detected during pre-export inspection.

Probability of distribution

The likelihood that OSS will be distributed to the endangered area as a result of the processing, sale or disposal of stone fruit from New Zealand: **Low**.

- Adults or immature forms may remain on the surface of the fruit during distribution via wholesale or retail trade.
- Distribution of the commodity in Western Australia would be for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- Adults or immature forms are likely to survive storage and transport and thus be associated with waste material.
- Disposal of waste material could occur near hosts.
- The only stages likely to move off of the importation pathway are adult males or crawlers. Crawlers, after hatching from their eggs, move for a short time and affix to the host (Ker & Walker, 1990). Adult males are winged, fragile and short-lived and only persist for a few days.
- Most crawlers are reported to move only a short distance before inserting their mouthparts into host material.

- Adult females are immobile and would need to be carried onto hosts by vectors such as other insects or people. However, forced removal of female scales that are attached to the plant by their mouthparts is likely to injure or kill the scale.
- The natural dispersal mechanism that allows the movement of scale species from discarded fruit waste to a suitable host is a significant limiting factor. Scales have a limited ability to disperse independently from the fruit pathway.

Probability of entry (importation x distribution)

The likelihood that OSS will enter Western Australia as a result of trade in stone fruit from New Zealand and be distributed in a viable state to the endangered area: **Very low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of ‘rules’ for combining descriptive likelihoods (Table 2).

Probability of establishment

The likelihood that OSS will establish based on a comparative assessment of factors in the source and destination areas considered pertinent to the ability of the pest to survive and propagate: **High**.

- OSS has a wide host range, mainly on deciduous trees. Host plants have been reported from 41 genera in 18 families. These hosts are widespread in Western Australia.
- OSS is widely distributed in Palaearctic and Nearctic regions and has been introduced into Australia, Argentina, Canada and New Zealand (Brookes & Hudson, 1969; Kozár, 1990). Modelling studies in Western Australia suggest that there are regions within Western Australia suitable for the establishment of this pest.
- Although the precise climate tolerance of scales is unknown, they are considered to be tropical or subtropical pests, and are therefore less likely to establish in either cool or hot and dry climates.
- Females release sex pheromones during the day when males are active attracting the winged males for mating. Females have a high fecundity and can lay 100 to 200 eggs. A population can be started from these eggs.
- Populations of OSS are kept under control in its native range by the presence of a large number of parasitoids. Most of these parasitoids are not present in areas where OSS has been introduced resulting in inadequate natural regulation and subsequent outbreaks.
- Existing control programs may be effective for some hosts (e.g. broad spectrum pesticide applications) but not necessarily all hosts.

Probability of spread

The likelihood that OSS will spread based on a comparative assessment of those factors in the source and destination areas considered pertinent to the expansion of the geographical distribution of the pest: **Moderate**.

- OSS is reported from Victoria, South Australia and Tasmania but is absent from Western Australia. There are similar environments in Western Australia that would be suitable for its spread.

- Commercial fruit crop hosts of OSS are grown in southwestern Western Australia but there are natural barriers between some districts that could limit the natural movement from one district to another.
- OSS has limited independent dispersal capabilities. Long distance dispersal is through wind dispersal (Ben-Dov, 1994) or infested host material (Beardsley & Gonzalez, 1975). Interstate quarantine controls are in place on the movement of nursery stock. However, these controls would have no effect on the spread of OSS within Western Australia.
- Adult males are winged and are capable of short flights. Male dispersal by crawling or flight is strongly affected by the location of females and their production of sex pheromones.
- Natural enemies that attack OSS in New Zealand include parasitic wasps, several predatory mites including *Hemisarcoptes malus* and a ladybird of the genus *Rhyzobius* (CABI, 2004). Several species of *Rhyzobius* occur in Western Australia.

Probability of entry, of establishment and of spread

The overall likelihood that OSS will enter Western Australia as a result of trade in stone fruit from New Zealand, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **Very low**.

- The probability of entry, establishment or spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 2).

Consequences

Consequences (direct and indirect) of OSS: **Low**

Criterion	Estimate
Direct consequences	
Plant life or health	**C** — OSS can cause direct harm to a wide range of plant hosts. Damage to fruit produces red marks and such fruits are downgraded for fresh fruit markets (Beardsley & Gonzalez, 1975). Like other scale insects, OSS debilitates plant hosts by sucking sap during feeding. In cases of heavy infestation the branches of the trees can die (CABI, 2004).
Any other aspects of the environment	**A** — Scales introduced into a new environment will compete for resources with the native species. They are estimated to have consequences that are unlikely to be discernible at the national level and of minor significance at the local level.
Indirect consequences	
Eradication, control, etc.	**B** — Programs to minimise the impact of OSS on host plants are likely to be costly and include pesticide applications and crop monitoring. However, OSS is not considered an economically significant species in the areas where it has established in Australia and New Zealand. Control measures that are already in place for economically important scales are likely to be effective against OSS.
Domestic trade	**A** — The presence of OSS in the commercial stone fruit production areas of Western Australia is estimated to have consequences that are unlikely to be discernible at the regional level and of minor significance at the local level. It is doubtful that there would be any resulting interstate trade restrictions on host plants and plant material as OSS is present in other states.
International trade	**B** — The presence of this pest in commercial production areas of a range of commodities is likely to only have a minor effect at the district level due to any limitations to access to overseas markets where this pest is absent, as OSS is widespread in overseas countries.

Criterion	Estimate
Environment	**A** — Additional pesticide applications or other control activities may be required to control OSS on susceptible crops but any impact on the environment is likely to be minor at the local level.

Note: Refer to Table 3 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for OSS, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 4): **Negligible**.

4.2.2.1.4 Codling moth

Apple and pear are the main host plants for codling moth but it has also been shown to develop on walnut, quince, apricot, peach, almond, maize, sweet cherry and Japanese plum. There is no evidence that codling moth can maintain populations in orchards of peach, sweet cherry or almond (Barnes, 1991).

The moth examined in this pest risk analysis is:

- *Cydia pomonella* Linnaeus [Lepidoptera: Tortricidae] – Codling moth.

Introduction and spread probability

Probability of importation

The likelihood that codling moth will arrive in Western Australia with the importation of stone fruit from New Zealand: **Extremely low**.

- Codling moth has been recorded on stone fruit but is not considered a significant pest of these commodities. Codling moth is considered to occur only very rarely on stone fruit (McLaren *et al*., 1999).
- Larvae have been recorded feeding on fruit of peach, plum, apricot, cherry, orange, persimmon, pomegranate and chestnut but the species is essentially a pest of pome fruit (Hely *et al*., 1982).
- Eggs are preferentially laid on apple trees (Wearing *et al*., 1973) because apples release a naturally occurring oviposition stimulant for codling moth (Wearing & Hutchinson, 1973).
- Studies indicate that eggs are not laid on nectarine or cherry when these species are exposed to potential oviposition by codling moth (Wearing & McLaren, 1996).
- On pome fruit, the larvae often enter through the calyx and bore down to the core of the fruit, leaving a prominent entry hole. Codling moth feeding causes premature fall of infested fruit (Hely *et al*., 1982).
- Studies in New Zealand show that there was no damage to stone fruit despite the presence of codling moth damage in apples nearby (Wearing & McLaren, 1996).
- Fully-grown larvae are 20 mm long and pupae are 8.0 to 11.5 mm. Consequently, there is a high likelihood that codling moth would be detected during pre-export inspection.
- Post-harvest grading and packing procedures are likely to remove infested fruit as the entrance hole and frass deposited by developing larvae is easily detected.

Probability of distribution

The likelihood that codling moth will be distributed to the endangered area as a result of the processing, sale or disposal of stone fruit from New Zealand: **Moderate**.

- Distribution of the commodity in the PRA area would be for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- Early instar larvae escaping detection are likely to survive cold storage and distribution to the endangered area. Codling moth would enter the environment via adult emergence from pupae in waste that has been discarded from a distribution centre before the fruit desiccates or decays.
- Adult females would need to locate a male to mate with and then find a susceptible host on which to lay eggs.
- Female are capable of flying up to 600 m and males up to 1 km (HortResearch, 1999).

Probability of entry (importation x distribution)

The likelihood that codling moth will enter Western Australia as a result of trade in stone fruit from New Zealand and be distributed in a viable state to the endangered area: **Extremely low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 2).

Probability of establishment

The likelihood that codling moth will establish based on a comparative assessment of factors in the source and destination areas considered pertinent to the ability of the pest to survive and propagate: **High**.

- Although apple and pear are the main host plants for codling moth (Howell *et al*., 1992), it can complete its life cycle on other hosts. Larvae are known to be polyphagous and have been reported to also feed on cherry (Moffitt *et al*., 1992), nectarine (Curtis *et al*., 1991), prune (Yokoyama & Miller, 1999) and walnut (Vail *et al*., 1993). However, codling moth develops poorly on some potential hosts and cherries are noted to be a very poor host, or even a non-host (Wearing and McLaren, 2001). Codling moth hosts are widespread in Western Australia.
- Codling moth has been reported from New South Wales, Queensland, South Australia, Tasmania and Victoria. Current legislation in Western Australia prohibits the importation of apples and pears into Western Australia. However, several codling moth outbreaks have occurred in Western Australia and been successfully eradicated, indicating that climatic conditions are suitable for its establishment in Western Australia.
- Females vary in their fecundity (Wearing & Ferguson, 1971). Adult females usually lay approximately 250-300 eggs over 4 to 7 days and live for about 4 days after the last oviposition.
- Females lay eggs singly on leaves or, later in the season, on apple fruit (English, 2001). After hatching, the larvae burrow immediately into a fruitlet. Larvae pass through five instars whilst feeding within the fruit, and then leave the fruit.
- The number of generations per year varies from 1 to 4 depending on the climate and the host plant. During each generation a small proportion of the larvae enter diapause for up to two years (Yothers & Carlson, 1941).

Probability of spread

The likelihood that codling moth will spread based on a comparative assessment of those factors in the source and destination areas considered pertinent to the expansion of the geographical distribution of the pest: **High**.

- Codling moth is thought to have originated in the Palaearctic region and has spread along with the cultivation of apples to most temperate regions of the world, including Europe, China, North and South America, South Africa, Australia and New Zealand (Bradley *et al*., 1979).
- Codling moth has also spread in the eastern states of Australia and successfully entered Western Australia several times, indicating the environment in Western Australia would be suitable for its spread.
- Dispersal of codling moth is by the movement of infested fruit, or of cocoons in fruit containers (Hely *et al*., 1982). Natural physical barriers may prevent unaided long-distance spread of this pest but adult forms may spread undetected via the movement of fruit.
- Codling moth is rather sedentary for a winged species. Individual females spread over no more than five to ten trees in most orchards, while the males are more mobile (Hely *et al*., 1982).
- Studies indicate that males can fly for one km from a point of release and some individuals have been recovered up to 11 km away. On the other hand, females have been captured within 300m of their release point and maximum dispersal may be as low as 600 m (HortResearch, 1999).
- Many natural enemies have been reported to attack codling moth larvae and pupae and some are present in Western Australia. *Trichogramma minutem*, a minute parasite of codling moth eggs, is known to occur in Western Australia.

Probability of entry, of establishment and of spread

The overall likelihood that codling moth will enter Western Australia as a result of trade in stone fruit from New Zealand, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **Extremely low**.

- The probability of entry, establishment or spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 2).

Consequences

Consequences (direct and indirect) of the codling moth: **Moderate**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C** — Codling moth is capable of causing direct harm to a wide range of hosts. It can cause two types of damage: stings and deep entries. Stings are entries where larvae bore a short distance into the flesh before dying. The deep entries occur when larvae penetrate the fruit skin, bore into the core and feed in the seed cavity (English, 2001). Apple and pear crops are generally preferred by codling moth and losses of up to 70% have been recorded in a previous incursion in Western Australia.
Any other aspects of the environment	**A**— There are no known direct consequences of codling moth on the natural or built environment but their introduction into a new environment (Western Australia) may lead to competition for resources with native species.

Criterion	Estimate
Indirect consequences	
Eradication, control, etc.	**D** — Additional programs to minimise the impact of this pest on host plants may be necessary in Western Australia. Monitoring/surveillance will result in extra costs to control or eradicate codling moth. These costs would likely be borne primarily by pome fruit growers whose crops are likely to be most severely affected by this pest. It has already cost the WA Government and fruit growing industry several million dollars to eradicate three outbreaks since 1993; including a two-year eradication campaign to control an incursion at Dwellingup.
Domestic trade	**A** — The presence of codling moth in the commercial fruit production areas of Western Australia is estimated to have consequences that are unlikely to be discernible at the regional level and of minor significance at the local level. It is likely there would be no interstate trade restrictions on host plants and plant material for codling moth, as it is present in other states.
International trade	**C** — The presence of this pest in the commercial fruit production areas of Western Australia would have a significant effect at the district level due to any limitations to access to overseas markets (such as Japan) where this pest is absent.
Environment	**A** — Additional pesticide applications or other control activities may be required to control codling moth on susceptible crops but any impact on the environment is likely to be minor at the local level.

Note: Refer to Table 3 (The assessment of local, district, regional and national consequences) and text under the ‘Method for assessing consequences’ section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for codling moth, determined by combining the overall ‘probability of entry, of establishment and of spread’ with the ‘consequences’ using the risk estimation matrix (Table 4): **Negligible**.

4.2.2.1.5 Guava moth

Guava moth is a native of Australia, where it is commonly found feeding on ripening guava fruit during autumn (Hely *et al*., 1982). Guava moth, probably wind blown, was first found in 1997 in Northland, New Zealand (Froud & Dentener, 2002). In New Zealand, it is called fruit driller caterpillar and is a major concern for fruit and nut growers because of its wide host range and the severe damage it causes to a range of organic fruit and nut crops. The moth readily feeds on plums, feijoas, macadamias, loquats, citrus and a number of other fruits (Lees, 2002). Population explosions result from the caterpillar feeding on different fruits that ripen throughout the year, allowing many breeding cycles (Lees, 2002).

The moth examined in this pest risk analysis is:

- *Coscinoptycha improbana* Meyrick [Lepidoptera: Carposinidae] – guava moth.

Introduction and spread probability

Probability of importation

The likelihood that guava moth will arrive in Western Australia with the importation of stone fruit from New Zealand: **Low**.

- Guava moth has been recorded on *Prunus* species in non-commercial sites in the North Island (Froud & Dentener, 2002). Guava moth has been recorded attacking plums and peaches in New Zealand (Lees, 2002). However, *Prunus* is considered to be a minor host in New Zealand with most infestations recorded from feijoa and macadamia. Common (1990) lists the hosts of *C. improbana* as *Cassine australis* (red olive plum), *Schizomeria ovata* (white cherry), *Citrus*, *Psidium guajava* (guava) and *Feijoa sellowiana*. Stone fruit is not recorded as a host in Australia.

- Adult moths of the family Carposinidae are nocturnal, resting on tree trunks during the day and being attracted to lights at night (Common, 1990). It is unlikely that adults would be associated with harvested stone fruit.
- First instar larvae bore a small hole into the ripening fruit while the fruit is still on the tree. Larvae leave the fruit and pupate in the soil after the infested fruit ripens and falls to the ground. (Froud & Dentener, 2002).
- Fruit with distinct entry holes may be detected during post-harvest grading, washing and packing procedures. However, for soft fruit such as plums, there is little external evidence of infestation (Lees, 2002) reducing the likelihood of detection during pre-export inspection.
- There are no interception records for guava moth on any stone fruit from New Zealand (PDI, 2003).

Probability of distribution

The likelihood that guava moth will be distributed to the endangered area as a result of the processing, sale or disposal of stone fruit from New Zealand: **Moderate**.

- Larvae would remain in the infested fruit and be distributed via wholesale or retail sale.
- Distribution of the commodity in Western Australia would be for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- If adult moths were to survive cold storage, they could enter the environment by flight from fruit at the point of sale, during transportation of purchased fruit from retailers to households and from discarded fruit waste in landfills.
- The natural dispersal stage for the guava moth is the adult.
- Early instar larvae that have escaped detection during inspection would be unlikely to develop in discarded fruit before the fruit desiccates or decays.
- The larvae would also be unlikely to find a suitable host on which to complete their development.

Probability of entry (importation x distribution)

The likelihood that guava moth will enter Western Australia as a result of trade in stone fruit from New Zealand and be distributed in a viable state to the endangered area: **Low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of ‘rules’ for combining descriptive likelihoods (Table 2).

Probability of establishment

The likelihood that guava moth will establish based on a comparative assessment of factors in the source and destination areas considered pertinent to the ability of the pest to survive and propagate: **High**.

- Guava moth has a wide host range including red olive plum, white cherry, citrus, guava (Common, 1990), macadamia, loquat, plum, peach and mandarin (Froud & Dentener, 2002) and these hosts are present in the PRA area.

- Guava moth is a temperate to sub-tropical species. In the far north of Australia, breeding is continuous throughout the year with sufficient hosts available to sustain the population year round (Dymock, 2001).
- Guava moth is native to Australia and is reported from Queensland to Victoria and Tasmania (Common, 1990). This species is also reported in Norfolk Island and New Zealand (Froud & Dentener, 2002). This suggests that it may also establish in Western Australia.

Probability of spread

The likelihood that guava moth will spread based on a comparative assessment of those factors in the source and destination areas considered pertinent to the expansion of the geographical distribution of the pest: **High**.

- Commercial fruit crop hosts of guava moth are grown in south-western Western Australia and there are natural barriers between some districts.
- Guava moth occurs in the eastern states of Australia indicating the environment in Western Australia would be suitable for its spread.
- Larvae of Carposinid moths are reported to feed internally on flower buds, bark and galls (Jamieson *et al.*, 2004). Therefore, the movement of nursery stock could also contribute to the spread of this pest.
- Long-distance dispersal is through adult flight (Froud & Dentener, 2002). Short-distance dispersal also occurs, as adult moths are mobile and able to rapidly move between host plants. The adults of this family are nocturnal, resting on tree trunks during the day and are attracted to lights at night.
- The relevance of natural enemies to the spread of the guava moth in Western Australia is not known.

Probability of entry, of establishment and of spread

The overall likelihood that the guava moth will enter Western Australia as a result of trade in stone fruit from New Zealand, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **Low**.

- The probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 2).

Consequences

Consequences (direct and indirect) of the guava moth: **Low**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C**— Guava moth is capable of causing direct harm to a wide range of hosts (Hely *et al.,* 1982; Froud & Dentener, 2002). In contrast to eastern Australia where it is a minor pest, guava moth infests plum, peach, pear, nashi and apple in New Zealand (Lees, 2002).
Any other aspects of the environment	**A**— There are no known direct consequences of guava moth on the natural or built environment but its introduction into a new environment may lead to competition for resources with native species.
Indirect consequences	
Eradication, control, etc.	**B** — Programs to minimise the impact of guava moth on host plants are likely to

Criterion	Estimate
	be costly and include pesticide applications and crop monitoring. Existing control programs may be effective for some hosts but not necessarily all hosts.
Domestic trade	**A** — The presence of guava moth in the commercial stone fruit production areas of Western Australia is estimated to have consequences that are unlikely to be discernible at the regional level and of minor significance at the local level.
International trade	**C** — The presence of guava moth in commercial production areas in Western Australia may have an effect due to possible limitations to access to overseas markets where guava moth is absent.
Environment	**A** — Although additional pesticide applications or other control activities would be required to control guava moth on susceptible crops, any indirect effect on the environment is unlikely to be discernible.

Note: Refer to Table 3 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for guava moth, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 4): **Very low**.

4.2.2.1.6 Leafrollers

Leafrollers are the larval (caterpillar) stages of a number of species of moths. Leafrollers are members of the Tortricidae family, which include 5,000 species throughout the world. The larvae of leafrollers (*Planotortrix*, *Harmologa*, *Ctenopseustis*, *Cnephasia*) feed on leaves or fruit. The distribution and abundance of leafrollers is influenced by the presence of suitable host plants in the vicinity of individual orchards including fruit trees.

The leafrollers examined in this pest risk analysis are:

- *Cnephasia jactatana* (Walker) [Lepidoptera: Tortricidae] – black-lyre leafroller
- *Ctenopseustis herana* (Fold & Rogen) [Lepidoptera: Tortricidae] – brownheaded leafroller
- *Ctenopseustis obliquana* Walker [Lepidoptera: Tortricidae] – brownheaded leafroller
- *Harmologa amplexana* (Zeller) [Lepidoptera: Tortricidae] – native leafroller
- *Planotortrix excessana* Walker [Lepidoptera: Tortricidae] – greenheaded leafroller
- *Planotortrix flavescens* Butler [Lepidoptera: Tortricidae] – native leafroller
- *Planotortrix octo* Dugdale [Lepidoptera: Tortricidae] – greenheaded leafroller
- *Pyrgotis plagiatana* (Walker) [Lepidoptera: Tortricidae] – native leafroller

The leafroller species listed above are recognised as significant pests of stone fruit in New Zealand. These species have been grouped together because of their similar biology. Leafrollers lay eggs in clusters on host leaves and fruit. Larval stages feed on leaf tissue, shoot tips and fruit. On fruit, larvae may feed internally or externally. All species of leafroller larvae cause similar damage to foliage and fruits, with no way of differentiating between the damage caused by different species. Due to the recognised importance of the brownheaded and greenheaded leafrollers, they are used as the basis for the risk assessment.

Introduction and spread probability

Probability of importation

The likelihood that leafrollers will arrive in Western Australia with the importation of stone fruit from New Zealand**: High**.

- These leafrollers are endemic in New Zealand and have been reported from summer fruit orchards (McLaren *et al*, 1999). The distribution and importance of each species in orchard areas varies nationally with latitude (Foster *et al*., 1991).
- Leafrollers feed on leaves and fruit (McLaren *et al*., 1999). Superficial fruit damage is common on apple and stone fruit (Thomas, 1998).
- Egg masses are laid in clusters on the upper surface of host leaves and fruit (Penman, 1984). All five to six larval stages are completed on leaves or fruit. Pupae are rare on fruit (McLaren *et al*., 1999).
- The larvae may feed internally or externally on fruit. Internally feeding larvae eject droppings (frass) outside the fruit or protective shelter (Thomas, 1998). Most fruit with internally feeding larvae would show external damage or the presence of frass and are therefore likely to be rejected during sorting.
- Microbial breakdown can occur on infested fruit and such fruit may be detected during packinghouse procedures.
- Adult brownheaded leafrollers are 8-12 mm, while adult greenheaded leafrollers are 8-14mm. Larvae feeding externally on fruit are likely to be eliminated by packinghouse procedures (including washing, sorting and grading).
- Leafrollers can survive packinghouse procedures. AQIS inspectors have intercepted leafrollers on apricots (in 2000, 2002), peaches (in 2000) and nectarines (2000) from New Zealand (PDI, 2003).

Probability of distribution

The likelihood that leafrollers will be distributed to the endangered area as a result of the processing, sale or disposal of stone fruit from New Zealand: **Moderate**.

- Adults and immature forms could be present in the stem end of the fruit and remain with the commodity during distribution via wholesale or retail trade.
- Distribution of the commodity in the PRA area would be for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- In the Canterbury region of the South Island of New Zealand, larvae of greenheaded leafrollers overwinter as late instars (Thomas, 1998), suggesting they may survive cold storage employed by wholesalers and retailers.
- If adult moths were to survive cold storage, they could enter the environment by flight from fruit at the point of sale, during transportation of purchased fruit from retailers to households and from discarded fruit waste at landfills.
- The natural dispersal stage for these pests is the adult.
- Early instar larvae that have escaped detection during inspection would be unlikely to develop in discarded fruit before the fruit desiccates or decays.
- Such larvae would also be unlikely to find a suitable host on which to complete their development.

Probability of entry (importation x distribution)

The likelihood that leafrollers will enter Western Australia as a result of trade in stone fruit from New Zealand and be distributed in a viable state to the endangered area: **Moderate**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 2).

Probability of establishment

The likelihood that leafrollers will establish based on a comparative assessment of factors in the source and destination areas considered pertinent to the ability of the pest to survive and propagate: **High**.

- These leafrollers are polyphagous (except for *Harmologa oblonga*), feeding on more than 250 plant species in New Zealand (McLaren *et al*., 1999), many of which occur in Western Australia, such as apple, cherry, kiwifruit, peach, plum and wattle.
- Brownheaded and greenheaded leafrollers are found throughout New Zealand and some offshore islands, where climatic conditions are similar to parts of Western Australia.
- Eggs are laid in clusters of 3-150 on the upper surface of host leaves and produce two to six overlapping generations per year depending on latitude and climate.
- After larvae hatch, they need to find a host before they can develop, pupate, become adults, mate and lay eggs to establish a new population.
- Leafrollers only reproduce sexually. Adults have a short life span and any delay in mating generally shortens the oviposition period and reduces fecundity and fertility (Foster *et al*., 1995).
- Existing control programs may not be effective, as several leafroller species including *Planotortrix octo* have developed resistance to organophosphate and carbamate insecticides (Lo *et al*., 1997).

Probability of spread

The likelihood that leafrollers will spread based on a comparative assessment of those factors in the source and destination areas considered pertinent to the expansion of the geographical distribution of the pest: **High**.

- There is little information on the ability of these leafrollers to spread beyond natural barriers. The long distances between the main commercial orchard districts could make it difficult for these leafrollers to disperse naturally from one area to another. However, the highly polyphagous nature of these species may enable them to locate suitable hosts in the intervening areas.
- Studies have shown that adults are able to fly at least 400 metres and are predominantly nocturnal fliers (HortResearch, 1999).
- First instar larvae are mobile and during this phase caterpillars may move to new host plants, often dispersing into fruit tree orchards (HortResearch, 1999).
- Environments (e.g. temperature, rainfall) similar to those in New Zealand occur in parts of Western Australia.
- Human activity can help the spread of these pests, as larvae associated with fruit may be moved around with the commodity.

- Leafrollers are attacked by a wide range of parasitoids and generalist predators in New Zealand, including several introduced from Australia. However, the importance of these natural enemies in Western Australia is not known.
- Because these species have multiple generations, are capable of flight and can be spread by humans in plant material, their likelihood of spread is rated as high.

Probability of entry, of establishment and of spread

The overall likelihood that leafrollers will enter Western Australia as a result of trade in stone fruit from New Zealand, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **Moderate**.

- The probability of entry, establishment or spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 2).

Consequences

Consequences (direct and indirect) of leafrollers: **Moderate**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C** — These leafrollers are recorded as being capable of causing direct damage to host plants. Some of the leafrollers are rated as primary economic pests in New Zealand where they damage the leaves, buds and fruit of their hosts (Wearing *et al*., 1991).
Any other aspects of the environment	**A** — There are no known consequences of leafrollers on other aspects of the environment but their introduction into a new environment may lead to competition for resources with native species.
Indirect consequences	
Eradication, control, etc.	**D** — Additional programs to minimise the impact of these pests on host plants may be necessary. Existing control programs may not be effective. Several leafroller species including *Planotortrix octo* in New Zealand have developed resistance to organophosphate and carbamate insecticides (Lo *et al*., 1997). Eradication and control would be significant at the regional level. These pests may potentially increase production costs by triggering specific controls as these pests are of quarantine concern to important trading partners.
Domestic trade	**C** — The presence of these pests in commercial production areas may have a highly significant effect at the local level due to any resulting interstate trade restrictions on a wide range of commodities. These restrictions could lead to a loss of markets, which in turn would be likely to require industry adjustment.
International trade	**D** — Leafrollers are endemic in New Zealand and are treated as quarantine pests by many countries (McLaren *et al*., 1999). The presence of these leafrollers in commercial production areas on a range of commodities could have a significant effect at the regional level due to any limitations to access to overseas markets where these pests are absent.
Environment	**A** — Although additional pesticide applications or other control activities would be required to control these pests on susceptible crops, these are not considered to impact on the environment.

Note: Refer to Table 3 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for leafrollers, determined by combining the overall ‘probability of entry, of establishment and of spread’ with the ‘consequences’ using the risk estimation matrix (Table 4): **Moderate**.

4.2.2.1.7 Grey-brown cutworm

Grey-brown cutworm (GBC) is native to New Zealand and is found in apple orchards throughout the country. This pest is generally controlled by applications of insecticides.

The species examined in this pest risk analysis is:

- *Graphania mutans* Walker [Lepidoptera: Noctuidae] – grey-brown cutworm

Introduction and spread probability

Probability of importation

The likelihood that GBC will arrive in Western Australia with the importation of stone fruit from New Zealand: **Low**.

- While recorded as a pest of apples, there is no published scientific literature to support its presence on stone fruit and GBC is not included as a pest of stone fruit by McLaren *et al.* (1999). There is a single positive interception of GBC (as *Melanchra mutans*) recorded from plums imported from New Zealand in 1988 (PDI, 2003).
- GBC larvae are recorded to feed on apple fruit and can cause characteristic scar tissue on fruit, and damage apical shoots affecting tree vigour (Suckling *et al*., 1990).
- GBC lays eggs in batches on foliage or sometimes on young apple fruit (Burnip *et al*., 1995). However, there is no evidence that it lays eggs on stone fruit.
- The hatching larvae disperse to feed on foliage for a short time. Most of the young caterpillars then descend from the trees to the orchard understorey where they feed on a variety of ground cover plants (HortResearch, 1999).
- Fruit with characteristic scar tissue would be detected during grading and packing procedures.
- Larvae are likely to be detected because of their size (fully-grown larvae are about 25 mm in length).
- Post-harvest grading, washing and packing procedures are likely to remove the majority of this pest from the fruit.
- GBC can survive packinghouse procedures. AQIS inspectors have intercepted GBC on plums from New Zealand in 1998 (PDI, 2003).

Probability of distribution

The likelihood that GBC will be distributed to the endangered area as a result of the processing, sale or disposal of stone fruit from New Zealand: **Moderate**.

- Distribution of the commodity in Western Australia would be for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- Barratt and Patrick (1987) indicate that GBC is a general herb feeder. This increases the likelihood of larvae finding a suitable host.

- In orchards, larvae of GBC feed initially on leaves and fruit, but descend from trees to feed on a variety of pasture grasses (HortResearch, 1999). Therefore, there is a range of suitable hosts on which GBC can complete its development.
- GBC has been intercepted on plums exported from New Zealand to Australia indicating that larvae can survive transport and cold storage (PDI, 2003).
- The natural dispersal stage for GBC is the adult.
- Early instar larvae that have escaped detection during inspection would be unlikely to develop in discarded fruit before the fruit desiccates or decays.
- However, larvae would be unlikely to find a suitable host on which to complete their development in distribution centres or retailer premises.

Probability of entry (importation x distribution)

The likelihood that GBC will enter Western Australia as a result of trade in stone fruit from New Zealand and be distributed in a viable state to the endangered area: **Low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of ‘rules’ for combining descriptive likelihoods (Table 2).

Probability of establishment

The likelihood that GBC will establish based on a comparative assessment of factors in the source and destination areas considered pertinent to the ability of the pest to survive and propagate: **High**.

- GBC has a wide host range including both horticultural and pasture crops (HortResearch, 1999), many of which are widespread in Western Australia.
- Two distinct taxa exist within *Graphania mutans* based on sex pheromone evidence (Frerot & Foster, 1991), suggesting that it has the potential to readily adapt to new environments.
- GBC is found in regions of New Zealand, where climatic conditions are similar to those in some areas of Western Australia.
- GBC only reproduces sexually. Successful mating between a male and a female must occur before eggs are produced. When hatched larvae find a suitable host, they need to develop, pupate, become adults and mate before laying their eggs to establish a new colony.

Probability of spread

The likelihood that GBC will spread based on a comparative assessment of those factors in the source and destination areas considered pertinent to the expansion of the geographical distribution of the pest: **High**.

- There are environments in Western Australia that are similar to those in New Zealand that would be suitable for the spread of GBC.
- Long-distance dispersal is through adult flights, as both males and females are winged.
- Larvae are reported to descend from host trees to feed on a variety of pasture plants below the tree canopy (HortResearch, 1999). Therefore, it is unlikely that the larval stage is important in the independent distribution of this pest.
- Eggs are recorded to be deposited on some fruit, such as apples (Burnip *et al*., 1995), so the movement of infested fruit for consumption may also be an important factor for

the spread of the pest. However, this would require young larvae to find a new host before the fruit is eaten.

- The main commercial hosts of GBC, including stone fruit, apple and pastures, are grown in Western Australia. Natural barriers exist between the areas where these hosts are grown.
- Other host plants growing between commercial stone fruit and apple orchards in different production areas would help the spread of GBC.
- Long distance spread of GBC could also occur on nursery stock, as there are no intrastate quarantine controls on the movement of nursery stock in place in Western Australia.
- The relevance of potential natural enemies in Western Australia is not known.

Probability of entry, of establishment and of spread

The overall likelihood that GBC will enter Western Australia as a result of trade in stone fruit from New Zealand, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **Low**.

- The probability of entry, establishment or spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 2).

Consequences

Consequences (direct and indirect) of the GBC: **Low**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C** — GBC is a polyphagous insect that feeds on a variety of pasture plants and grasses. GBC is known to cause damage to apples in New Zealand. Feeding damage reduces marketability of produce.
Any other aspects of the environment	**A** — There are no known direct consequences of GBC on the natural or built environment but its introduction into a new environment may lead to competition for resources with native species.
Indirect consequences	
Eradication, control, etc.	**C** — Additional programs to minimise the impact of GBC on host plants may be necessary. Existing control programs may be effective for some hosts but not necessarily all hosts. A control or eradication program would increase the cost of production of host crops.
Domestic trade	**C** — The presence of GBC in commercial stone fruit production areas of Western Australia could have a significant effect at the district level due to any limitations to access to interstate markets where this pest is absent.
International trade	**C** — The presence of GBC in commercial production areas of a range of commodities could have a significant effect at the district level due to any limitations to access to overseas markets where this pest is absent.
Environment	**A** — Additional pesticide applications or other control activities may be required to control GBC on susceptible crops but any impact on the environment is likely to be minor at the local level.

Note: Refer to Table 3 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for GBC, determined by combining the overall ‘probability of entry, of establishment and of spread’ with the ‘consequences’ using the risk estimation matrix (Table 4): **Very low**.

4.2.2.1.8 Oriental fruit moth

The oriental fruit moth (OFM) is native to northwest China, and spread from Japan to Australia, central Europe, the east coast of the USA and Brazil at the beginning of the twentieth century. Since then, the pest has been introduced into many other countries (Gonzalez, 1978). The oriental fruit moth is a serious pest of stone fruit in Europe, Australia and North America (Murrell & Lo, 1998).

The species examined in this pest risk analysis is:

- *Grapholita molesta* Busck [Lepidoptera: Tortricidae] – oriental fruit moth

Introduction and spread probability

Probability of importation

The likelihood that OFM will arrive in Western Australia with the importation of stone fruit from New Zealand: **Moderate**.

- OFM has been reported on all stone fruit in New Zealand (McLaren *et al*., 1999). Peach and nectarine are reported to be favoured hosts.
- OFM has a restricted distribution in New Zealand (Cox & Dale, 1977; Baker, 1982; Murrell & Lo, 1998). Based on limited trapping data, the south island of New Zealand appears to be free of OFM and trapping systems are in place to monitor for the pest. However, there is no restriction on the movement of OFM hosts from the north island (where OFM is present) to the south island, making area freedom status for the south island problematic.
- OFM lay eggs near young shoots and after hatching the larvae bore into the shoot and feed inside the stem, passing through four larval stages. Later larval generations may live inside fruit, especially in late-maturing peaches (McLaren *et al*., 1999).
- Neonate larvae are usually unable to directly penetrate hard young fruit. Later instars are able to enter fruit after feeding in the pedicel (Rothschild & Vickers, 1991).
- Up to 50% of spring and early generations form their cocoons on trees. However later generations form cocoons on the ground (Russell, 1986).
- Where fruit is attacked directly, an individual larva will usually feed within the same fruit (Rothschild & Vickers, 1991).
- Gum and frass protrude from the wound area as the larvae bore into the fruit. As the gum ages, a sooty mould may form on it, turning the wound area black (Polk *et al*., 2003).
- Fully-grown larvae are approximately 12 mm long, while the moth is 10-16mm (Rothschild & Vickers, 1991). Consequently, there is a high likelihood that OFM would be detected during pre-export inspection.
- Larvae may occasionally enter fruit through the inside of the stem, and therefore leave no wound area except for a small mark at the stem end of the picked fruit (Polk *et al*., 2003).

- Infested fruit exhibiting gum or superficial feeding wounds would be rejected during routine quality inspection. However, early instar larvae may escape detection during grading operations because of lack of gum or surface feeding scars on fruit and their small size.
- OFM was intercepted by AQIS inspectors on apricots and nectarines from New Zealand in 1990.

Probability of distribution

The likelihood that OFM will be distributed to the endangered area as a result of the processing, sale or disposal of stone fruit from New Zealand: **Moderate**.

- Immature forms could be present in the fruit and remain with the commodity during distribution via wholesale or retail trade.
- Distribution of the commodity in Western Australia would be for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- Early instar larvae escaping detection are likely to survive cold storage and distribution to the endangered area where they could develop to pre-pupation within the fruit before fruit desiccation or decay. Provided a sheltered site is available, larvae that escape detection could pupate and emerge as adults. The ability to find a suitable pupation site would be a limiting factor for distribution.
- Alternately, larvae in fruit would need to find another suitable host on which to complete development prior to pupation.
- Adult females would need to locate a mate and then find a susceptible fruiting host to lay eggs.

Probability of entry (importation x distribution)

The likelihood that OFM will enter Western Australia as a result of trade in stone fruit from New Zealand and be distributed in a viable state to the endangered area: **Low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of ‘rules’ for combining descriptive likelihoods (Table 2).

Probability of establishment

The likelihood that OFM will establish based on a comparative assessment of factors in the source and destination areas considered pertinent to the ability of the pest to survive and propagate: **High**.

- The principal economic hosts are peach, apricot, nectarine, almond, apple, quince, pear, plum and cherry (Howitt, 1993). Many woody ornamental plants are also hosts (Howitt, 1993). Late ripening peach cultivars are particularly vulnerable to this pest. Some of these host species are widespread in Western Australia.
- OFM is already reported from New South Wales, Queensland, South Australia, Tasmania and Victoria.
- The previously eradicated incursion of oriental fruit moth in Western Australia indicates that areas with a suitable environment for the establishment of OFM occur in Western Australia.
- OFM only reproduces sexually and mating activity occurs in the upper canopy of peach trees (Rothschild & Vickers, 1991).

- Egg deposition usually begins 2-5 days after the females emerge and continues for 7-10 days or longer (USDA, 1958). Eggs are laid singly and each female lays 50-200 eggs on the underside of the leaves near growing tips. Life cycle development is temperature dependent and ranges from 11-40 days (Rothschild & Vickers, 1991).
- OFM over winters as a full-grown larva in a cocoon. Cocoons are found in cracks, under flakes of bark, under old bark wounds and in holes in twigs exposed by pruning. They are also found under infested trees, where they occur in the dried remains of fruit, in the stems of stubble and even in cracks in the soil. Early in the spring, at temperatures above 10°C, pupation takes place. The duration of the pupal stage averages 16 days, compared with a mean of 7 days in summer (Enukidze, 1981).
- OFM does not rely on fruit for establishment, as larvae emerging in spring will attack new vegetative shoots (Robinson, 1997).
- Mated females lay their eggs singly on twigs or on the undersides of leaves near growing terminal shoots. A population can be started from these eggs.

Probability of spread

The likelihood that the OFM will spread based on a comparative assessment of those factors in the source and destination areas considered pertinent to the expansion of the geographical distribution of the pest: **High**.

- OFM has spread throughout the eastern Australian States and New Zealand since its accidental introduction. It may also spread in similar environments in the PRA area.
- OFM can disperse with host fruit and nursery stock, by adult flight, and in association with farm equipment and packaging.
- Long distance spread of OFM could occur in nursery stock, as there are no intrastate quarantine controls in place in Western Australia on the movement of nursery stock.
- The commercial stone fruit production districts in Western Australia are located in the far south west of the State. Natural barriers, including arid areas, climatic differentials and long distances between hosts, may limit the natural spread of OFM.
- Natural enemies may be present in Western Australia but there is no information available on their effect on spread.

Probability of entry, of establishment and of spread

The overall likelihood that the OFM will enter Western Australia as a result of trade in stone fruit from New Zealand, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **Low**.

- The probability of entry, establishment or spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 2).

Consequences

Consequences (direct and indirect) of the OFM: **Moderate**.

Criterion	Estimate
Direct consequences	
Plant life or health	**D** — OFM is a serious pest of economic importance in commercial peach, nectarine and apricot orchards and can also attack and cause economic damage to other commercial fruits. In severe attacks, young trees can suffer distortion of growing shoots and stems. Fruit damage considerably reduces quality and

Criterion	Estimate
	market value (Hogmire & Beavers, 1998).
Any other aspects of the environment	**A**— There are no known direct consequences of OFM on the natural or built environment but its introduction into a new environment (Western Australia) may lead to competition for resources with native species.
Indirect consequences	
Eradication, control, etc.	**D** — Additional programs to minimise the impact of this pest on host plants may be necessary in Western Australia. Monitoring/surveillance will result in extra costs to stone fruit growers and eradication is an expensive option. It has already cost the WA Government and fruit growing industry several million dollars to eradicate an outbreak of oriental fruit moth in 1952. Eradication and control would be significant at the regional level. OFM may potentially increase production costs by triggering specific controls as this pest is of quarantine concern to important trading partners.
Domestic trade	**A** — The presence of OFM in the commercial stone fruit production areas of Western Australia is estimated to have consequences that are unlikely to be discernible at the regional level and of minor significance at the local level. It is doubtful that there would be any resulting interstate trade restrictions on host plants and plant material as OFM is present in other states.
International trade	**C** — The presence of this pest in commercial stone fruit production areas of Western Australia could have a significant effect at the district level due to any limitations to access to overseas markets where this pest is absent.
Environment	**A** — Additional pesticide applications or other control activities may be required to control this pest on susceptible crops but any impact on the environment is likely to be minor at the local level.

Note: Refer to Table 3 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for OFM, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 4): **Low**.

4.2.2.1.9 New Zealand flower thrips

New Zealand flower thrips (NZFT) is native to New Zealand and can be found on the flowers of a wide range of native and introduced plants. It is also found on the surface of various fruits. NZFT is highly mobile. Its distribution within the tree varies with the stage of development of the host plant, time of day and temperature (McLaren & Fraser, 2002).

The species examined in this pest risk analysis is:

- *Thrips obscuratus* (Crawford) [Thysanoptera: Thripidae] – New Zealand flower thrips

Introduction and spread probability

Probability of importation

The likelihood that NZFT will arrive in Western Australia with the importation of stone fruit from New Zealand: **High**.

- NZFT are found throughout New Zealand (excluding the Chatham Islands), from alpine regions down to sea level (HortResearch, 1999). They are found on the flowers of a wide range of both native plants, such as New Zealand flax and introduced plants including kiwifruit, pome fruit, stone fruit and citrus.

- NZFT are found throughout New Zealand on all stone fruit (McLaren *et al*., 1999).
- NZFT feeds on flowers and fruitlets causing damage to the fruit (McLaren, 1992). Damage to nectarine fruit depends on the stage of development of the fruit when attacked and the length of the feeding time (McLaren *et al*., 1999).
- Eggs are laid under the skin at the stem end of apricot and nectarine fruit, or into the flower stalk or petals of cherry (McLaren *et al*., 1999). Larvae crawl inside the flowers (apricot and nectarine) and into the bracts at the base of cherry flowers to feed on pollen or nectar. On nectarine, larvae also feed on the exposed surface of the fruitlet.
- Adults sometimes lay eggs on the surface of stone fruit (HortResearch, 1999).
- Adults and larvae are attracted to ripening stone fruit (McLaren *et al*., 1999).
- Infested fruit exhibit russeting and silvering of the skin, symptoms that could be detected during routine quality grading.
- Post-harvest grading, washing and packing procedures are likely to reduce the number of NZFT on the fruit.
- NZFT can survive packinghouse procedures. AQIS inspectors have intercepted NZFT on apricots (in 1992, 1997 and 1999), nectarines (in 1989, 1991, 1992, 1995 and 2000) and peaches (in 1988, 1991, 1992, 1994, 1995 and 2000) from New Zealand (PDI, 2003).

Probability of distribution

The likelihood that NZFT will be distributed to the endangered area as a result of the processing, sale or disposal of stone fruit from New Zealand: **Moderate**.

- NZFT hidden in the stem end of stone fruit may remain with the commodity during distribution via wholesale or retail trade.
- NZFT are likely to survive cold storage and transportation as they have previously been intercepted in Australia on stone fruit exported from New Zealand.
- Distribution of the commodity in Western Australia could be for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- NZFT could enter the environment directly from fruit during distribution and sale and through eggs that have hatched in discarded fruit or fruit waste before the fruit desiccates or decays.
- NZFT is highly polyphagous and the dispersal of adults and nymphs is via wind-assisted flight (Teulon *et al.,* 1995).

Probability of entry (importation x distribution)

The likelihood that NZFT will enter Western Australia as a result of trade in stone fruit from New Zealand and be distributed in a viable state to the endangered area: **Moderate**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of ‘rules’ for combining descriptive likelihoods (Table 2).

Probability of establishment

The likelihood that NZFT will establish based on a comparative assessment of factors in the source and destination areas considered pertinent to the ability of the pest to survive and propagate: **Moderate**.

- NZFT are highly polyphagous and have been reported feeding on 225 species of host plants (McLaren *et al*., 1999). These hosts are widespread in Western Australia.
- NZFT reproduced continuously in warmer climates resulting in several generations per year and may reach populations as high as 3000 individuals on a single plant (Mound & Walker, 1982).
- Many environments in Western Australia, and Australia in general, would be suitable for the thrips' survival and reproduction, as this species is noted for its tolerance of a range of ecological and physiological conditions.
- NZFT has limited thermal tolerance, particularly to high temperatures (McLaren & Fraser, 1998). High temperatures during the period when stone fruit may be imported (i.e. during spring and summer), would increase the mortality of thrips.
- There is no evidence that this species has established in Australia, although it may have had opportunities to do so in the past. However, quarantine conditions are imposed for NZFT intercepted on other produce.
- Mated females lay eggs that produce female thrips, whereas eggs from unmated females produce males. A pollen supply is necessary for egg laying (McLaren *et al*., 1999).
- Many generations are produced every year. The number of generations in any year varies with temperature (McLaren *et al*., 1999).
- Eggs are laid under the skin of the stem end of apricot and nectarine, or into the flower stalk or petals of cherry (McLaren *et al*., 1999). Larvae crawl inside the flowers (apricot and nectarine) and into bracts at the base of cherry flowers to feed on pollen or nectar. On completion of two larval stages, preppie drop to the ground for the pupal stage. Adults emerge to start a new generation on a new host.
- There is no reproductive diapause in this species, enabling both adults and larvae to be present throughout the year. In stone fruit, population numbers peak in mid summer with adults feeding and laying eggs on the fruit (Teulon *et al.,* 1995).

Probability of spread

The likelihood that the NZFT will spread based on a comparative assessment of those factors in the source and destination areas considered pertinent to the expansion of the geographical distribution of the pest: **High**.

- NZFT has been reported from all over New Zealand. There are similar environments in Western Australia that would be suitable for its spread.
- There is little information on the ability of NZFT to spread beyond natural barriers. The long distances between the main commercial orchard districts in Western Australia may make it difficult for NZFT to disperse by natural means from one area to another.
- While NZFT are considered unable to overwinter in cold regions such as Central Otago, large thrips populations are often recorded in early spring. Hayes *et al.* (1999) linked this early season population to wind assisted dispersal and represents a 200km movement of NZFT populations over a short period of time.
- Dispersal of adults and nymphs is via wind-assisted flight (Teulon *et al.,* 1995).

- The highly polyphagous nature of this pest should enable it to locate suitable hosts in the intervening areas.
- Long distance dispersal of NZFT is facilitated by the commercial distribution of host fruit and nursery stock. There are no intrastate restrictions on the movement of fruit or nursery stock in Western Australia.
- Other thrips species such as *Thrips palmi, T. tabaci and Frankliniella occidentalis* are reported to be readily dispersed with trade of horticultural produce due to the difficulties in detecting these pests (Lewis, 1997).
- The relevance of potential natural enemies in Western Australia is not known.

Probability of entry, of establishment and of spread

The overall likelihood that the NZFT will enter Western Australia as a result of trade in stone fruit from New Zealand, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **Low**.

- The probability of entry, establishment or spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 2).

Consequences

Consequences (direct and indirect) of the New Zealand flower thrips: **Moderate**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C** — NZFT are capable of causing direct harm to a wide range of hosts (McLaren *et al*., 1999). Both adults and larvae feed on the cell contents of soft plant tissues and from pollen grains (McLaren & Walker, 1998). In stone fruit, feeding damage can lead to the discolouration, bleaching and speckling of fruit. Damage can range from an inoffensive cosmetic blemish to a significant downgrading of fruit (Teulon & Penman, 1996). NZFT could increase levels of diseases in nectarines (McLaren *et al*., 2003).
Any other aspects of the environment	**A** — There are no known direct consequences of NZFT on any aspects of the environment but their introduction into a new environment may lead to competition for resources with native species.
Indirect consequences	
Eradication, control, etc.	**C** — Programs to minimise the impact of NZFT on host plants are likely to be costly and include pesticide applications and crop monitoring. Insecticides are applied when spray thresholds are exceeded (McLaren & Fraser, 2000). A control or eradication program would add to the cost of production of many of its hosts.
Domestic trade	**C** — The presence of NZFT in commercial production areas may have a significant effect at the district level due to any resulting interstate trade restrictions on a wide range of commodities. These restrictions could lead to a loss of markets, which in turn would be likely to require industry adjustment.
International trade	**D** — The presence of NZFT in commercial production areas on a range of commodities (stone fruit, cut flowers, asparagus and capsicum) may have a significant effect at the regional level due to any limitations to access to overseas markets where this pest is absent. This thrips is not recorded from many of Australia's major trading partners and has the potential to impact on many different crops.
Environment	**A** — Additional pesticide applications or other control activities may be required to control NZFT on susceptible crops but any impact on the environment is likely to be minor at the local level.

Note: Refer to Table 3 (The assessment of local, district, regional and national consequences) and text under the ‘Method for assessing consequences’ section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for the New Zealand flower thrips, determined by combining the overall ‘probability of entry, of establishment and of spread’ with the ‘consequences’ using the risk estimation matrix (Table 4): **Low**.

4.2.2.1.10 Western flower thrips

Western flower thrips (WFT) is a serious worldwide pest of ornamentals, vegetables and fruit crops in the field and greenhouse (Ludwig & Oetting, 2001). It is an efficient vector of impatiens necrotic spot and tomato spotted wilt tospoviruses, which cause serious diseases of a wide variety of plants, including vegetable, flower, and ornamental crops (Allen *et al*., 1990; Jones, 1993). There are no records of impatiens necrotic spot tospovirus for Australia but tomato spotted wilt virus is present in Australia (Jones, 1993). Transmission of tospoviruses by thrips is dependent on the development of the thrips on infected plants. WFT is the only thrips species that can transmit impatiens necrotic spot virus (Cloyd & Sadof, 2003).

The thrips examined in this pest risk analysis is:

- *Frankliniella occidentalis* (Pergande) [Thysanoptera: Thripidae] – western flower thrips.

Introduction and spread potential

Probability of importation

The likelihood that western flower thrips (WFT) will arrive in Western Australia with the importation of stone fruit from New Zealand**: High**.

- WFT is known to be associated with stone fruit in New Zealand (McLaren *et al*., 1999).
- The female WFT has an external ovipositor with two opposable serrated blades that are used to cut through the plant epidermis and deposit eggs in the tissues below (Childers & Achor, 1995).
- The small size of thrips allows them to hide themselves into small crevices and tightly closed plant parts. Adults and immature forms may hide in crevices on fruit stems.
- Post-harvest grading and packing procedures are likely to reduce the number of WFT on the fruit.
- WFT can survive packinghouse procedures. AQIS inspectors have intercepted WFT on apricot from New Zealand (PDI, 2003).

Probability of distribution

The likelihood that WFT will be distributed to the endangered area as a result of the processing, sale or disposal of stone fruit from New Zealand: **Moderate**.

- Adults and immature forms may hide within in crevices on the fruit stems and therefore remain with the commodity during distribution via wholesale or retail sale.

- The commodity may be distributed throughout Western Australia for retail sale. The intended use of the commodity is human consumption but waste material would be generated.
- Adults and larvae of WFT can survive sub-zero temperatures and still reproduce effectively (McDonald *et al*., 1997). The eggs are probably susceptible to desiccation and subject to high mortality, but there is also high mortality due to failure of first instar larvae to emerge safely from their egg.
- WFT could enter the environment directly from fruit during distribution and sale and through eggs that have hatched in discarded fruit or fruit waste before the fruit desiccates or decays.
- WFT is highly polyphagous and adults and nymphs can disperse locally by wind-assisted flight (CABI/EPPO, 1997).

Probability of entry (importation x distribution)

The likelihood that WFT will enter Western Australia as a result of trade in stone fruit from New Zealand and be distributed in a viable state to the endangered area: **Moderate**.

- The overall probability of entry is determined by combining the probabilities of importation and of distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Probability of establishment

Comparative assessment of factors in the source and destination areas considered pertinent to the ability of the pest to survive and propagate: **High**.

- WFT is highly polyphagous (Carnations, *Citrus*, Cucurbitaceae, *Phaseolus* and *Prunus*) and hosts are commonly found in Western Australia.
- Depending on environmental conditions and nutrient levels, female WFT lay 130–230 eggs during their lifetime (CABI, 2004). Eggs are deposited in leaves, bracts, and petals and hatch in 2 to 4 days (Pfleger *et al*., 1995). The development time from egg to adult is 7 to 13 days when temperatures range from 18 to 23ºC (CABI, 2004).
- WFT has a high reproductive potential and under glasshouse conditions can have 15 generations per year (Bryan & Smith, 1956; Lublinkhof & Foster, 1977).
- Many Australian environments are suitable for the survival and reproduction of thrips, as these pests are noted for their ecological and physiological tolerance. WFT is already established in most areas of Australia but is absent from the Northern Territory and under official control in Tasmania.
- Existing control programs may be effective for some hosts (e.g. broad spectrum pesticide applications) but not all hosts (e.g. citrus where specific integrated pest management programs are used). However, WFT has developed resistance to the major classes of insecticides used for its control (Brodsgaard, 1994; Zhao *et al*, 1995).

Probability of spread

Comparative assessment of those factors in the source and destination areas considered pertinent to the expansion of the geographical distribution of the pest: **High**.

- Natural physical barriers (e.g. deserts/arid areas) may prevent these pests spreading unaided but adults are capable of flight.

- Adults and immature forms may spread undetected via the movement of fruit or infested vegetative host material.
- The international spread of the western flower thrips occurred predominantly by the movement of horticultural material, such as cuttings, seedlings and potted plants.
- WFT has rapid reproductive cycles, and increase their population faster than their predators (Mound & Teulon, 1995).
- The relevance of natural enemies in Australia is not known.
- Similar environments (e.g. temperature, rainfall) occur in New Zealand and Western Australia.

Probability of entry, of establishment and of spread

The overall likelihood that WFT will enter Western Australia as a result of trade in stone fruit from New Zealand, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **Moderate**.

- The probability of entry, of establishment and of spread is determined by combining the probabilities of entry, establishment and spread using the matrix of 'rules' for combining descriptive likelihoods (Table 2).

Consequences

Consideration of the direct and indirect consequences of WFT: **Low**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C** — WFT is a quarantine pest for Western Australia as it is the vector of impatiens necrotic spot tospovirus (INSV) (Cloyd & Sadof, 2003), which it could introduce from New Zealand. The larvae of WFT acquire INSV during feeding on infected plants and viruliferous adults are able to transmit the virus to host plants. INSV has a wide host range and has become a major pathogen in the floriculture industry in the USA and Europe, particularly in greenhouse production. INSV could have a significant effect at the district level.
Any other aspects of the environment	**A** — There are no known direct consequences of WFT species on any aspects of the environment.
Indirect consequences	
Eradication, control, etc.	**B** — Additional programs to minimise the impact of WFT on host plants may be necessary. Existing control programs may be effective for some hosts (e.g. broad spectrum pesticide applications) but not all hosts (e.g. where specific integrated pest management programs are used).
Domestic trade	**C** — The introduction of WFT into commercial production areas of Northern Territory and Tasmania may have a significant effect due to any resulting interstate trade restrictions on a wide range of commodities. Interstate measures are currently in place for WFT.
International trade	**C** — The presence of WFT in commercial production areas of a range of commodities (e.g. vegetables, ornamentals and stone fruit) may have a significant effect at the district level due to any limitations to access to overseas markets where this pest is absent.
Environment	**A** — Although additional pesticide applications or other control activities would be required to control these pests on susceptible crops but any impact on the environment is likely to be minor at the local level.

Note: Refer to Table 3 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate determined by combining the overall 'probability of entry, establishment or spread' with the 'consequences' using the risk estimation matrix (Table 4)**: Low**.

4.2.2.2 Biological control agents

4.2.2.2.1 Phytoseiid mites

Phytoseiid mites are predators of phytophagous mites and insects and are of ecological and economic significance as biological control agents in most agricultural and natural environments (McMurtry, 1982; Helle & Sabelis, 1985; Kostiainen & Hoy, 1996). Two distinct feeding types of phytoseiid mites have been recognised: the specialised feeders that feed almost exclusively on spider mites and the generalists that feed on spider mites, insects and pollen (Luh & Croft, 2001).

The phytoseiid mites examined in this pest risk analysis are:

- *Amblyseius waltersi* Schicha [Acari: Phytoseiidae] – phytoseiid mite
- *Neoseiulus caudiglans* Schuster [Acari: Phytoseiidae] – phytoseiid mite
- *Neoseiulus fallacis* (Garman) [Acari: Phytoseiidae] – phytoseiid mite
- *Typhlodromus pyri* Scheuten [Acari: Phytoseiidae] – phytoseiid mite

The phytoseiid mites listed above have been recorded in stone fruit orchards in New Zealand. These species have been grouped together because of their similar biology. Their life stages are the egg, a six legged larva, eight-legged protonymph and deutonymph stages and the adult. Typically, adults and immature stages will search all parts of the plant for prey or alternative food, for example pollen, and are strongly attracted to chemicals given off either by plants damaged by the prey species or by the prey species itself Due to the recognised importance of *Neoseiulus fallacis* in integrated pest management systems, this species was used as the basis for the risk assessment.

Introduction and spread probability

Probability of importation

The likelihood that phytoseiid mites will arrive in Western Australia with the importation of stone fruit from New Zealand: **High**.

- These phytoseiid mites are reported from stone fruit production areas in New Zealand (NZ MAF, 2003).
- *Neoseiulus fallacis* is a highly mobile, generalist predator. Adults and immatures will search all parts of the plant for prey (Weeden *et al*., 2005) or alternative food, for example pollen, and are strongly attracted to chemicals given off either by plants damaged by the prey species or by the prey species itself (Gilstrap & Friese, 1985).
- *Neoseiulus fallacis* has a strong preference for tetranychid mites such as the European red mite and the two-spotted spider mite (Weeden *et al*., 2005). In New Zealand

orchards, this species showed a preference for feeding on the two-spotted spider mite rather than the European red mite (Hortnet, 2005).

- Plants infested by phytophagous mites emit volatile organic compounds, and predatory mites use these volatiles as cues to find their prey (Dicke *et al*., 1986; Llusia & Penuelas, 2001).
- Phytophagous mites also directly emit volatile organic compounds that can elicit searching behaviour in phytoseiid mites (Dicke *et al*, 1986).
- *Neoseiulus fallacis* is a voracious consumer of mites and its population increases quickly in relation to its prey allowing them to overtake expanding pest populations (Weeden *et al*., 2005).
- Phytoseiid mites can survive packinghouse procedures. AQIS inspectors have intercepted phytoseiid mites on various horticultural produce (PDI, 2003).

Probability of distribution

The likelihood that phytoseiid mites will be distributed to the endangered area as a result of the processing, sale or disposal of stone fruit from New Zealand: **Low**.

- Adults or nymphs may remain on the surface of the fruit during distribution via wholesale or retail trade.
- Distribution of the commodity in Western Australia could be for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- Extended cold storage can reduce the survival of phytoseiid mites (Gillespie & Ramey, 1988).
- Disposal of waste material could occur near plants with prey species.
- Phytoseiid mites need time to adapt to new environmental conditions (Castagnoli *et al*., 2001). Among the phytoseiid mite life stages, the eggs and larvae are most sensitive to moderate humidities (Croft *et al*., 1993).
- The generalist diet would increase survival chances. *Neoseiulus fallacis* can survive for a few days without eating prey by feeding on other food sources when facing starvation (Pratt *et al*., 1999).
- Predatory mites use volatiles emitted from herbivore-infested plants when searching for their prey/host (Dicke, 1994; Takabayashi & Dicke, 1996). Herbivore induced plant volatiles may guide predators/parasitoids to their preferred host/prey (Vet & Dicke, 1992).
- *Neoseiulus* species are capable of aerial dispersal (Johnson & Croft, 1981; McMurtry & Croft, 1997; Tixier *et al*., 1998). The population on discarded fruit may decline quickly as a result of desiccation; eggs are particularly sensitive to desiccation (Karban *et al*., 1995).

Probability of entry (importation x distribution)

The likelihood that phytoseiid mites will enter Western Australia as a result of trade in stone fruit from New Zealand and be distributed in a viable state to the endangered area: **Low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of ‘rules’ for combining descriptive likelihoods (Table 2).

Probability of establishment

The likelihood that phytoseiid mites will establish based on a comparative assessment of factors in the source and destination areas considered pertinent to the ability of the pest to survive and propagate: **Moderate**.

- *Neoseiulus fallacis* is associated with several agricultural crops including strawberry, hops, mint, (Croft *et al*., 1993), apples (Lester *et al*., 1998) and stone fruits (Lester *et al*, 1999; NZ MAF, 2003). These hosts are widespread in Western Australia.
- *Neoseiulus fallacis* feeds on important fruit pests such as two-spotted spider mite, the European spider mite, Pacific mite and Bank's grass mite (McMurtry & Croft, 1997). Some of these mite species are widespread in Western Australia.
- *Neoseiulus fallacis* is found throughout the temperate, humid areas of North America (McMurtry & Croft, 1997) and has been introduced to New Zealand (Hortnet, 2005). In Australia, this species has already been reported in NSW, Victoria and Tasmania (APPD, 2006). Similar environments occur in Western Australia that would be suitable for establishment of this mite.
- Among the phytoseiid mite life stages, the eggs and larvae are most sensitive to desiccation at moderate humidities (Croft *et al*., 1993). This is also reflected in the distribution of *Neoseiulus fallacis* at moderate humidities. Low growing plants with higher canopy humidity are preferred by *Neoseiulus fallacis* (Monetii & Croft. 1997).
- *Neoseiulus* spp. are opportunist predators and are capable of feeding on several different types of prey including thrips (Sabelis & Van Rijn, 1997) and other phytoseiid mites (Walzer & Schausberger, 1999) in addition to tetranychid mites, indicating that they have high survival rates at low prey densities (McMurtry, 1982).
- In phytoseiid mites, prey consumption affects egg production, which reaches its maximum early in the oviposition period (Abou-Setta & Childers, 1991; Sabelis & Janssen, 1993).
- Mated females overwinter in bark crevices and under insect scales and lay 40 to 60 eggs (Weeden *et* al., 2005). Populations are developed on other host plants during spring and early summer (Lester *et al*., 2000).
- *Neoseiulus* spp. have short generation times. The life cycle of these mites takes between 3-4 weeks, depending on temperature (McMurtry & Croft, 1997).
- Persistence after prey extinction is related to a predator's capacity to survive on alternative food sources and to out compete other predatory species, frequently of closely related taxa (Duso & Vettorazzo, 1999).
- *Neoseiulus fallacis* has developed resistance to commonly used pesticides including DDT, organophosphates and carbamates (Croft, 1990).

Probability of spread

The likelihood that phytoseiid mites will spread based on a comparative assessment of those factors in the source and destination areas considered pertinent to the expansion of the geographical distribution of the pest: **Moderate**.

- Movement of commodities would help the dispersal of phytoseiid mites because mites could potentially be on the fruit. Adults and juvenile stages may be spread on contaminated plant material.
- Movement of mites in a colony or patch occurs frequently, is mostly by walking and has a low risk of mortality (Strong *et al*., 1999). Movement of mites from one isolated

plant to another (interpatch) occurs less frequently and has a higher risk of mortality (Nachman, 1988).

- Within a patch, the movement of phytoseiid mites is affected by prey species (Sabelis & van de Baan, 1983), prey emitted volatiles and other physical stimuli (Zhang & Sanderson, 1992), prey density (Croft *et al*., 1995), predator hunger (Croft & Jung 2001), degree of food specialisation of species (Pratt *et al*., 1999), walking pattern (Berry & Holtzer, 1990), temperature and humidity (Penman & Chapman, 1990), wind (Sabelis & van den Weel, 1993) and spatial structure of the patch (Strong *et al*., 1999).
- Phytoseiid mites lack eyes and visual stimuli do not affect movement but photo-orientation may occur (Jung & Croft, 2000).
- Phytoseiid mites disperse mostly by walking and aerial means (Croft & Jung, 2001; Johnson & Croft, 1981; McMurtry & Croft, 1997; Tixier *et al*., 1998). Dispersal by walking occurs in a local patch when food, shelter and oviposition or wintering sites are sought. Aerial dispersal often results in the movement of mites to a new sites and spread of a population over a crop (Croft & Jung, 2001).
- In aerial dispersal, phytoseiid mites move to the edge of the leaf and then orientate to the air flow (Johnson & Croft, 1976). Both wind speed and direction have an impact on dispersal (Tixier *et al*., 1998).
- Starved adult females of phytoseiid mites display explicit aerial dispersal behaviour in low to moderate wind speeds. Well-fed mites do not show aerial dispersal behaviour, indicating food availability is a component stimulating aerial dispersal (Hoy *et al*., 1985).
- Predators need to locate prey patches once aerial dispersal has occurred. Kairomones produced by spider mites as well as predator-emitted marking pheromones (Hislop & Prokopy, 1981) assist the predators in locating or staying in patches of prey (Zhang & Sanderson, 1997). Such activities help spread phytoseiid mites into new environments.
- Phytoseiid mites are active and fast moving (Muma & Selhime, 1971) and move continuously while foraging for prey or other food (Sabelis, 1985). Foraging behaviour depends upon prey availability and on abiotic factors such as relative humidity, temperature and light intensity (Villanueva & Childers, 2005).
- Several carnivorous species have been reported to respond to volatile compounds produced by leaves infested with prey mites (Dicke *et al*., 1990; Gnanvossou *et al*., 2002; Shimoda *et al*., 1997).

Probability of entry, of establishment and of spread

The overall likelihood that phytoseiid mites will enter Western Australia as a result of trade in stone fruit from New Zealand, be distributed in a viable state to suitable hosts, establish in the area and subsequently spread within Western Australia: **Low**.

- The probability of entry, establishment or spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of ‘rules’ for combining descriptive likelihoods (Table 2).

Consequences

Consequences (direct and indirect) of phytoseiid mites: **Moderate**.

Criterion	Estimate
Direct consequences	

Criterion	Estimate
Plant life or health	**A** — There is no evidence of phytophagy even under instances of extreme starvation although *Neoseiulus* species can live for a few days on pollen and reproduce using only this food source (Pratt *et al*., 1999). In addition to plant chemical defences reducing phytophagous mites, they may also reduce predator densities (Lester *et al*., 2000).
Any other aspects of the environment	**D** — Predacious mites interact inter-specifically through competition for prey or feeding on each other (Croft & MacRae, 1993). Mutual predation reported among predatory mites could result in localised displacement of established mites in the natural ecosystem (Reitz & Trumble, 2002). Phytoseiid mites may have some effect on arthropod fauna at the national level. Generalist predators may compete for prey with local fauna and have the potential to feed on all available suitable hosts (Howarth, 1991).
Indirect consequences	
Eradication, control, etc.	**C** — Additional programs to minimise the impact of phytoseiid mites would be necessary. Some populations of phytoseiid mites are resistant to several pesticides, including pyrethroid insecticides (Thistlewood *et al*., 1995).
Domestic trade	**A** — The presence of phytoseiid mites in the PRA area is estimated to have consequences that are unlikely to be discernible at the regional level and of minor significance at the local level.
International trade	**A** — The presence of phytoseiid mites in the PRA area would not have a significant effect, as phytoseiid mites are widely used as biological control agents in various countries.
Environment	**B** — The presence of exotic mites may result in modified or additional insecticide regimes which may result in some impacts on the natural environment. However, mites recognised as biological control agents may be encouraged in agricultural systems if they provide economic benefits.

Note: Refer to Table 3 (The assessment of local, district, regional and national consequences) and text under the ‘Method for assessing consequences’ section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for phytoseiid mites, determined by combining the overall ‘probability of entry, of establishment and of spread’ with the ‘consequences’ using the risk estimation matrix (Table 4): **Low**.

4.2.2.3 Pathogens

4.2.2.3.1 Bacterial decline

Bacterial decline of stone fruit was first noted almost simultaneously in France and in New Zealand, together with a closely related pathogen from myrobalan plum in England (Young *et al*., 1996). It has been reported on nectarine and peach in France and on nectarine, peach and Japanese plum in New Zealand (Young, 1988) and myrobalan plum in England (Young *et al*., 1996). The disease is more common in nurseries and orchards in the cooler southern regions of New Zealand (McLaren *et al*., 1999).

The species examined in this pest risk analysis is:

- *Pseudomonas syringae* pv. *persicae* (Prunier *et al*.) Young *et al*. – bacterial decline

Introduction and spread probability

Probability of importation

The likelihood that *P. syringae* pv. *persicae* will arrive in Western Australia with the importation of stone fruit from New Zealand: **Very low**.

- *Pseudomonas syringae* pv. *persicae* is known to be associated with nectarine and peach fruit (McLaren *et al*., 1999).
- In nectarine and peach, symptoms include dieback, limb and root injury, tree death, leaf spot and fruit lesions. On Japanese plum, symptoms are mainly confined to dieback and occasionally limb death and leaf spots (Ogawa *et al*., 1995). As only the fruit will be imported, only fruit infections are important for determining the probability of importation.
- Initially small, olive, water-soaked lesions appear on fruit. These can be associated with the exudation of gum. In favorable conditions, especially in nectarine, these spots continue to expand during the spring and can cause severe distortion to developing fruit.
- Pathogenic activity is greatest during winter and early spring (Ogawa *et al*., 1995). Fruit are likely to be infected at an early stage and develop symptoms, rather than acquire an asymptomatic infection late in the season.
- Infected fruit with necrotic spots covered by a transparent gum (Diekmann & Putter, 1998) are likely to be detected and removed during routine grading and packing activities.
- Post-harvest grading, washing and packing procedures are likely to remove this bacterium from the fruit.
- *Pseudomonas syringae* pv. *persicae* has not been intercepted in Australia on stone fruit from New Zealand (PDI, 2003).

Probability of distribution

The likelihood that *P. syringae* pv. *persicae* will be distributed to the endangered area as a result of the processing, sale or disposal of stone fruit from New Zealand: **Very low**.

- Infected fruit could be distributed via wholesale and retail trade.
- Distribution of the commodity in Western Australia could be for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- There is no published information that this bacterium is seed-borne or that it can multiply in the fruit lesions. However, the pathogen survives as a resident or in subclinical infections on stems, leaves and fruit (Luisetti *et al*., 1976).
- The pathogen is known to be dispersed by rain splash (McLaren *et al.,* 1999). It is possible that the pathogen may also be spread short distances by wind driven rain. However, infected fruit waste would need to be disposed of in close proximity to susceptible hosts for bacteria to be likely to move to suitable sites on susceptible hosts.
- Examples of suitable sites for infection include either open cuts (such as pruning wounds), water soaked bark during autumn or winter (CABI/EPPO, 1997) or leaf scars. Wet leaves may also be susceptible to infection (McLaren *et al.,* 1999).
- During the warmer months, most of the bacteria in cankers die out, greatly reducing the amount of inoculum that might be present on imported fruit.

Probability of entry (importation x distribution)

The likelihood that *P. syringae* pv. *persicae* will enter Western Australia as a result of trade in stone fruit from New Zealand and be distributed in a viable state to the endangered area: **Extremely low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 2).

Probability of establishment

The likelihood that *P. syringae* pv. *persicae* will establish based on a comparative assessment of factors in the source and destination areas considered pertinent to the ability of the pest to survive and propagate: **Moderate**.

- Nectarine, peach, Japanese plum (Young, 1988) and almond (McLaren *et al*., 1999) are the hosts of *P. syringae* pv. *persicae*, and these plants are found in temperate areas of Western Australia.
- Disease development is mainly associated with cold, wet weather (Ogawa *et al.* 1995). The environmental conditions in some regions of Western Australia are similar to those where the disease is found and are likely be suitable for the establishment of *P. syringae* pv. *persicae*.
- In spring, *P. syringae* pv. *persicae* spreads to young shoots (Gardan *et al*., 1972).
- The pathogen becomes active in buds, leaf scars and hydathodes, causing small, local necrotic lesions. Infection spreads to leaves and fruit (Luisetti *et al*., 1976).
- Pruning wounds also provide a means of entry, particularly those made in winter on susceptible tissues and with pruning tools carrying the pathogen (Luisetti *et al*., 1981).
- During the summer, disease activity ceases, the pathogen surviving as a resident or in subclinical infections on stems, leaves and fruit (Luisetti *et al*., 1976).
- In autumn, leaf scars, buds and wounds are infected from the resting population. During winter, bacteria in main branches and trunks become active producing extensive necrotic cankers (Luisetti *et al*., 1976).

Probability of spread

The likelihood that *P. syringae* pv. *persicae* will spread based on a comparative assessment of those factors in the source and destination areas considered pertinent to the expansion of the geographical distribution of the pest: **Moderate**.

- Bacteria in subclinical infections could spread undetected via the movement of fruit.
- The major commercial stone fruit production districts in Western Australia are located in the south-west of the State between Perth and Albany and in the Carnarvon region in the north-west. Natural barriers, including climatic differentials and long distances, may limit the natural spread of the pathogen.
- The pathogen can be carried in aerosols and therefore could be spread between trees and adjacent orchards by wind driven rain (Luisetti *et al*., 1976).
- As the pathogen can infect through wounds, it can also be spread on orchard equipment such as pruning implements (Luisetti *et al*., 1976).
- Long distance dispersal is facilitated by the commercial distribution of nursery stock as *P. syringae* pv. *persicae* can spread with host material.

Probability of entry, of establishment and of spread

The overall likelihood that *P. syringae* pv. *persicae* will enter Western Australia as a result of trade in stone fruit from New Zealand, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **Extremely low**.

- The probability of entry, establishment or spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 2).

Consequences

Consequences (direct and indirect) of the *P. syringae* pv. *persicae*: **Low**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C**— *Pseudomonas syringae* pv. *persicae* is capable of causing direct harm to its hosts (McLaren *et al*., 1999). In severe cases, the disease can cause wilting and death of main branches or the whole tree (Vigouroux *et al*., 1987). Apricot, cherry, peach and nectarine are particularly susceptible and plums are least susceptible. Extensive cankering and girdling of the main limbs causes tree losses and intensive surface spotting cause fruit losses (McLaren *et al*., 1999).
Any other aspects of the environment	**A**— There are no known direct consequences of *P. syringae* pv. *persicae* on the natural or built environment but its introduction into a new environment may lead to competition for resources with native species.
Indirect consequences	
Eradication, control, etc.	**B** — Additional programs to minimise the impact of *P. syringae* pv. *persicae* on host plants may be necessary. Existing control programs may be effective for some hosts but not necessarily all hosts. Copper sprays in autumn during leaf fall will reduce bud and stem dieback in spring (Luisetti *et al*., 1976). Calcium amendments to soil may limit disease (Vigouroux *et al*., 1987).
Domestic trade	**B** — The presence of *P. syringae* pv. *persicae* in commercial production areas may have a significant effect at the local level due to any resulting interstate trade restrictions on host commodities. These restrictions could lead to a loss of markets, which in turn would be likely to require industry adjustment.
International trade	**C** — The presence of *P. syringae* pv. *persicae* in commercial production areas on host commodities could have a significant effect at the district level due to any limitations to access to overseas markets where this pest is absent.
Environment	**A** — Chemical applications or other control activities may be required to control this bacterium on susceptible crops but any impact on the environment is likely to be minor at the local level.

Note: Refer to Table 3 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for *P. syringae* pv. *persicae*, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 4): **Negligible**.

4.2.2.3.2 Powdery mildew

The powdery mildew fungi are common obligate plant pathogens distributed throughout the world. Powdery mildews are particularly prevalent when conditions are warm and dry during the day and cold at night, and on dry soils, so are often most severe at the end of the growing season.

The species examined in this pest risk analysis is:

- *Podosphaera tridactyla* (Wallr.) de Bary – powdery mildew

Introduction and spread probability

Probability of importation

The likelihood that *P. tridactyla* will arrive in Western Australia with the importation of stone fruit from New Zealand: **Very low**.

- *Podosphaera tridactyla* is associated with nectarine and peach fruit in New Zealand (NZ MAF, 2003).
- *Podosphaera tridactyla* is primarily a foliar pathogen and is rarely found on fruit. Foliar infections are characterised by white mycelium on both leaf surfaces (Ogawa *et al*., 1995).
- Post-harvest grading, washing and packing procedures are likely to reduce the amount of powdery mildew on the surface of fruit.
- Powdery mildew has not been intercepted in Australia on stone fruit from New Zealand (PDI, 2003).

Probability of distribution

The likelihood that *P. tridactyla* will be distributed to the endangered area as a result of the processing, sale or disposal of stone fruit from New Zealand: **Low**.

- Powdery mildew on the surface of infected fruit could be distributed via wholesale and retail trade.
- Distribution of the commodity in Western Australia could be for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- The fungus is an obligate parasite and requires living plant tissue in order to grow and reproduce. Any fungus on infected fruit would have limited time available for growth and sporulation.
- Spores and mycelium are sensitive to extreme heat and direct sunlight (Moorman, 2002). Fungus on discarded fruit may be damaged or killed by environmental conditions.
- Conidia of other powder mildews (such as *P. clandestina*) are reported not to germinate if the soluble solids (brix) in fruit are above 15-16% (Ogawa *et al*., 1995). Ripe fruit may not be suitable for the germination and growth of conidia. Therefore, should conidia be present on the surface of fruit they would need to be mechanically transferred to hosts, as dispersal by wind is considered important for conidia present on conidiophores.

Probability of entry (importation x distribution)

The likelihood that *P. tridactyla* will enter Western Australia as a result of trade in stone fruit from New Zealand and be distributed in a viable state to the endangered area: **Very low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 2).

Probability of establishment

The likelihood that *P. tridactyla* will establish based on a comparative assessment of factors in the source and destination areas considered pertinent to the ability of the pest to survive and propagate: **High**.

- Nectarine and peach are the only reported hosts of *P. tridactyla* in New Zealand. Other plants such as Myrobalun plum (Penrose, 1990) are also reported as hosts. These plants are widely distributed in Western Australia.
- Powdery mildew fungi generally do not require moist conditions to establish, as surface moisture prevents the germination of conidia (Moorman, 2002). Powdery mildews generally grow and spread well in warmer climates. The fungus overwinters as cleistothecia on the surface of shoots, on dead leaves on the ground in orchards and on bark. Ascospores are produced from these structures during spring rains and infect the developing foliage (Ogawa *et al*., 1995).
- The conidia are carried by wind currents and germinate on the surface of leaves. Although humidity requirements for germination vary, many powdery mildew species can germinate and infect leaves in the absence of water. Low relative humidity during the day and high relative humidity during the night are reported to be favourable for development of the fungus (Moorman, 2002). Conidia of some powdery mildews are killed, or germination and growth are inhibited, by water on plant surfaces.
- Moderate temperatures and shady conditions generally favour the development of powdery mildew.
- Climatic conditions in Western Australia are favourable for the establishment of *P. tridactyla*, given that other closely related powdery mildews are already established in Western Australia.
- The historical establishment and spread of other powdery mildews in Australia indicates that this fungus would be likely to establish in Western Australia.

Probability of spread

The likelihood that *P. tridactyla* will spread based on a comparative assessment of those factors in the source and destination areas considered pertinent to the expansion of the geographical distribution of the pest: **High**.

- Conidia, which are the primary means of dispersal, make up the bulk of the powdery growth on infected plant tissue.
- Conidia are wind-dispersed and therefore can be transported between trees and adjacent orchards (Ogawa *et al*., 1995).
- Long distance spread by wind is unlikely, due barriers such as the presence of deserts or regions where no hosts are present, or by mountainous regions.
- Facilitated distribution is required for long distance spread. This may occur through the movement of fruit, nursery stock or other propagative material. No intrastate restrictions on the movement of nursery stock exist in Western Australia.
- Conidia and mycelium are sensitive to extreme heat and direct sunlight. The time from germination to formation of new conidia may be as short as 48 hours. High humidity

favours the formation of conidia, while low humidity favours the dispersal of conidia (Moorman, 2002).

Probability of entry, of establishment and of spread

The overall likelihood that *P. tridactyla* will enter Western Australia as a result of trade in stone fruit from New Zealand, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **Very low**.

- The probability of entry, establishment or spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 2).

Consequences

Consequences (direct and indirect) of *P. tridactyla*: **Low**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C**— *Podosphaera tridactyla* is capable of causing direct harm to its hosts (Ogawa *et al*., 1995). Areas of white powdery fungal growth, roughly circular in shape, develop on the fruit. These infected areas later become scabby and dry. Control measures, where implemented, may reduce the impact of this fungus. However, control may not be implemented to all susceptible crops. *Podosphaera tridactyla* is estimated to have consequences of minor significance at the regional level.
Any other aspects of the environment	**A**— There are no known direct consequences of this pathogen on the natural or built environment.
Indirect consequences	
Eradication, control, etc.	**A** — Programs to minimise the impact of this disease on host plants are unlikely to be required. Existing management measures to control more severe powdery mildew pathogens (*Sphaerotheca pannosa* and *Podosphaera clandestina*) would be effective to control this fungus.
Domestic trade	**A**— The presence of this pathogen in the commercial stone fruit production areas of Western Australia is estimated to have consequences that are unlikely to be discernible at the regional level and of minor significance at the local level.
International trade	**A**— The presence of this pathogen in the commercial stone fruit production areas of Western Australia is estimated to have consequences that are unlikely to be discernible at the regional level and of minor significance at the local level. It is doubtful that there would be any limitations in access to overseas markets.
Environment	**A** — Fungicides required to control powdery mildew are estimated to have consequences that are unlikely to be discernible at the regional level and of minor significance at the local level.

Note: Refer to Table 3 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for *P. tridactyla*, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 4): **Negligible**.

4.2.2.3.3 Plum pockets

Fungi of the genus *Taphrina* cause several similar stone fruit diseases. *Taphrina* spp. produce various types of "pockets" on wild plum, some domestic plum hybrids, sand cherry, wild black cherry (*Prunus serotina*) and chokecherry. The fruits become hollow, bladder-like and enlarged (Lamey & Stack, 1991). In addition to the fruit "pockets", enlarged and deformed shoots and curled leaves may develop on chokecherry, wild black cherry, wild plum and domestic plum. A leaf curl and witch's broom (clusters of small branches) may develop on sour cherry, sand cherry, apricot, Mayday tree and some wild cherries, but no fruit "pockets" are formed (Lamey & Stack, 1991).

The species examined in this pest risk analysis is:

- *Taphrina pruni* (Tulasne) – plum pockets

Introduction and spread probability

Probability of importation

The likelihood that *Taphrina pruni* will arrive in Western Australia with the importation of stone fruit from New Zealand: **Very low**.

- *Taphrina pruni* is associated with plum fruit in New Zealand (NZ MAF, 2003).
- *Taphrina pruni* affects the leaves, shoots and fruits. Symptoms on fruit are visible soon after fruit set. The fungus causes small, white blisters on immature fruits. These blisters enlarge as the fruit develops and soon cover the entire fruit (Behrendt & Floyd, 1999).
- Infected fruit become abnormally large, misshapen and bladder-like with a thick spongy flesh (Behrendt & Floyd, 1999). As their spongy interiors dry up, the plums turn velvety grey as spores grow on their surface. Infected fruit becomes hollow in the centre, turns brown, withers and falls from the tree (Travis & Rytter, 2003).
- Infected plums enlarge to many times normal size, become hollow and fail to form seeds (Tisserat, 2004).
- Infected fruit exhibiting symptoms of plum pockets (Behrendt & Floyd, 1999) would be rejected during routine harvesting and grading operations.
- Post-harvest grading, washing and packing procedures are likely to significantly reduce the number of spores (ascospores or bud-conidia) of *T. pruni* on the surface of healthy fruit.
- Plum pockets has not been intercepted in Australia on stone fruit from New Zealand (PDI, 2003).

Probability of distribution

The likelihood that *T. pruni* will be distributed to the endangered area as a result of the processing, sale or disposal of stone fruit from New Zealand: **Very low**.

- Spores (ascospores or bud-conidia) of *T. pruni* on the surface of fruit could be distributed via wholesale and retail trade.
- Distribution of the commodity in Western Australia could be for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- Discarded waste containing this fungus would be rapidly colonised by other saprophytic microorganisms. The likelihood of spores of this fungus multiplying on the

surface of discarded fruit and these spores being distributed to buds on a susceptible host is very low.

- Infection by spores of *T. pruni* requires undifferentiated (meristematic) host tissues and cool, wet conditions. This would occur during bud-break in spring. Spores would need to overwinter on discarded fruit and multiple in the following spring or would need to be distributed to host plants and overwinter until suitable host tissue becomes available.
- *Taphrina pruni* infects mainly cultivated plums.

Probability of entry (importation x distribution)

The likelihood that *T. pruni* will enter Western Australia as a result of trade in stone fruit from New Zealand and be distributed in a viable state to the endangered area: **Extremely low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 2).

Probability of establishment

The likelihood that *T. pruni* will establish based on a comparative assessment of factors in the source and destination areas considered pertinent to the ability of the pest to survive and propagate: **Moderate**.

- Plums are the main hosts of *T. pruni* and are widely distributed in Western Australia. While most commercial production is located in the south-west of the state, commercial and non-commercial production is widely distributed.
- *Taphrina pruni* overwinters as dormant spores (ascospores or bud-conidia) in bud scales and bark crevices (Tisserat, 2004). During cool, wet periods in spring, these spores germinate and infect expanding leaves and young fruit (Tisserat, 2004).
- Spores (ascospores or bud-conidia) produced on the surface of diseased tissue are washed or blown from tree to tree (Tisserat, 2004). These spores then remain dormant until the following spring and do not infect mature leaves and fruit. Thus, disease development is limited to a short period in the spring (Tisserat, 2004).
- Cool and wet conditions generally favour the development of plum pockets. When the temperature is cool, slowly emerging leaves are susceptible to infection by the fungus for a longer period of time (Hartman & Bachi, 1994).
- When environmental conditions are cool and wet, the spores germinate and infect the leaf tissue (Travis & Rytter, 2003). Late in summer, plum pockets and other infected parts (shoots, leaves) may become mouldy and develop a dark, sooty or velvety appearance (Lamey & Stack, 1991).
- Climatic conditions in the PRA area are favourable for the establishment of *Taphrina pruni* given that the closely related fungus *Taphrina deformans* is already established in the PRA area.
- A number of fungicides are effective as dormant sprays for the control of plum pockets (Hartman & Bachi, 1994; Tisserat, 2004). The fungicides used in Western Australia to control other diseases on plum will give control of plum pockets.

Probability of spread

The likelihood that *Taphrina pruni* will spread based on a comparative assessment of those factors in the source and destination areas considered pertinent to the expansion of the geographical distribution of the pest: **Moderate**.

- Spores (ascospores or bud-conidia) are produced on infected fruit and leaf (Tisserat, 2004) and are the primary means of dispersal.
- Spores are splashed or blown from tree to tree (Tisserat, 2004). These spores then remain dormant until the following spring, when they infect developing buds (Tisserat, 2004).
- Spores may be spread between trees within orchards or between adjacent orchards by wind. Long distance spread by wind is unlikely to due barriers such as the presence of deserts or regions where no hosts are present, or by mountainous regions. Facilitated distribution is required for long distance spread. This may occur through the movement of nursery stock or other propagative material.
- *Taphrina pruni* could be spread between orchard districts in Western Australia as dormant spores on buds of nursery trees.
- This fungus is most prevalent on infected fruit, rather than on leaves or shoots (Ogawa *et al.*, 1995). Infected fruit would be unsaleable and would not be likely to be distributed, limiting the opportunities for spread of this fungus.

Probability of entry, of establishment and of spread

The overall likelihood that *Taphrina pruni* will enter Western Australia as a result of trade in stone fruit from New Zealand, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **Extremely low**.

- The probability of entry, establishment or spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of ‘rules’ for combining descriptive likelihoods (Table 2).

Consequences

Consequences (direct and indirect) of *Taphrina pruni*: **Low**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C**— *Taphrina pruni* is capable of causing direct harm to wild and cultivated plums (Behrendt & Floyd, 1999). The most conspicuous symptoms occur on the fruit. Blisters enlarge as the fruit develops and soon cover the entire fruit (Behrendt & Floyd, 1999). Young leaves and shoots may be distorted but symptoms are not common (Flynn, 1997).
Any other aspects of the environment	**A**— There are no known direct consequences of this pathogen on the natural or built environment.
Indirect consequences	
Eradication, control, etc.	**A** — Fungicides can be applied to control this disease (Tisserat, 2004). The fungicides used in Western Australia to control other diseases on plum will give control of plum pockets.
Domestic trade	**A**— The presence of this pathogen in the commercial stone fruit production areas of Western Australia is estimated to have consequences that are unlikely to be discernible at the regional level and of minor significance at the local level.
International trade	**A**— The presence of this fungus in the commercial stone fruit production areas of Western Australia is estimated to have consequences that are unlikely to be

Criterion	Estimate
	discernible at the regional level and of minor significance at the local level. It is doubtful that there would be any limitations in access to overseas markets.
Environment	**A** — Fungicides required to control plum pockets are estimated to have consequences that are unlikely to be discernible at the regional level and of minor significance at the local level.

Note: Refer to Table 3 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for *Taphrina pruni*, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 4): **Negligible**.

4.2.3 Risk Assessment Conclusion

Table 8 summarises the detailed risk assessments and provides unrestricted risk estimates for the quarantine pests considered being associated with stone fruit from New Zealand.

Oriental fruit moth, citrophilus mealybug, thrips and biological control agents (phytoseiid mites) were assessed to have unrestricted risk estimates of "low", while leafrollers were assessed to have an unrestricted risk of "moderate". The unrestricted risk estimates for these pests exceeds Australia's appropriate level of protection. Specific risk management measures are therefore required for stone fruit imported from New Zealand into Western Australia to adequately address the potential quarantine risks.

Five arthropods (bronze beetle, oystershell scale, codling moth, guava fruit moth, and grey-brown cut worm) and three pathogens (*Pseudomonas syringae* pv. *persicae*, *Podosphaera tridactyla*, *Taphrina pruni*) were assessed to have an unrestricted risk of "negligible" or "very low" and therefore do not require the application of any specific phytosanitary measures in order to maintain Australia's appropriate level of protection.

Table 8: Unrestricted risk summary

Pest name	Probability of					Overall probability of entry, of establishment and of spread	Consequences	Unrestricted Risk
	Entry			Establishment	Spread			
	Importation	Distribution	Overall probability of entry					
ARTHOPODS								
Bronze beetle	Very low	Moderate	Very low	High	High	Very low	Low	Negligible
Citrophilus mealybug	High	Moderate	Moderate	High	High	Moderate	Low	**Low**
Oystershell scale	Low	Low	Very low	High	Moderate	Very low	Low	Negligible
Codling moth	Extremely low	Moderate	Extremely low	High	High	Extremely low	Moderate	Negligible
Guava moth	Low	Moderate	Low	High	High	Low	Low	Very low
Leafrollers	High	Moderate	Moderate	High	High	Moderate	Moderate	**Moderate**
Grey-brown cutworm	Low	Moderate	Low	High	High	Low	Low	Very low
Oriental fruit moth	Moderate	Moderate	Low	High	High	Low	Moderate	**Low**
New Zealand flower thrips	High	Moderate	Moderate	Moderate	High	Low	Moderate	**Low**
Western flower thrips	High	Moderate	Moderate	High	High	Moderate	Low	**Low**
BIOLOGICAL CONTROL AGENTS								
Phytoseiid mites	High	Low	Low	Moderate	Moderate	Low	Moderate	**Low**
PATHOGENS								
Bacterial decline	Very low	Very low	Extremely low	Moderate	Moderate	Extremely low	Low	Negligible
Powdery mildew	Very low	Low	Very Low	High	High	Very low	Low	Negligible
Plum pockets	Very low	Very low	Extremely low	Moderate	Moderate	Extremely low	Low	Negligible

Table 9 provides the final list of quarantine pests of stone fruit from New Zealand that have been assessed to have unrestricted risk estimates above Australia's ALOP for Western Australia. These pests require the use of risk management measures in addition to the standard commercial practices used in the production of commercial stone fruit in New Zealand to meet Australia's ALOP for Western Australia. The proposed risk management measures are described in the following section.

Table 9: Quarantine pests of stone fruit from New Zealand assessed to have unrestricted risk estimates above Australia's ALOP for Western Australia

Pest	Common name
ARTHOPODS	
Cnephasia jactatana (Walker) [Lepidoptera: Tortricidae]	Black-lyre leafroller
Ctenopseustis herana (Felder & Rogenhofer) [Lepidoptera: Tortricidae]	Brownheaded leafroller
Ctenopseustis obliquana Walker [Lepidoptera: Tortricidae]	Brownheaded leafroller
Frankliniella occidentalis (Pergande) [Thysanoptera: Thripidae]	Western flower thrips
Grapholita molesta Busck [Lepidoptera: Tortricidae]	Oriental fruit moth
Harmologa amplexana (Zeller) [Lepidoptera: Tortricidae]	Native leafroller
Planotortrix excessana Walker [Lepidoptera: Tortricidae]	Greenheaded leafroller
Planotortrix flavescens Butler [Lepidoptera: Tortricidae]	Native leafroller
Planotortrix octo Dugdale [Lepidoptera: Tortricidae]	Greenheaded leafroller
Pseudococcus calceolariae (Maskell) [Hemiptera: Pseudococcidae]	Citrophilus mealybug
Pyrgotis plagiatana (Walker) [Lepidoptera: Tortricidae]	Native leafroller
Thrips obscuratus (Crawford) [Thysanoptera: Thripidae]	New Zealand flower thrips
BIOLOGICAL CONTROL AGENTS	
Amblyseius waltersi Schicha [Acari: Phytoseiidae]	Phytoseiid mite
Neoseiulus caudiglans Schuster [Acari: Phytoseiidae]	Phytoseiid mite
Neoseiulus fallacis (Garman [Acari: Phytoseiidae]	Phytoseiid mite
Typhlodromus pyri Scheuten [Acari: Phytoseiidae]	Phytoseiid mite

4.3 Stage 3: Pest Risk Management

Pest risk management evaluates and selects options for measures to reduce the risk of entry, establishment or spread of quarantine pests for Western Australia assessed to have an unrestricted risk estimate above Australia's ALOP via the importation of stone fruit from New Zealand produced using the SummerGreen™ program and subjected to standard harvesting and packing activities.

Stone fruit is produced commercially in New Zealand using the management system developed by Summerfruit New Zealand. This management system includes (a) appropriate field sanitation programs and (b) cultural and chemical control programs. Details of this management system are given in the SummerGreen Manual, which is only available to growers and participants in the SummerGreen™ Program.

It is important to note that it is only appropriate for the unrestricted risk estimates to take into account the minimum border procedures used by relevant government agencies and not those measures approved by such agencies that are intended to mitigate risks associated with the commodity itself. The minimum procedures include verifying that the commodity is as described in the shipping documents and identifying external and internal contaminations of containers and packaging. In order to have least trade restrictive measures, evaluation of restricted risk management options started with consideration of the use of a 600-unit inspection in detecting quarantine pests requiring risk management, and the subsequent remedial actions or treatments that might be applied if a quarantine pest is intercepted.

The standard AQIS sampling protocol requires inspection of 600 units, for quarantine pests in random samples per homogeneous inspection lot from a consignment. The unit for stone fruit is defined as one fruit. Biometrically, if no pests are detected by the inspection, this size sample achieves a confidence level of 95% that not more than 0.5% of the units are infested/infected in the consignment. The level of confidence depends on each fruit in the consignment having about the same likelihood of being affected by a quarantine pest and the inspection technique being able to reliably detect all quarantine pests in the sample. If no live quarantine pests are detected in the sample, the consignment is considered to be free from quarantine pests and would be released from quarantine. Where a pest of quarantine concern to Western Australia is intercepted in a sample, the remedial actions or treatments may (depending on the location of the inspection) include:

- withdrawing the consignment from export to Western Australia;
- re-export of the consignment from Western Australia;
- destruction of the consignment; or
- treatment of the consignment and re-inspection to ensure that the pest is no longer viable.

It should be emphasised that inspection is not a measure that mitigates the risk of a pest. It is the remedial actions or treatment that can be taken based on the results of the inspection that would reduce a pest risk.

Biosecurity Australia considers that the risk management measures described in this document are commensurate with the identified risks and will provide an appropriate level of protection for Western Australia against citrophilus mealybug, leafrollers, oriental fruit moth, thrips and biological control agents (phytoseiid mites). These measures form the basis of the final import conditions for stone fruit from New Zealand being imported into Western Australia.

4.3.1 Risk management measures and phytosanitary procedures

The measures and phytosanitary procedures listed below form the basis of import conditions for stone fruit from New Zealand into Western Australia. These measures and procedures are detailed in the section entitled 'Import Conditions'.

- pest free area, pest free places of production or pest free production sites, area of low pest prevalence or methyl bromide fumigation for oriental fruit moth;
- visual inspection and remedial action for citrophilus mealybug, leafrollers, thrips and biological control agents (phytoseiid mites); and
- operational systems for the maintenance and verification of the phytosanitary status of New Zealand stone fruit.

4.3.1.1 Oriental fruit moth

Oriental fruit moth (OFM) has been assessed to have an unrestricted risk estimate of "low" and measures are therefore required to manage this risk.

Visual inspection of fruit alone is not considered to be an appropriate risk management measure because clear external visual signs of infestation may not always be present. If infested fruit was not detected at inspection, OFM may enter, establish or spread in Western Australia.

The proposed measures for OFM apply to both the South and North Islands. However, for the North Island where OFM is present, the details of the arrangements for establishing and managing areas of low pest prevalence and area freedom including pest free places of production and pest free production sites need to be considered further in consultation with DAFWA.

Option 1: Sourcing fruit from pest free areas, pest free places of production or pest free production sites

Pest freedom is a measure that might be applied to manage the risk posed by OFM. Pest freedom might be declared for an area (such as a country or part of a country), place of production (such as a property managed by a single producer) or production site (a specific portion of a place of production). If Biosecurity New Zealand wishes to consider the option of pest freedom as a management measure for oriental fruit moth, Biosecurity Australia will assess any proposal from New Zealand in consultation with the Department of Agriculture and Food, Western Australia (DAFWA).

The requirements for establishing pest free areas are set out in the International Standards for Phytosanitary Measures Publication No. 4 *Establishment of pest free areas* (FAO, 1996) and International Standards for Phytosanitary Measures Publication No 10 *Requirements for the establishment of pest free places of production and pest free production sites* (FAO, 1999).

Biosecurity New Zealand will be responsible for verifying the pest free status of areas, places of production or production sites through official surveys, monitoring or other equivalent activities. These results must be submitted to Biosecurity Australia before access can be considered.

The objective of this risk management measure is to ensure that stone fruit exported to Western Australia from New Zealand is not infested with oriental fruit moth.

The detection of any live or dead oriental fruit moth associated with stone fruit consignments for Western Australia would indicate non-compliance with the pest free status. In this circumstance, recognition of the pest free status for the affected areas would be suspended until Biosecurity Australia (in consultation with DAFWA and Biosecurity New Zealand) is satisfied that appropriate corrective action has been taken to re-instate the pest free status for oriental fruit moth. Reinstatement of the affected area(s) would involve a specified period of freedom as determined by trapping, and may involve other measures such as a more intensive inspection regime and fruit cutting for a period of time sufficient to restore confidence in the pest free status of the area(s).

Option 2: Sourcing fruit from areas of low pest prevalence

Low pest prevalence is a measure that might be applied to manage the risk posed by oriental fruit moth to Western Australia.

The requirements for establishing areas of low pest prevalence are set out in International Standards for Phytosanitary Measures Publication No. 22 *Requirements for the establishment of areas of low pest prevalence* (FAO, 2005).

The South Island of New Zealand appears to be free of OFM, based on many years of trapping data provided by Biosecurity New Zealand for the production areas. The situation is different in the North Island, where OFM is more widespread.

For the South Island, pre-harvest monitoring and pheromone trapping are proposed as ways to establish areas of low pest prevalence for oriental fruit moth. For the North Island, the lack of trapping data demonstrating low pest numbers will require additional or different criteria for recognition of areas of low pest prevalence.

Application for recognition of areas of low pest prevalence in the North Island will be assessed by Biosecurity Australia in consultation with DAFWA.

Pre-harvest monitoring

The purpose of pre-harvest orchard monitoring is to identify tip growth dieback caused by oriental fruit moth infestations. It is proposed that inspections on a random sample of host trees within an orchard are to be undertaken by NZ MAF or approved crop scouts. Orchard monitoring is to be conducted up to 4 weeks prior to harvest to determine with a 95% certainty that infestations occur at a level of no greater than 0.5%. These monitoring results will be valid for a 4-week period following inspection.

Pheromone trapping

It is proposed that pheromone trapping for oriental fruit moth will be undertaken by NZ MAF or approved crop scouts to demonstrate areas of low pest prevalence. Pheromone traps should be in place prior to the emergence of new season adults and remain in place until the fruit is harvested. Traps should be inspected weekly to ensure that any moths that are trapped are in suitable condition for taxonomic identification. Trap densities from a minimum of 3 traps per production site to one trap per 2 hectares are proposed by

Biosecurity Australia. As oriental fruit moth flights are light and temperature dependent, with most activity taking place 2-3 hours before sunset, traps should be placed such that the pheromone plume stays within the monitoring area at these times. To ensure the pheromone traps remains efficient, the lures should be replaced monthly. Growers must certify that no mating disruption dispensers are in use within the orchards as these have a detrimental effect on the efficiency of trapping.

Upon the detection of an oriental fruit moth (live or dead), the area of low pest prevalence will be suspended until the extent of the infestation is determined and Biosecurity Australia (in consultation with DAFWA and Biosecurity New Zealand) is satisfied that areas of low prevalence status can be reinstated. A visual inspection for tip dieback will be required on a random sample of host trees within the affected orchard to determine with 95% certainty that the infestation level is no greater than 0.5% of the trees. In addition, trapping data for a period of time will be required to determine re-instatement. The period of time until re-instatement will be determined by Biosecurity Australia (in consultation with DAFWA and Biosecurity New Zealand), considering factors such as the number of subsequent OFM detections and the results of the tip dieback inspections.

Option 3: Methyl bromide fumigation

Methyl bromide fumigation is a measure that might be applied to manage the risk posed by oriental fruit moth. It is proposed that the fumigation treatment could be performed either pre-shipment or on-arrival.

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

- 32g/m^3 at a pulp temperature of 21ºC or greater – minimum concentration time (CT) product of 47gh/m^3;
- 40g/m^3 at a pulp temperature of 16ºC or greater – minimum concentration time (CT) product of 58gh/m^3; or
- 48g/m^3 at a pulp temperature of 10ºC or greater – minimum concentration time (CT) product of 70gh/m^3.

It is proposed that fruit should not be fumigated if the pulp temperature is below 10ºC and that fumigations should be carried out in accordance with AQIS fumigation standards as set out in "*AQIS Quarantine Treatments Aspects and Procedures version 1.0*".

All pre-shipment (off-shore) fumigation certificates would need to contain the following fumigation details:

- the name of the fumigation facility;
- the date of fumigation;
- rate of methyl bromide used, that is initial dosage (g/m^3);
- the fumigation duration (hours);
- ambient air temperature during fumigation (°C);
- minimum fruit pulp temperature during fumigation (°C); and
- the concentration time (CT) product of methyl bromide achieved by the fumigation (gh/ m^3).

The objective of these procedures is to provide measures that will reduce the risk of the importation of the oriental fruit moth into Western Australia to a level that will maintain Australia's appropriate level of protection.

4.3.1.2 Citrophilus mealybug, leafrollers, thrips and biological control agents

Citrophilus mealybug, thrips and biological control agents (phytoseiid mites) have been assessed to have an unrestricted risk estimate of "low" and measures are therefore required to manage this risk. Leafrollers have been assessed to have an unrestricted risk of "moderate" and measures are also required to manage this risk.

Inspection and remedial action

Visual inspection would involve the examination of a sample of stone fruit to detect the presence of the citrophilus mealybug, leafrollers, thrips and biological control agents (phytoseiid mites). Remedial action when pests are present is proposed as an appropriate risk management option for these pests, given trained inspectors can readily detect these pests.

The objective of this measure is to ensure that consignments of stone fruit from New Zealand infested with these pests can be readily identified and subjected to appropriate remedial action. This measure is considered to reduce the risk associated with citrophilus mealybug, leafrollers, thrips and biological control agents (phytoseiid mites) to a very low level.

4.3.1.3 Operational systems for the maintenance and verification of phytosanitary status

It is necessary to have a system of operational procedures in place to ensure that the phytosanitary status of stone fruit from New Zealand is maintained and verified during the process of production and export to Western Australia. Details of the operational system, or equivalent, will be determined by agreement between Biosecurity Australia (in consultation with DAFWA) and Biosecurity New Zealand.

The proposed system of operational procedures for the production and export of stone fruit from New Zealand to Western Australia would include:

- registration of export orchards;
- phytosanitary system for oriental fruit moth;
- registration of packinghouses and auditing of procedures;
- packaging and labelling;
- specific conditions for storage and movement of produce;
- pre-export phytosanitary inspection by NZ MAF;
- phytosanitary certification by NZ MAF; and
- pre-clearance or on-arrival quarantine clearance by AQIS.

4.3.1.3a Registration of export orchards

All stone fruit for export from New Zealand to Western Australia must be sourced from commercial registered orchards registered with NZ MAF. A list of registered orchards is to be provided to AQIS (who will copy to DAFWA) at the start of each season and as amended by NZ MAF. NZ MAF will be required to register each export orchards prior to commencement of exports from that orchard.

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

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

4.3.1.3b Phytosanitary system for oriental fruit moth

The details of the phytosanitary system for oriental fruit moth is set out in Section 4.3.1.1 Oriental fruit moth and includes: Option 1 Sourcing fruit from pest free areas, pest free places of production or pest free production sites; Option 2 Sourcing fruit from areas of low pest prevalence; and Option 3 Methyl bromide fumigation.

4.3.1.3c Registration of packinghouses and auditing of procedures

All packinghouses intending to export stone fruit to Western Australia will be required to be registered with NZ MAF for trace-back purposes.

The list of registered packinghouses must be kept by NZ MAF and provided to AQIS (who will copy to DAFWA) prior to exports commencing with updates provided if packinghouses are added or removed from the list.

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

4.3.1.3d Packaging and labelling

All stone fruit for export must be free from regulated articles[2] (e.g. trash). No unprocessed packing material of plant origin will be allowed. All wood material used in packaging of stone fruit must comply with the AQIS conditions (e.g. those in “Cargo containers: quarantine aspects and procedures”).

All boxes must be labelled with the orchard registration number. Palletised product is to be identified by attaching a uniquely numbered pallet card to each pallet or part pallet to enable trace back to registered orchards.

The objectives of this procedure are to ensure that:

2 The IPPC defines a regulated article as “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.

- Stone fruit exported to Western Australia is not contaminated by quarantine pests or regulated articles; and
- Unprocessed packing material (which may vector pests identified as not on the pathway and pests not known to be associated with stone fruit) is not imported with the stone fruit.

4.3.1.3e Specific conditions for storage and movement

Packed product and packaging is to be protected from pest contamination during and after packing, during storage and during movement between locations (that is, packinghouse to cool storage/depot, to inspection point, to export point).

Product for export to Western Australia that has been inspected and certified by NZ MAF must be maintained in secure conditions that will prevent mixing with fruit for domestic consumption or export to other destinations.

Security of the consignment is to be maintained until release from quarantine in Western Australia.

Arrangements for secure storage and movement of produce are to be developed by Biosecurity New Zealand in consultation with Biosecurity Australia/AQIS.

The objective of this procedure is to ensure that the phytosanitary status of the product is maintained during storage and movement.

4.3.1.3f Phytosanitary inspection by NZ MAF

NZ MAF will inspect all consignments in accordance with official procedures for all visually detectable quarantine pests and other regulated articles[3]. Sample rates must achieve a confidence level of 95% that not more than 0.5% of the units are infested/infected in the consignment. This equates to a level of zero units infested by quarantine pests in a sample of 600 units selected randomly from each homogenous inspection lot[4] from a consignment[5]. For stone fruit, a unit is defined as one fruit.

Detection of live quarantine pests, or dead oriental fruit moth in stone fruit from pest free areas, pest free places of production, pest free production sites or areas of low pest prevalence, or other regulated articles will result in failure of the consignment. If a consignment fails inspection by NZ MAF, the exporter will be given the option of treatment and re-inspection of the consignment or removal of the consignment from the export pathway.

Detection of oriental fruit moth in consignments from pest free areas, pest free places of production, pest free production sites or areas of low pest prevalence will result in the loss of the relevant pest status.

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[3] The IPPC defines a regulated article as “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.

[4] An inspection lot is the number of boxes presented for a single phytosanitary inspection.

[5] A consignment is the number of boxes of stone fruit in a shipment from New Zealand to Western Australia covered by one phytosanitary certificate.

Records of the interceptions made during these inspections (live quarantine pests, dead oriental fruit moth from pest free areas, pest free places of production, pest free production sites or areas of low pest prevalence, and regulated articles) are to be maintained by NZ MAF and made available to Biosecurity Australia as requested or upon the detection of live or dead oriental fruit moth. This information will assist in future reviews of this import pathway and consideration of the appropriateness of the phytosanitary measures that have been applied.

4.3.1.3g Phytosanitary certification by NZ MAF

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

4.3.1.3h Pre-clearance or on-arrival phytosanitary inspection by AQIS

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

The sample size for inspection of stone fruit is given below.

Consignment size (Units*)	Sample size (Units)
For consignments of less than 1000 units	Either 450 units or 100% of consignment (whichever is smaller)
For consignments equal to or greater than 1000 units	600 units

* Unit = one stone fruit

The sample will be drawn proportionally from each grower contributing to the inspection lot.

The detection of live quarantine pests, or dead oriental fruit moth in stone fruit from pest free areas, pest free places of production, pest free production sites or areas of low pest prevalence, or other regulated articles, will result in the failure of the inspection lot.

Detection of oriental fruit moth in consignments from pest free areas, pest free places of production, pest free production sites or areas of low pest prevalence will result in the loss of the relevant pest status.

An updated pre-clearance work plan for New Zealand stone fruit to Australia that includes specific conditions for Western Australia, including risk mitigation measures for oriental fruit moth, will be developed by NZ MAF (and its independent verification authority) in consultation with AQIS and DAFWA.

For pre-clearance inspections in New Zealand, AQIS will confirm that a Declaration of Intent (DOI) to export is completed and relates to the product presented for inspection, undertake inspection of the inspection lot, and authorise the DOI. AQIS will undertake a documentation compliance examination for consignment verification purposes at the port of entry in Australia prior to release from quarantine.

For on-arrival inspections, no land bridging of goods will be permitted until goods have cleared quarantine. If no live quarantine pests, or dead oriental fruit moth in stone fruit from pest free areas, pest free places of production, pest free production sites or areas of low pest prevalence, or other regulated articles are detected in the inspection lot, the consignment will be released from quarantine.

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

4.3.2 Action for non-complying lots

Where inspection lots are found to be non-compliant with requirements, remedial action must be taken as outlined at the beginning of this section. If product continually fails inspection, Biosecurity Australia/AQIS reserves the right to suspend the export program and conduct an audit of the stone fruit risk management systems in New Zealand. The program will recommence only after Biosecurity Australia/AQIS (in consultation with DAFWA) is satisfied that appropriate corrective action has been taken.

4.3.3 Uncategorised pests

If an organism is detected on stone fruit from New Zealand that has not been categorised, it will require assessment to determine its quarantine status and if phytosanitary action is required. The detection of any pests of quarantine concern not already identified in the analysis may result in the suspension of trade while a review is conducted to ensure that the existing measures continue to provide the appropriate level of phytosanitary protection for Australia.

5 IMPORT CONDITIONS

The import conditions described below are based on the conclusions of the pest risk analysis. Specifically, these conditions reflect the proposed risk management measures in the previous section.

The components of the import conditions are summarised in dot point format below and the risk management measure that links with each component is given in brackets ( ).

- Registration of export orchards (4.3.1.3a)
- Registration of packinghouses and auditing of procedures (4.3.1.3b)
- Pre-export or on-arrival methyl bromide fumigation (4.3.1.1)
- Packing and labelling (4.3.1.3c)
- Storage (4.3.1.3d)
- Pre-export phytosanitary inspection and remedial action (4.3.1.3e)
- Phytosanitary certification (4.3.1.3f)
- Pre-clearance or on-arrival phytosanitary inspection, remedial action and clearance by AQIS (4.3.1.3g)
- Review of protocol

5.1 Registration of Export Orchards

Stone fruit for export to Western Australia must be sourced from orchards registered with NZ MAF. A list of registered orchards is to be provided to AQIS and DAFWA at the start of each season and as amended by NZ MAF. NZ MAF is required to register each export orchard prior to commencement of exports from that orchard to enable trace-back in the event of non-conformance.

All export orchards are expected to produce commercial stone fruit under standard cultivation, harvesting and packing activities.

5.2 Registration of Packinghouses and Auditing of Procedures

All packinghouses intending to export fruit to Western Australia are to be registered with NZ MAF for trace-back purposes.

Packinghouses are required to identify individual orchards with a numbering system and identify fruit from individual orchards by marking cartons or pallets (one orchard per pallet) with a unique orchard number. The packinghouse and packing area would need to be well lit, and the storage areas will need to be secure to ensure fruit is not infested after packing.

Packing procedures should ensure that the stone fruit is free of pests of concern to Western Australia and regulated articles.

NZ MAF must ensure that fruit destined for Western Australia is not mixed with fruit for other destinations. The identity and origin of the fruit for export is to be maintained throughout the process.

The list of registered packinghouses must be kept by NZ MAF and provided to AQIS and DAFWA prior to exports commencing, with updates provided if packinghouses are added or removed from the list.

5.3 Methyl bromide fumigation

Methyl bromide fumigation for oriental fruit moth, where required, may be conducted in New Zealand or on-arrival in Australia. For fumigations in New Zealand, treatment schedules as specified in 4.3.1.1 are to be followed and recorded and monitored by NZ MAF. If treatment is conducted in containers, fruit should not be loaded until the pulp temperature of the fruit has reached the treatment temperature. If warehouses in New Zealand are used, NZ MAF will have to ensure the security of each consignment and monitor the treatment.

5.4 Packing and Labelling

Stone fruit must be packed into new cardboard boxes or cartons. No fresh or dried packing material of plant origin (e.g. straw) is to be used; only processed or synthetic packing material can be used.

Each carton must identify the packinghouse and be labelled with a unique ‘orchard’ number to allow trace-back in the event of non-compliance.

5.5 Specific Conditions for Storage and Movement of Produce

NZ MAF is to ensure that:

- registered packinghouses are maintained in a condition that would provide security against reinfestation/reinfection;
- the movement of stone fruit from the time of arrival at the storage premises through to the time of export is recorded; and
- records of sufficient detail to allow trace-back to orchard and packinghouse must be available to AQIS through Biosecurity New Zealand, if required.

Packinghouses must ensure that records are kept to facilitate auditing by NZ MAF during grading, packing and storage.

Fruit inspected and certified by NZ MAF for export to Australia must be stored under quarantine security and segregated by at least one metre from all other fruit in a cold store until loaded into refrigerated containers. NZ MAF must ensure that container doors are sealed after loading.

Non-compliance with any of the above requirements will result in suspension of the facility by NZ MAF until corrective action has been completed and AQIS has agreed to reinstate the facility.

5.6 Pre-export Inspection by NZ MAF and Remedial Action

NZ MAF will inspect all consignments[6] for visually detectable quarantine pests and other regulated articles[7] (e.g. trash). The pre-export inspection requires inspection for quarantine pests of 600 units selected randomly from each homogeneous inspection lot[8] from a consignment. For stone fruit, a unit is defined as one fruit.

The detection of live quarantine pests, or dead oriental fruit moth in stone fruit from pest free areas, pest free places of production, pest free production sites or areas of low pest prevalence, or regulated articles during an inspection will result in the failure of the inspection lot. Remedial action may then be taken. Action for the consignment may include:

- withdrawing the consignment from export to Australia; or
- treatment of the consignment and re-inspection to ensure that the pest is no longer viable.

Detection of oriental fruit moth in consignments from pest free areas, pest free places of production, pest free production sites or areas of low pest prevalence will result in the loss of the relevant pest status. Recognition of the pest status for the affected areas will be suspended until Biosecurity Australia (in consultation with DAFWA and Biosecurity New Zealand) is satisfied that appropriate corrective action has been taken to re-instate the relevant pest status.

Records of the interceptions made during these inspections (live quarantine pests, dead oriental fruit moth from pest free areas, pest free places of production, pest free production sites or areas of low pest prevalence, and regulated articles) are to be maintained by NZ MAF and made available to Biosecurity Australia as requested or upon the detection of live or dead oriental fruit moth. This information will assist in future reviews of this import pathway and consideration of the appropriateness of the phytosanitary measures that have been applied.

5.7 Phytosanitary Certification

NZ MAF will issue an International Phytosanitary Certificate (IPC) for each consignment upon completion of pre-export inspection and methyl bromide fumigation (if used as the mitigation measure for oriental fruit moth), containing the following information:

Additional declarations

- *"Stone fruit in this consignment has been sourced from pest free areas or areas of low pest prevalence and inspected and found free of quarantine pests"*

or if the methyl bromide fumigation option for oriental fruit moth is undertaken pre-shipment

[6] A consignment is the number of boxes of stone fruit in a shipment from New Zealand to Western Australia covered by one phytosanitary certificate.

[7] The IPPC defines a regulated article as "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.

[8] An inspection lot is the number of boxes presented for a single phytosanitary inspection.

- *"Stone fruit in this consignment has been fumigated with methyl bromide for oriental fruit moth and inspected and found free of quarantine pests".*

and where consignments have been pre-cleared by AQIS

- *"AQIS pre-clearance inspection undertaken in New Zealand in accordance with the Work Plan for the Pre-clearance of New Zealand stone fruit to Australia".*

Distinguishing marks

- The appropriate 'orchard' numbers, packinghouse identification, number of cartons per 'inspection lot', container and seal numbers, and date.

Treatments

- For methyl bromide fumigation: dosage; duration; temperature; CT product; loading rate; date; and facility need to be included.

5.8 Phytosanitary Inspection by AQIS

Phytosanitary inspection by AQIS may be undertaken either in New Zealand as a pre-clearance inspection or on arrival in Australia.

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

The sample size for inspection of stone fruit is given below.

Consignment size (Units*)	Sample size (Units)
For consignments of less than 1000 units	Either 450 units or 100% of consignment (whichever is smaller)
For consignments equal to or greater than 1000 units	600 units

* Unit = one stone fruit

The sample will be drawn proportionally from each grower contributing to the inspection lot.

The detection of live quarantine pests, or dead oriental fruit moth in stone fruit from pest free areas, pest free places of production, pest free production sites or areas of low pest prevalence, or other regulated articles, will result in the failure of the inspection lot.

Detection of oriental fruit moth in consignments from pest free areas, pest free places of production, pest free production sites or areas of low pest prevalence will result in the loss of the relevant pest status. Recognition of the pest status for the affected areas will be suspended until Biosecurity Australia (in consultation with DAFWA and Biosecurity New Zealand) is satisfied that appropriate corrective action has been taken to re-instate the relevant pest status.

Pre-clearance inspections of stone fruit consignments in New Zealand for Western Australia are to be carried out in accordance with the pre-clearance work plan for New Zealand stone fruit to Australia. AQIS will confirm that a Declaration of Intent (DOI) to export is completed and relates to the product presented for inspection, undertake inspection of the inspection lot, and authorise the DOI. AQIS will undertake a documentation compliance examination for consignment verification purposes at the port of entry in Australia prior to release from quarantine.

For on-arrival inspections, no land bridging of goods will be permitted until goods have cleared quarantine. If no live quarantine pests, or dead oriental fruit moth in stone fruit from pest free areas, pest free places of production, pest free production sites or areas of low pest prevalence, or other regulated articles are detected in the inspection lot, the consignment will be released from quarantine.

5.8.1 Remedial action for produce inspected on arrival

If quarantine pests or regulated articles are found during an inspection, the importer will be given the option to treat (if a suitable treatment is available), re-export or destroy the consignment.

5.8.2 Documentation errors

Any 'consignment' with incomplete documentation, or where certification does not conform to specifications, or seals on the containers are damaged or missing, will be held pending clarification by NZ MAF and determination by AQIS, with the options of re-export or destruction. NZ MAF will be notified immediately by AQIS of any such problems.

5.9 Audit of Protocol

All New Zealand growers and exporters must register with the compliance program to export stone fruit to Western Australia. The compliance program is audited by a NZ MAF authorised independent verification agency. The first audit is conducted before registration to ensure staff is competent with the process and pheromone traps for oriental fruit moth are correctly placed. Growers will only be registered once this audit is complete. A random sample of growers will be audited twice during the season, with some growers being audited a third time if concerns arise from the previous audits.

During the first season of trade, an officer from Biosecurity Australia and/or an officer from AQIS will visit areas in New Zealand designated for export of stone fruit to Western Australia in order to audit the operation of the protocol including registration and operational procedures.

5.10 Review of Policy

The adopted policy will be reviewed at the end of the first year of export of stone fruit from New Zealand to Western Australia, or earlier in the event of new outbreaks in New Zealand of pests of concern to Western Australia.

6 CONCLUSIONS

The findings of this pest risk analysis are based on a comprehensive analysis of relevant available scientific literature and existing import requirements for stone fruit from New Zealand into Australia, and cherry fruit from South Australia, New Zealand and Tasmania and apricot fruit from South Australia and Tasmania into Western Australia.

Biosecurity Australia considers that the proposed risk management measures will provide an appropriate level of protection against the pests identified in the pest risk analysis.

In the course of preparing the final report for the pest risk analysis, Biosecurity Australia received and considered stakeholder comments on the draft report. Biosecurity Australia considered all scientific issues raised in the submissions of stakeholders and material matters raised have been incorporated into, or addressed in, this final report.

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APPENDIX – 1: PEST CATEGORISATION

1a: Pest Categorisation for Stone Fruit from New Zealand – Presence/Absence

1b: Pest Categorisation for Stone Fruit from New Zealand – Pathway Association

1c: Potential for Establishment or Spread and Associated Consequences for Stone Fruit from New Zealand

Appendix – 1a: Pest Categorisation for Stone Fruit from New Zealand – Presence/Absence[9]

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
ARTHROPODS					
Acari (mites)					
Aculus fockeui Nalepa & Trouessart [Acari: Eriophyidae]	Plum rust mite	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (ICDB, 2003)	No
Bdellodes sp. [Acari: Bdellidae]	Snout mite	Yes (NZ MAF, 2003)	Yes (Halliday, 1998)	Yes (Halliday, 1998)	No
Bryobia praetiosa [Acari: Tetranychidae]	Almond mite	Yes (Helson, 1952)	Yes (Halliday, 1998)	Yes (Michael & Carmody, 2002)	No
Bryobia rubrioculus (Scheuten) [Acari: Tetranychidae]	Brown mite	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Woods *et al*., 1996)	No
Bryobia rubrioculus f. *prunicola* Mathys [Acari: Tetranychidae]	Brown mite	Yes (NZ MAF, 2003)	No	No	No[10]
Diptactus gigantorhynchus (Nalepa) [Acari: Rhyncaphytoptidae]	Big beak plum mite	Yes (NZ MAF, 2003)	No	No	**Yes**
Orthotydeus californicus (Banks) [Acari: Tydeidae]	Tydeid mite	Yes (NZ MAF, 2003)	Yes (Smith *et al*., 1997)	No	**Yes**
Orthotydeus caudatus (Dugès) [Acari: Tydeidae]	Tydeid mite	Yes (NZ MAF, 2003)	No	No	**Yes**
***Orthotydeus* sp.** [Acari: Tydeidae]	Tydeid mite	Yes (NZ MAF, 2003)	No	No	**Yes**
Panonychus ulmi (Koch) [Acari: Tetranychidae]	European red mite	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Botha & Learmonth, 2005)	No
Phyllocoptes abaenus Keifer [Acari: Eriophyidae]	Plum leaf vagrant	Yes (NZ MAF, 2003)	Yes (Naumann, 1993a)	No	**Yes**
Suskia mansoni Lindquist [Acari: Tarsonemidae]	Tarsonemid mite	Yes (NZ MAF, 2003)	No	No	**Yes**
Tarsonemus bakeri Ewing [Acari: Tarsonemidae]	Tarsonemid mite	Yes (NZ MAF, 2003)	No	No	**Yes**
Tarsonemus parawaitei Kim *et al*. [Acari: Tarsonemidae]	Tarsonemid mite	Yes (NZ MAF, 2003)	Yes (Kim *et al*., 1998)	No	**Yes**

9 Pests recorded on sweet cherries only are not included in this list.

10 Species present in Australia including Western Australia but sub species is not recorded. Not sufficient evidence to consider this species at lower level.

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
Tarsonemus smithi Ewing [Acari: Tarsonemidae]	Tarsonemid mite	Yes (PDI, 2003)	No	No	**Yes**
Tarsonemus waitei Banks [Acari: Tarsonemidae]	Peach bud mite	Yes (NZ MAF, 2003)	Yes (Smith *et al*., 1997)	No	**Yes**
Tetranychus lambi Pritchard & Baker [Acari: Tetranychidae]	Banana mite	Yes (NZ MAF, 2003)	Yes (Halliday, 1998)	Yes (Richards, 1968)	No
Tetranychus urticae Koch [Acari: Tetranychidae]	Two spotted spider mite	Yes (NZ MAF, 2003)	Yes (Halliday, 1998)	Yes (Herron *et al*., 1997)	No
Tyrophagus longior (Gervais) [Acari: Acaridae]	Seed mite	Yes (NZ MAF, 2003)	Yes (Champ, 1966)	Yes (Champ, 1966)	No
Tyrophagus putrescentiae (Shrank) [Acari: Acaridae]	Mould mite	Yes (NZ MAF, 2003)	Yes (Halliday, 1998)	Yes (AGWEST, 2001)	No
Coleoptera (beetles, weevils)					
Araecerus palmaris (Pascoe) [Coleoptera: Anthribidae]	Dried apple beetle	Yes (Kuschel, 1972)	Yes (APPD, 2004)	No	**Yes**
Aridius bifasciatus (Reitter) [Coleoptera: Lathridiinae]	Fungus beetle	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	No	**Yes**
Aridius nodifer (Westwood) [Coleoptera: Lathridiinae]	Fungus beetle	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	No	**Yes**
***Atheta* sp.** [Coleoptera: Staphylinidae]	Rove beetle	Yes (NZ MAF, 2003)	No	No	**Yes**
Berosus australiae Mulsant & Rey [Coleoptera: Hydrophilidae]		Yes (PDI, 2003)	Yes (Halse *et al*., 1998)	Yes (Halse *et al*., 1998; APPD, 2005)	No
Carpophilus davidsoni Dobson [Coleoptera: Nitidulidae]	Dried fruit beetle	Yes (NZ MAF, 2003)	Yes (James *et al*, 2000)	Yes (James *et al*, 2000)	No
Carpophilus dimidiatus Fabricius [Coleoptera: Nitidulidae]	Dried fruit beetle	Yes (PDI, 2003)	Yes (APPD, 2004)	Yes (James *et al.*, 2000)	No
Carpophilus gaveni Dobson [Coleoptera: Nitidulidae]	Dried fruit beetle	Yes (NZ MAF, 2003)	Yes (James *et al*, 2000)	Yes (James *et al.*, 2000)	No
Carpophilus hemipterus (Linnaeus) [Coleoptera: Nitidulidae]	Dried fruit beetle	Yes (NZ MAF, 2003)	Yes (James *et al*., 2000)	Yes (James *et al*., 2000)	No
Carpophilus humeralis (Fabricius) [Coleoptera: Nitidulidae]	Dried fruit beetle	Yes (NZ MAF, 2003)	Yes (James *et al*., 2000)	Yes (James *et al*., 2000)	No
Carpophilus mutilatus (Erichson) [Coleoptera: Nitidulidae]	Dried fruit beetle	Yes (PDI, 2003)	Yes (James *et al*., 2000)	Yes (James *et al*., 2000)	No
Coccinella undecimpunctata Linnaeus [Coleptera:	Eleven-spotted	Yes (PDI, 2003)	Yes (APPD, 2005)	Yes (ICDB, 2005)	No

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
Coccinellidae]	ladybird				
Conoderus exsul Sharp [Coleoptera: Elateridae]	Pasture wireworm	Yes (Robertson, 1987)	No	No	**Yes**
Corticaria hirtalis Broun [Coleoptera: Lathridiidae]	Fungus beetle	Yes (NZ MAF, 2003)	Yes (Lawrence & Britton (1991))	No	**Yes**
Costelytra zealandica (White) [Coleoptera: Scarabaeidae]	Grass grub	Yes (NZ MAF, 2003)	No	No	**Yes**
Epilachna doryca (Boisduval) [Coleoptera: Coccinellidae]	Ladybird	Yes (PDI, 2003)	No	No	**Yes**
Epurea takhtajani Medvedev & Ter-Minasyan [Coleoptera: Nitidulidae]	Yellow sap beetle	Yes (NZ MAF, 2003)	No	No	**Yes**
Eucolaspis brunnea (Fabricius) [Coleoptera: Chrysomelidae]	Bronze beetle	Yes (NZ MAF, 2003)	No	No	**Yes**
Hylastes ater Paykull [Coleoptera: Scolytidae]	Black pine bark beetle	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Abbott, 1985)	No
Hylurgus ligniperda (Fabricius) [Coleoptera: Scolytidae]	Golden haired bark beetle	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Abbott, 1985)	No
Irenimus parilis (Pascoe) [Coleoptera: Curculionidae]	Broad nosed weevil	Yes (NZ MAF, 2003)	No	No	**Yes**
Leptopius squalidus [Coleoptera: Curculionidae]	Fruit tree weevil	Yes (Kuschel, 1972)	Yes (Malipatil *et al.*, 1997)	No	**Yes**
Listronotus bonariensis (Kuschel) [Coleoptera: Curculionidae]	Argentine stem weevil	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (APPD, 2004)	No
Naupactus leucoloma (Boheman) [Coleoptera: Curculionidae]	Whitefringed weevil	Yes (Kuschel, 1972)	Yes (APPD, 2004)	No	**Yes**
Navomorpha sulcatus (Fabricius) [Coleoptera: Cerambycidae]	Cerambycid beetle	Yes (Spiller & Wise, 1982)	No	No	**Yes**
Oemona hirta (Fabricius) [Coleoptera: Cerambycidae]	Lemon tree borer	Yes (NZ MAF, 2003)	No	No	**Yes**
Otiorhynchus ovatus (Linnaeus) [Coleoptera: Curculionidae]	Strawberry root weevil	Yes (NZ MAF, 2003)	Yes (Nielsen *et al.*, 1989)	No	**Yes**
Otiorhynchus sulcatus (Fabricius) [Coleoptera: Curculionidae]	Black vine weevil	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	No	**Yes**

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
Pantomorus cervinus (Boheman) [Coleoptera: Curculionidae]	Fuller's rose weevil	Yes (NZ MAF, 2003)	Yes (Baker, 1998)	Yes (Woods *et al*., 1996)	No
Paraphloeostiba gayndahensis MacLeay (Coleoptera: Staphylinidae)	Rove beetle	Yes (NZ MAF, 2003)	Yes (Thayer, 2001)	No	**Yes**
Phlyctinus callosus Boheman [Coleoptera: Curculionidae]	Garden weevil	Yes (NZ MAF, 2003)	Yes (Learmonth & Matthiessen, 1990)	Yes (Learmonth & Matthiessen, 1990)	No
Sitona discoideus Gyllenhal [Coleoptera: Curculionidae]	Sitona weevil	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (APPD, 2004)	No
Stethorus bifidus Kapur [Coleoptera: Coccinellidae]	Apple mite ladybird	Yes (NZ MAF, 2003)	No	No	**Yes**
Stethorus sp. [Coleoptera: Coccinellidae]	Ladybird	Yes (NZ MAF, 2003)	Yes (Readshaw, 1975)	Yes (AGWEST, 2001)	No
Typhaea stercorea [Coleoptera: Mycetophagidae]	Hairy fungus beetle	Yes (PDI, 2003)	Yes (APPD, 2004)	Yes (APPD, 2004)	No
Xyleborus saxesini (Ratzeburg) [Coleoptera: Curculionidae]	Fruit tree pinhole borer	Yes (Kuschel, 1972)	Yes (Hely *et al*., 1982)	Yes (Abbott, 1985)	No
Zorion minutum Fabricius [Coleoptera: Cerambycidae]	Flower longhorn	Yes (NZ MAF, 2003)	No	No	**Yes**
Collembola (Springtail)					
Ceratophysella denticulata (Bagnall) [Collembola: Hypogastruridae]	Mushroom springtail	Yes (NZ MAF, 2003)	Yes (Greenslade & Ireson, 1986)	No	**Yes**
Dermaptera (Earwigs)					
Forficula auricularia Linnaeus. [Dermaptera: Forficulidae]	European earwig	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Rees & Postle, 1995)	No
Labidura truncata Kirby [Dermaptera: Labiduridae]	Riparian earwig	Yes (Hudson, 1973)	Yes (APPD, 2005)	Yes (APPD, 2005)	No
Diptera (flies)					
Drosophila sp. [Diptera: Drosophilidae]	Ferment fly	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (ICBD, 2003)	No
Melangyna novaezealandiae Macquart [Diptera: Syrphidae]	Large hoverfly	Yes (NZ MAF, 2003)	No	No	**Yes**
Hemiptera (aphids, leafhoppers, mealybugs, scales. True bugs, whiteflies)					
Aspidiotus nerii Bouché [Hemiptera: Diaspididae]	Oleander scale	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Abbot, 1995)	No
Aulacorthum circumflexum (Buckton) [Hemiptera: Aphididae]	Lily aphid	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	No	**Yes**

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
Brachycaudus helichrysi (Kaltenbach) [Hemiptera: Aphididae]	Leaf curl plum aphid	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Berlandier, 1999)	No
Brachycaudus persicae (Passerini) [Hemiptera: Aphididae]	Black peach aphid	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Berlandier, 1999)	No
Calocoris norvegicus (Gmelin) [Hemiptera: Miridae]	Potato bug	Yes (McLaren *et al.*, 1999)	Yes (APPD, 2004)	No	**Yes**
Coccus hesperidum Linnaeus [Hemiptera: Coccidae]	Soft brown scale	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Broughton, 2003)	No
Diaspidiotus ostreaeformis (Curtis) Borchsenius [Hemiptera: Diaspididae]	Oystershell scale	Yes (NZ MAF, 2003)	Yes (Brookes & Hudson, 1969)	No	**Yes**
Diaspidiotus perniciosus (Comstock) [Hemiptera: Diaspididae]	San Jose scale	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (APPD, 2004)	No
Diomocoris maoricus (Walker) [Hemiptera: Miridae]	Native mirid	Yes (Eyles, 1999)	No	No	**Yes**
Eriococcus coriaceus Maskell [Hemiptera: Eriococcidae]	Gum tree scale	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Buckland *et al.*, 1990)	No
Hemiberlesia lataniae (Signoret) [Hemiptera: Diaspididae]	Lataniae scale	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (APPD, 2004)	No
Hemiberlesia rapax (Comstock) [Hemiptera: Diaspididae]	Greedy scale	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (AGWEST, 2001)	No
Lepidosaphes ulmi (Linnaeus) [Hemiptera: Diaspididae]	Apple mussel scale	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Powell, 1938)	No
Myzus ornatus Laing [Hemiptera: Aphididae]	Ornate aphid	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	No	**Yes**
Myzus persicae Sulzer [Hemiptera: Aphididae]	Green peach aphid	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Berlandier, 1999)	No
Nezara viridula (Linnaeus) [Hemiptera: Pentatomidae]	Green vegetable bug	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Clarke, 1992)	No
Nysius huttoni White [Hemiptera: Lygaeidae]	New Zealand wheat bug	Yes (NZ MAF, 2003)	No	No	**Yes**
Parlatoria pergandii Comstock [Hemiptera: Diaspididae]	Chaff scale	Yes (NZ MAF, 2003)	Yes (ABRS, 2005)	No	**Yes**
Parthenolecanium corni (Bouché) [Hemiptera: Coccidae]	European fruit scale	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	No	**Yes**
Parthenolecanium persicae (Fabricius) [Hemiptera: Coccidae]	European peach scale	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Woods *et al.*, 1996)	No

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
Phenacoccus graminicola Leonardi [Hemiptera: Pseudococcidae]	Ryegrass mealybug	Yes (NZ MAF, 2003)	Yes (Williams, 1985)	Yes (Szito & Michael, 2002)	No
Pseudococcus calceolariae (Maskell) [Hemiptera: Pseudococcidae]	Citrophilus mealybug	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	No	**Yes**
Pseudococcus longispinus Targioni-Tozzetti [Hemiptera: Pseudococcidae]	Long-tailed mealybug	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Ben-Dov, 1994)	No
Pseudococcus viburni (Signoret) [Hemiptera: Pseudococcidae]	Tuber mealybug	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (APPD, 2004)	No
Pulvinaria vitis (Linnaeus) [Hemiptera: Coccidae]	Cottony vine scale	Yes (McLaren *et al*., 1999)	No	No	**Yes**
Rhopalosiphum nymphaeae (Linnaeus) [Hemiptera: Aphididae]	Plum aphid	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Carver & Reid, 1994)	No
***Rhypodes* sp.** [Hemiptera: Lygaeidae]	Seed bug	Yes (NZ MAF, 2003)	No	No	**Yes**
Saissetia oleae (Olivier) [Hemiptera: Coccidae]	Black scale	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Smith *et al*., 1997)	No
Scolypopa australis (Walker) [Hemiptera: Ricaniidae]	Passionvine hopper	Yes (Tomkins *et al*., 2000a)	Yes (Hely *et al*., 1982)	No	**Yes**
Hymenoptera (ants; wasps)					
Caliroa cerasi Linnaeus [Hymenoptera: Tenthridinidae]	Cherry slug	Yes (NZ MAF, 2003)	Yes (Woods *et al*., 1996)	Yes (Woods *et al*., 1996)	No
Monomorium antarcticum (F. Smith) [Hymenoptera: Formicidae]	Southern Ant	Yes (NZ MAF, 2003)	No	No	**Yes**
Vespula germanica Fabricius [Hymenoptera: Vespidae]	European wasp	Yes (Helson, 1952)	Yes (Davis, 1998)	No. Eradicated (Davis, 1998)	**Yes**
Lepidoptera (leafrollers, moths, butterflies)					
Aenetus virescens (Doubleday) [Lepidoptera: Hepialidae]	Puriri moth	Yes (Spiller & Wise, 1982)	No	No	**Yes**
Cnephasia jactatana (Walker) [Lepidoptera: Tortricidae]	Black-lyre leafroller	Yes (NZ MAF, 2003)	No	No	**Yes**
Coscinoptycha improbana Meyrick [Lepidoptera: Carposinidae]	Guava moth	Yes (Froud & Dentener, 2002)	Yes (Nielsen & Common, 1991)	No	**Yes**

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
Ctenopseustis herana (Felder & Rogenhofer.) [Lepidoptera: Tortricidae]	Brown headed leafroller	Yes (NZ MAF, 2003)	No	No	**Yes**
Ctenopseustis obliquana (Walker) [Lepidoptera: Tortricidae]	Brown headed leafroller	Yes (NZ MAF, 2003)	No	No	**Yes**
Cydia pomonella (Linnaeus) [Lepidoptera: Tortricidae]	Codling moth	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	No. Eradicated	**Yes**
Epiphyas postvittana (Walker) [Lepidoptera: Tortricidae]	Light brown apple moth	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Geier & Springett, 1976)	No
Eutorna phaulocosma Meyrick [Lepidoptera: Depressariidae]	Blackberry bud moth	Yes (McLaren *et al*., 1999)	Yes (Neilsen *et al.,* 1996)	No	**Yes**
Graphania mutans (Walker) [Lepidoptera: Noctuidae]	Noctuid moth	Yes (NZ MAF, 2003)	No	No	**Yes**
Grapholita molesta (Busck) [Lepidoptera: Tortricidae]	Oriental fruit moth	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	No	**Yes**
Harmologa amplexana (Zeller) [Lepidoptera: Tortricidae]	Native leafroller	Yes (NZ MAF, 2003)	No	No	**Yes**
Harmologa oblongana (Walker) [Lepidoptera: Tortricidae]	Native leafroller	Yes (NZ MAF, 2003)	No	No	**Yes**
Helicoverpa armigera (Hübner) [Lepidoptera: Noctuidae]	Tomato fruitworm	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (APPD, 2004)	No
Heterocrossa adreptella Walker [Lepidoptera: Carposinidae] [11]	Raspberry bud moth	Yes. Possibly the *C. adreptella* referred to by McLaren *et al*., 1999	No	No	**Yes**
Heterocrossa rubophaga Dugdale [Lepidoptera: Carposinidae]	Raspberry bud moth	Yes (NZ MAF, 2003)	No	No	**Yes**
Phyllonorycter messaniella (Zeller) [Lepidoptera: Gracillariidae]	Native leafminer	Yes (NZ MAF, 2003)	Neilsen *et al*.,1996	No	**Yes**
Planotortrix excessana Walker [Lepidoptera: Tortricidae]	Green headed leafroller	Yes (NZ MAF, 2003)	No	No	**Yes**
Planotortrix flavescens (Butler) [Lepidoptera: Tortricidae]	New Zealand native leafroller	Yes (Wearing *et al*., 1991)	No	No	**Yes**

[11] There is some confusion over the correct identify of the raspberry bud moth that may be associated with stone fruit in New Zealand. Therefore, both *H. adreptella* and *H. rubrophaga* have been considered in this report.

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
Planotortrix notophaea (Turner) [Lepidoptera: Tortricidae]	Black headed leafroller	Yes (McLaren *et al.*, 1999)	No	No	**Yes**
Planotortrix octo Dugdale [Lepidoptera: Tortricidae]	Green headed leafroller	Yes (NZ MAF, 2003)	No	No	**Yes**
Pyrgotis plagiatana (Walker) [Lepidoptera: Tortricidae]	Native leafroller	Yes (NZ MAF, 2003)	No	No	**Yes**
Stathmopoda sp. Herrich-Schäffer [Lepidoptera: Oecophoridae]	Yellow stathmopoda moth	Yes (McLaren *et al.*, 1999)	Yes (Nielsen *et al.*, 1996)	Yes (ICDB, 2003)	No
Teia anartoides Walker [Lepidoptera: Lymantriidae]	Painted apple moth	Yes (Suckling *et al.*, 2004)	Yes (Hely *et al.*, 1982)	No	**Yes**
Orthoptera (crickets, grasshoppers)					
Caedicia simplex (Walker) [Orthoptera: Tettigoniidae]	Katydid	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Rentz, 1996)	No
Hemideina thoracica (White) [Orthoptera: Stenopelmatidae]	Auckland tree weta	Yes (NZ MAF, 2003)	No	No	**Yes**
Psocoptera (booklice)					
Ectopsocus briggsi McLachlan [Psocoptera: Ectopsocidae]	Booklice	Yes (McLaren *et al.*, 1999)	Yes (ABRS, 2005)	Yes (ABRS, 2005)	No
Thysanoptera (thrips)					
Aeolothrips fasciatus (Linnaeus) [Thysanoptera: Aeolothripidae]	Banded thrips	Yes (Bejakovich *et al.*, 1998)	Yes (APPD, 2004)	No	**Yes**
Anaphothrips obscurus (Müller) [Thysanoptera: Thripidae]	Grass thrips	Yes (Mound, 1996)	Yes (APPD, 2004)	Yes (Mound, 1996)	No
Chirothrips manicatus (Haliday) [Thysanoptera: Thripidae]	Cocksfoot thrips	Yes (McLaren, 1992)	Yes (APPD, 2004)	Yes (APPD, 2004)	No
Frankliniella occidentalis (Pergande) [Thysanoptera: Thripidae]	Western flower thrips (WFT)	Yes (NZ MAF, 2003)	Yes (Mound & Gillespie, 1997)	Yes (Mound & Gillespie, 1997)	**Yes**[12]
Haplothrips niger (Osbom) [Thysanoptera: Phlaeothripidae]	Red clover thrips	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	No	**Yes**
Heliothrips haemorrhoidalis Bouché [Thysanoptera: Thripidae]	Greenhouse thrips	Yes (NZ MAF, 2003)	Yes (Mound, 1996)	Yes (Mound, 1996)	No

[12] WFT is under official control in Northern Territory and Tasmania. WFT is the vector of impatiens necrotic spot tospovirus.

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
Hercinothrips femoralis (Reuter) [Thysanoptera: Thripidae]	Banded glass house thrips	Yes (Mound & Walker 1982)	Yes (APPD, 2004)	Yes (APPD, 2004)	No
Linzothrips cerealiuni [Thysanoptera: Thripidae]		Yes (McLaren, 1992)	No	No	**Yes**
Tenothrips frici (Uzel) [[Thysanoptera: Thripidae]	Dandelion thrips	Yes (McLaren, 1992)	Yes (APPD, 2004)	Yes (APPD, 2004)	**Yes**
Thrips australis (Bagnall) [Thysanoptera: Thripidae]	Eucalyptus thrips	Yes (PDI, 2003)	Yes (Mound, 1996)	Yes (Mound, 1996)	No
Thrips imaginis (Bagnall) [Thysanoptera: Thripidae]	Plague thrips	Yes (PDI, 2003)	Yes (APPD, 2004)	Yes (Poole *et al*., 2004)	No
Thrips obscuratus (J.C. Crawford) [Thysanoptera: Thripidae]	New Zealand flower thrips	Yes (NZ MAF, 2003)	No	No	**Yes**
Thrips tabaci Lindeman [Thysanoptera: Thripidae]	Onion thrips	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (APPD, 2004)	No
BIOLOGICAL CONTROL AGENTS					
Acari (mites)					
Agistemus longisetus González-Rodríguez [Acari: Stigmaeidae]	Stigmaeid mite	Yes (Hortnet, 2003a)	Yes (Readshaw, 1975)	No	**Yes**
Amblyseius waltersi Schicha [Acari: Phytoseiidae]	Phytoseiid mite	Yes (NZ MAF, 2003)	Yes (NSW Agriculture, 2003)	No	**Yes**
Anystis baccarum (Linnaeus) [Acari: Anystidae]	Whirlygig mite	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (ICDB, 2003)	No
Asca aphidioides Linnaeus [Acari: Ascidae]	Mesostigmatid mite	Yes (NZ MAF, 2003)	No	No	**Yes**
Cyta latirostris (Hermann) [Acari: Bdellidae]	Bdellid mite	Yes (NZ MAF, 2003)	Yes (Wallace & Mohon, 1973)	Yes (ICDB, 2003)	No
Eryngiopus bifidus Wood [Acari: Stigmaeidae]	Stigmaeid mite	Yes (NZ MAF, 2003)	No	No	**Yes**
***Eugamasus* sp.** [Acari: Parasitidae]	Parasitid mite	Yes (NZ MAF, 2003)	No	No	**Yes**
Hemisarcoptes coccophagus Meyer [Acari: Hemisarcoptidae]		Yes (Charles, 1998)	No	No	**Yes**
Metaseiulus occidentalis Nesbitt [Acari: Phytoseiidae]	Western predatory mite	Yes (NZ MAF, 2003)	Yes (AGWEST, 2001)	Yes (AGWEST, 2001)	No
Neoseiulus caudiglans Schuster [Acari: Phytoseiidae]	Phytoseiid mite	Yes (NZ MAF, 2003)	No	No	**Yes**
Neoseiulus fallacis (Garman) [Acari: Phytoseiidae]	Phytoseiid mite	Yes (NZ MAF, 2003)	Yes (Halliday, 1998)	No	**Yes**
Parasitus fimetorum (Berlese) [Acari: Parasitidae]	Parasitid mite	Yes (NZ MAF, 2003)	No	No	**Yes**

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
***Pergamasus* sp.** [Acari: Parasitidae]	Parasitid mite	Yes (NZ MAF, 2003)	No	No	**Yes**
Phytoseiulus persimilis Athias-Henriot [Acari: Phytoseiidae]	Chilean predatory mite	Yes (NZ MAF, 2003)	Yes (Halliday, 1998)	Yes (Graham & Gatter, 1990)	No
Typhlodromus pyri Scheuten [Acari: Phytoseiidae]	Phytoseiid mite	Yes (NZ MAF, 2003)	Yes (Walter, 1997)	No	**Yes**
Coleoptera (beetles, weevils)					
Adalia bipunctata (Linnaeus) [Coleoptera: Coccinellidae]	Two spotted lady beetle	Yes (Hortnet, 2003e)	Yes (APPD, 2004)	Yes (Waterhouse & Sands (2001).	No
Cryptolaemus montrouzieri Mulsant [Coleoptera: Coccinellidae]	Mealybug destroyer	Yes (Valentine, 1967)	Yes (Booth & Pope, 1986)	Yes (Booth & Pope, 1986)	No
Halmus chalybeus Boisduval [Coleoptera: Coccinellidae]	Steel blue ladybird	Yes (Hortnet, 2004d)	Yes (APPD, 2004)	Yes (Waterhouse & Sands (2001).	No
Leis conformis Boisduval [Coleoptera: Coccinellidae]	ladybird	Yes (Valentine, 1967)	Yes (ICDB, 2003)	Yes (ICDB, 2003)	No
Mecodema occiputale Brown [Coleoptera: Carabidae]		Yes (Spiller & Wise, 1982)	No	No	**Yes**
Rhyzobius ventralis (Erichson) [Coleoptera: Coccinellidae]	Gumtree scale ladybird	Yes (Valentine, 1967)	Yes (APPD, 2004)	Yes (APPD, 2004)	No
Diptera (flies)					
Cryptochetum iceryae (Williston) [Diptera: Cryptochetidae]	Parasitoid fly	Yes (Valentine, 1967)	Yes (Waterhouse & Sands, 2001)	No	**Yes**
Pales feredayi (Hutton) [Diptera: Tachinidae]	Tachinid fly	Yes (Valentine, 1967)	No	No	**Yes**
Pales funesta (Hutton) [Diptera: Tachinidae]	Tachinid fly	Yes (Valentine, 1967)	No	No	**Yes**
Syrphus ortas [Diptera: Syrphidae]	Hover fly	Yes (Valentine, 1967)	No	No	**Yes**
Syrphus ropalus Walker [Diptera: Syrphidae]	Hover fly	Yes (Valentine, 1967)	No	No	**Yes**
Uclesiella irregularis Malloch [Diptera: Tachinidae]	Tachinid fly	Yes (Valentine, 1967)	No	No	**Yes**
Hemiptera (aphids, leafhoppers, mealybugs, scales. True bugs, whiteflies)					
Cardiastethus consors White [Hemiptera: Anthocoridae]	Anthocorid bug	Yes (Larivière, & Larochelle, 2004)	No	No	**Yes**
Cardiastethus poweri White [Hemiptera: Anthocoridae]	Anthocorid bug	Yes (Larivière, & Larochelle, 2004)	No	No	**Yes**

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
Ceramatulus nasalis (Westwood) [Hemiptera: Pentatomidae]	Pentatomid bug	Yes (Larivière, & Larochelle, 2004)	Yes (ICDB, 2003)	Yes (ICDB, 2003)	No
Lyctocoris campestris (Fabricius) [Hemiptera: Anthocoridae]	Debris bug	Yes (Larivière, & Larochelle, 2004)	Yes (APPD, 2004)	Yes (ICDB, 2003)	No
Nabis capsiformis Germar [Hemiptera: Nabidae][13]	Nabid bug	Yes (Valentine, 1967)	Yes (Woodward, 1982)	Yes (Carver *et al*., 1991)	No
Nabis kingbergii Reuter [Hemiptera: Nabidae]	Nabid bug	Yes (Larivière, & Larochelle, 2004)	Yes (Cassis & Gross, 1995)	Yes (Cassis & Gross, 1995)	No
Oechalia schellenbergii Guerin [Hemiptera: Pentatomidae]	Pentatomid bug	Yes (Larivière, & Larochelle, 2004)	Yes (ICDB, 2003)	Yes (ICDB, 2003)	No
Orius vicinus Ribaut [Hemiptera: Anthocoridae]	Orius bug	Yes (NZ MAF, 2003)	No	No	**Yes**
Ploiaria antipoda (Bergroth) [Hemiptera: Reduviidae]	Fragile assassin bug	Yes (Larivière, & Larochelle, 2004)	No	No	**Yes**
Hymenoptera (ants; wasps)					
***Adelius* sp.** [Hymenoptera: Braconidae]	Braconid parasitic wasp	Yes (Valentine, 1967)	No	No	**Yes**
Apanteles ruficrus Haliday [Hymenoptera: Braconidae]	Braconid parasitic wasp	Yes (Valentine, 1967)	Yes (APPD, 2005)	Yes (APPD, 2005)	No
Aphelinus abdominalis (Dalman) [Hymenoptera: Aphelinidae]	Parasitic wasp	Yes (Hortnet, 2003b)	Yes (APPD, 2004)	No	**Yes**
Aphytis chilensis Howard [Hymenoptera: Aphelinidae]	Pine needle scale parasite	Yes (Valentine, 1967)	Yes (Waterhouse & Sands, 2001)	No	**Yes**
Aphytis chrysomphali (Mercet) [Hymenoptera: Aphelinidae]	Red scale parasite	Yes (Valentine, 1967)	Yes (APPD, 2004)	Yes (APPD, 2004)	No
Aphytis diaspidis (Howard) [Hymenoptera: Aphelinidae]	Parasitic aphelinid wasp.	Yes (Valentine, 1967)	Yes (Waterhouse & Sands, 2001)	No	**Yes**
Aphytis mytilaspidis (Le Baron). [Hymenoptera:	Aphelinid parasitic	Yes (HortNet 2005c)	No	No	**Yes**

13 *Nabis capsiformis* is not listed as present in New Zealand, reference to *Nabis capsiformis* in Valentine (1967) should be referred to *Nabis kingbergii* the species that has consistently been misidentified in both Australia and New Zealand (Woodward, 1982).

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
Aphelinidae]	wasp				
Apsicolpus hudsoni Turner [Hymenoptera: Braconidae]	Braconid parasitic wasp	Yes (Wang, & Shi, 1999)	No	No	**Yes**
Ascogaster quadridentata Wesmael [Hymenoptera: Braconidae]	Codling moth parasite	Yes (Valentine, 1967)	No	No	**Yes**
***Campoplex* sp.** [Hymenoptera: Ichneumonidae]	Ichneumonid parasitic wasp	Yes (Wang & Shi, 1999)	No	No	**Yes**
Coccophagus gurneyi Compere [Hymenoptera: Aphelinidae]	Obscure mealybug parasite	Yes (Valentine, 1967)	Yes (ABRS, 2005)	No	**Yes**
Coccophagus ochraceus (Howard) [Hymenoptera: Aphelinidae]	Aphelinid parasitic wasp	Yes (Valentine, 1967)	Yes (Waterhouse & Sands, 2001)	No	**Yes**
Coccophagus scutellaris (Dalman) [Hymenoptera: Aphelinidae]	Aphelinid parasitic wasp	Yes (Valentine, 1967)	Yes (Waterhouse & Sands, 2001)	Yes (ICDB, 2003)	No
***Diadegma* sp.** [Hymenoptera: Ichneumonidae]	Ichneumonid parasitic wasp	Yes (HortResearch, 1999)	No	No	**Yes**
Diplazon laetatorius (Fabricius) [Hymenoptera: Ichneumonidae]	Ichneumonid parasitic wasp	Yes (Valentine, 1967)	Yes (Waterhouse & Sands, 2001)	No	**Yes**
Echthromorpha intricatoria (Fabricius) [Hymenoptera: Ichneumonidae]	Cream spotted Ichneumonid	Yes (Valentine, 1967)	Yes (APPD, 2004)	Yes (APPD, 2004)	No
Encarsia citrina Craw [Hymenoptera: Aphelinidae]	Oystershell scale parasitoid	Yes (Blank *et al*., 1995)	Yes (Elder *et al.*, 1998)	No	**Yes**
Encarsia perniciosi (Tower) [Hymenoptera: Aphelinidae]	Red scale parasite	Yes (Hortnet, 2004b)	Yes (ABRS, 2005)	No	**Yes**
Epitetracnemus zetterstedtii (Westwood) [Hymenoptera: Encyrtidae]	Encyrtid parasitic wasp	Yes (Valentine, 1967)	No	No	**Yes**
***Eupsenella* sp.** [Hymenoptera: Bethylidae]	Bethylid parasitic wasp	Yes (Berry, 1998)	Yes (Naumann, 1993b)	No	**Yes**
***Eupteromalus* sp.** [Hymenoptera: Ptreromalidae]	Ptreromalid parasitic wasp	Yes (Valentine, 1967)	No	No	**Yes**
Euxanthellus philippiae Silvestri [Hymenoptera: Aphelinidae]	Aphelinid parasitic wasp	Yes (Valentine, 1967)	Yes (Waterhouse & Sands, 2001)	No	**Yes**

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
Glabridorsum stokesii (Cameron) [Hymenoptera: Ichneumonidae]	Ichneumonid parasitic wasp	Yes (Hortnet, 2004a)	Yes (Waterhouse & Sands, 2001)	No	**Yes**
***Goniozus* jacintae** Farrugia [Hymenoptera: Bethylidae]	Bethylid wasp	Yes (Berry, 1998)	Yes (Berry, 1998)	Possibly widespread in Australia, but no specific records for WA.	**Yes**
Liotryphon caudatus (Ratzeburg) [Hymenoptera: Ichneumonidae]	Ichneumonid parasitic wasp	Yes (Valentine, 1967)	No	No	**Yes**
Metaphycus claviger (Timberlake) [Hymenoptera: Encyrtidae]	Encyrtid parasitic wasp	Yes (Valentine, 1967)	No	No	**Yes**
Meteorus pulchricornis (Wesmael) [Hymenoptera: Braconidae]	Braconid parasitic wasp	Yes (Berry, 1997)	No	No	**Yes**
Platygaster demades (Walker) [Hymenoptera: Platygasteridae]	Platygasterid parasitic wasp	Yes (Tomkins *et al*.,, 2000b)	No	No	**Yes**
Signiphora merceti Malenotti [Hymenoptera: Signiphoridae]	Signiphorid parasitic wasp	Yes (Blank *et al*., 1995)	No	No	**Yes**
Sympiesis sp. [Hymenoptera: Eulophidae]	Eulophid parasitic wasp	Yes (Hortnet, 2003e)	Yes (ICBD, 2003)	Yes (ICDB, 2003)	No
Tetracnemoidea peregrina (Compère) [Hymenoptera: Encyrtidae]	Encyrtid parasitic wasp	Yes (Valentine, 1967; Hortnet 2005a)	Yes (Waterhouse and Sands 2001)	No	**Yes**
Tetracnemoidea sydneyensis [Hymenoptera: Encyrtidae]	Encyrtid parasitic wasp	Yes (Valentine, 1967)	No	No	**Yes**
Trichogramma funiculatum Carver [Hymenoptera: Trichogrammatoidea]	Trichogrammatoid parasitic wasp	Yes (Stevens, 2000)	Yes (Thomson *et al*., 2000)	No	**Yes**
Trichogrammatoidea bactrae Nagaraja [Hymenoptera: Trichogrammatoidea]	Trichogrammatoid parasitic wasp	Yes (Stevens, 2000)	Yes (Waterhouse & Sands, 2001)	No	**Yes**
Trissolcus basalis (Wilson) [Hymenoptera: Scelionidae]	Scelionid parasitic wasp	Yes (Valentine, 1967)	Yes (APPD, 2004)	Yes (APPD, 2004)	No
Xanthocryptus novozelandicus (Dalla Torre) [Hymenoptera: Ichneumonidae]	Ichneumonid parasitic wasp	Yes (Wang & Shi, 1999)	Yes (Townes *et al*., 1961)	No	**Yes**

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
Neuroptera					
Cryptoscenea australiensis (Enderlein) [Neuroptera: Coniopterygidae]	Lacewing	Yes (Charles, 1993)	Yes (New, 1996)	No	**Yes**
Thysanoptera (thrips)					
Haplothrips kurdjumovi Karny [Thysanoptera: Phlaeothripidae]	Predatory thrips	Yes (NZ MAF, 2003)	No	No	**Yes**
PATHOGENS					
BACTERIA					
Pseudomonas syringae* pv. *persicae Prunier *et al*.,	Bacterial decline	Yes (NZ MAF, 2003)	No	No	**Yes**
Pseudomonas syringae van Hall pv *syringae* van Hall	Bacterial canker, blast	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Pseudomonas viridiflava (Burkholder) Dowson		Yes (Pennycook, 1989)	Yes (Moffett, 1983)	Yes (APL, 2002)[14]	No
Rhizobium radiobacter (Beijerinck & van Delden) Young *et al*.	Crown gall	Yes (Pennycook, 1989)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Rhizobium rhizogenes (Riker et al.) Young et al.		Yes (ICMP, 2005)	Yes (APPD, 2005)	Yes (Shivas, 1989)	No
Xanthomonas arboricola pv. *pruni* (Smith) Vauterin *et al*.	Bacterial spot	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
FUNGI					
Alternaria alternata (Fr.: Fr.) Keissl.	Black mould, fruit rot, mould	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Amylostereum sacratum (G. H. Cunningham) Burdsall	Root rot	Yes (Pennycook, 1989)	No	No	**Yes**
Armillaria limonea (G. Stevenson) Boesewinkel	Root and crown rot	Yes (McLaren *et al*., 1999)	No	No	**Yes**
Armillaria novae-zelandiae (Stevenson) Herink	Root and crown rot	Yes (McLaren *et al*., 1999)	Yes (APPD, 2004)	No	**Yes**
Aspergillus niger Tiegh.		Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No

[14] This bacterium has been recorded in Western Australia on other hosts.

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
***Apiospora montagnei* Sacc.**		Yes (ICMP, 2005)	Yes (APPD, 2005)	No	**Yes**
Aureobasidium sp. Viala & Boyer		Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Botryosphaeria obtusa (Schwein.) Shoemaker		Yes (ICMP, 2005)	Yes (APPD, 2005)	Yes (WAC, 2005)	No
Botryosphaeria parva Pennycook & Samuels		Yes (ICMP, 2005)	Yes (APPD, 2005)	Yes (Burgess *et al.* 2005)	No
Botrytis cinerea Pers.: Fr. teleomorph *Botryotinia fuckeliana* (de Bary) Whetzel	Grey mould	Yes (NZ MAF, 2003)	Yes (APPD, 2005)	Yes (Shivas, 1989)	No
Botryosphaeria stevensii Shoemaker	Black rot, Diplodia canker	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Chondrostereum purpureum (Pers.: Fr.) Pouzar	Silver leaf	Yes (Pennycook, 1989)	Yes (APPD, 2004)	Yes (WA Herbarium, 2003)[15]	No
Cladosporium cladosporioides (Fresen.) GA. De Vries	Mould	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Cladosporium sp.	Mould	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Colletotrichum acutatum J.H. Simmonds	Anthracnose, bitter rot	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Collybia drucei (G. Stevenson) E. Horak	Wood decay & litter fungus	Yes (Pennycook, 1989)	No	No	**Yes**
Diaporthe eres Nitschke	Phomopsis rot	Yes (NZ MAF, 2003)	Yes (Shivas, 1989)	Yes (Shivas, 1989)	No
Diatrype stigma (Hoffmann: Fries) Fries	Wood rot	Yes (Pennycook, 1989)	No	No	**Yes**
Dipodascus geotrichum (Butler & Petersen) Arx	Sour rot	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Epicoccum nigrum Link.	Sooty mould	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (APPD, 2004)	No
Eutypa lata (Per.: Fr.) L.R. Tulasne & C. Tulasne	Eutypa canker	Yes (Pennycook, 1989)	Yes (Cooke & Dubé, 1989; Letham, 1995)	No	**Yes**
Fusarium culmorum (W.G. Sm.) Sacc.		Yes (ICMP, 2005)	Yes (APPD, 2005)	Yes (WAC, 2005)	No
Fusarium oxysporum Schltdl.		Yes (ICMP, 2005)	Yes (APPD, 2005)	Yes (WAC, 2005)	No
Fusarium poae (Peck) Wollenweber	Fusarium rot	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	No	**Yes**

15 Present in Western Australia but not recorded on *Prunus* species.

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
Ganoderma applanatum (Pers.) Patouillard	Trunk rot	Yes (Pennycook, 1989)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Ganoderma australe (Fr.: Fr.) Pat.	Trunk rot	Yes (Pennycook, 1989)	Yes (APPD, 2004)	Yes (APPD, 2004)	No
Gibberella avenacea R.J. Cook		Yes (ICMP, 2005)	Yes (APPD, 2005)	Yes (WAC, 2005)	No
Gibberella baccata (Wallr.) Sacc. anamorph *Fusarium lateritium* Nees: Fr.	Fruit rot, Fusarium rot	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Gibberella cyanogena **(Desmaz.) Sacc.**	Seedling blight	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	No	**Yes**
Gibberella intricans Wollenweber anamorph *Fusarium equiseti* (Corda) Sacc.	Fusarium rot	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Gibberella tricincta El-ghall *et al*.	Fusarium rot	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	No	**Yes**
Glomerella cingulata (Stoneman) Spauld. & H. Schrenk	Anthracnose	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (APPD, 2004)	No
Microsphaeropsis olivacea (Bonord.) Hohn.		Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Monilinia fructicola (G. Winter) Honey	Brown rot	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (AGWEST, 2000)	No
Monilinia laxa (Aderh. & Ruhland) Honey	Brown rot	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (AGWEST, 2000)	No
Mucor sp.	Mould, Mucor rot	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (APPD, 2004)[16]	No
Mycosphaerella tassiana (De Not.) Johans.	Cladosporium rot	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Nectria cinnabarina (Tode: FR.) Fr.	Coral spot	Yes (Pennycook, 1989)	Yes (APPD, 2004)	No	**Yes**
Nectria haematococca Berk. & Broome anamorph *Fusarium solani* (Mart.) Sacc.	Fusarium rot	Yes (NZ MAF, 2003)	Yers (APPD, 2004)	Yes (Shivas, 1989)	No
Nectria ochroleuca (Schweinitz) Berkeley	Die-back	Yes (Pennycook, 1989)	Yes (APPD, 2004)	No	**Yes**
Neofabraea malicorticis H.S. Jackson	Gleoesporium rot	Yes (NZ MAF, 2003)	No	No	**Yes**
Penicillium expansum Link	Blue mould	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Penicillium italicum Wehmer	Blue mould	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No

16 Few species of this genus have been recorded in Western Australia (Shivas, 1989; APPD, 2003). *Mucor* species are wide spread and cause storage rots (Ogawa *et al*., 1995).

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
Penicillium vulpinum (Cooke & Massee) Seifert & Samson		Yes (ICMP, 2005)	No	No	**Yes**
Penicillium sp.	Blue mould, mould	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Phellinus robustus (P. Karsten) Bourdot & Galzin	White wood rot	Yes (Cunningham, 1965)	Yes (APPD, 2004)	No	**Yes**
Phoma macrostoma var. *incolorata* (Horne) Boerema & Dorenbosch	Phoma rot	Yes (NZ MAF, 2003)	Yes (Washington & Nancarrow, 1983)	Yes (Shivas, 1989)[17]	No
Phoma pomorum Thuem.	Phoma fruit spot	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Phomopsis amygdali (Delacr.) Tuset & Portilla	Fusicoccum canker	Yes (NZ MAF, 2003)	No	No	**Yes**
Phytophthora cinnamomi Rand	Stem rot	Yes (Pennycook, 1989)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Phytophthora citricola Sawada	*Phytophthora* fruit rot	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Phytophthora cryptogea Pethybridge & Lafferty	Root rot	Yes (Pennycook, 1989)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Phytophthora syringae (Klebahn) Klebahn	Crown rot and root rot	Yes (Pennycook, 1989)	Yes (APPD, 2004)	No	**Yes**
Podosphaera tridactyla (Wallr.) de Bary	Powdery mildew	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	No	**Yes**
Pycnoporus coccineus (Fr.) Bondartsev & Singer	Wood rot	Yes (Pennycook, 1989)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Rhizopus stolonifer (Ehrenb.) Fr.) Vuill.	Mould, Rhizopus rot	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Rosellinia necatrix Prill	Rosellinia root rot	Yes (Pennycook, 1989)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Schizophyllum commune Fr.: Fr	Wood rot	Yes (Pennycook, 1989)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Sclerotinia sclerotiorum (Lib.) De Bary	Sclerotinia rot	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Sphaerotheca pannosa (Wallr.: Fr.) Lev	Powdery mildew	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No

[17] *Phoma macrostoma* has been reported from Western Australia (Shivas, 1989).

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
Stigmina carpophila (Lev.) M.B. Ellis	Shot-hole	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Taphrina deformans (Berk.) Tul.	Leaf curl	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Taphrina pruni Tulasne	Bladder plum or pocket plum	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	No	**Yes**
Thanatephorus cucumeris (A.B. Frank) Donk	Root rot	Yes (Pennycook, 1989)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Trametes hirsuta (Wulfen: Fr.) Quel.	Wood rot	Yes (Cunningham, 1965)	Yes (APPD, 2004)	No	**Yes**
Trametes versicolor (L: Fr.) Pilat	Wood rot	Yes (Pennycook, 1989)	Yes (APPD, 2004)	Yes (APPD, 2004)	No
Trametes zonata Wettst.	Wood rot	Yes (Cunningham, 1965)	Yes (APPD, 2004)	No	**Yes**
Tranzschelia pruni-spinosae var discolor (Fuckel) Dunegan	Rust	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Trichothecium roseum (Pers.: Fr.) Link	Mould, pink rot	Yes (NZ MAF, 2003)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
Truncatella laurocerasi (Westend.) Steyaert		Yes (ICMP, 2005)	No	No	**Yes**
Valsa cincta Curr.	Leucostoma canker	Yes (Pennycook, 1989)	Yes (APPD, 2004)	No	**Yes**
Valsa leucostoma (Persoon) Fries	Leucostoma canker	Yes (McLaren *et al*., 1999)	Yes (APPD, 2004)	No	**Yes**
Venturia carpophilia E.E. Fisher anamorph *Cladosporium carpophilum* Thuem.	Scab	Yes (NZ MAF, 2003)	Yes (Cook & Dubé, 1989)	Yes (Shivas, 1989)	No
Verticillium dahliae Klebahn	Verticillium wilt	Yes (Pennycook, 1989)	Yes (APPD, 2004)	Yes (Shivas, 1989)	No
NEMATODES					
Pratylenchus penetrans (Cobb) Filipjev & Schuurmans Stekhoven	Root lesion nematode	Yes (McLaren *et al*., 1999)	Yes (McLeod *et al*., 1994)	Yes (McLeod *et al*., 1994)	No
Xiphinema diversicaudatum Filipjev & Schuurmans Stekhoven	Dagger nematode	Yes (McLaren *et al*., 1999)	Yes (McLeod *et al*., 1994)	No	**Yes**

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
VIRUSES/VIRUS-LIKE DISORDERS					
Apple chlorotic leaf spot *trichovirus*		Yes (Pennycook, 1989)	Yes (Büchen-Osmond *et al*., 2002)	Yes (McLean & Price, 1984)	No
Apricot chlorotic leaf mottle		Yes (McLaren *et al*., 1999)	No	No	**Yes**
Apricot Moorpark mottle		Yes (Pennycook, 1989)	No	No	**Yes**
Apricot stone pitting		Yes (Pennycook, 1989)	No	No	**Yes**
Cherry necrotic rusty mottle		Yes (Diekmann & Putter, 1996)	No	No	**Yes**
Peach calico		Yes (McLaren *et al*., 1999)	No	No	**Yes**
Peach chlorotic spot		Yes (McLaren *et al*., 1999)	No	No	**Yes**
Peach seedling chlorosis		Yes (Pennycook, 1989)	No	No	**Yes**
Peach yellow mottle		Yes (McLaren *et al*., 1999)	No	No	**Yes**
Plum line pattern *ilarvirus*		Yes (McLaren *et al*., 1999)	Uncertain - Büchen-Osmond *et al*., 2002	No	**Yes**
Plum mottle leaf		Yes (McLaren *et al*., 1999)	No	No	**Yes**
Prune dwarf *ilarvirus*		Yes (Pennycook, 1989)	Yes (Büchen-Osmond *et al*., 2002)	Yes (McLean & Price, 1984)	No
Prunus necrotic ringspot *ilarvirus*		Yes (NZ MAF, 2003)	Yes (Cook & Dubé, 1989)	Yes (McLean & Price, 1984)	No
Sour cherry green ring mottle virus		Yes (McLaren *et al*., 1999)	No	No	**Yes**
Strawberry latent ringspot *nepovirus*		Yes (Fry & Wood,	Yes (Brunt *et al*.,	No	**Yes**

Pest	Common name	Presence in			Consider further (yes/no)
		NZ	Australia	WA	
		1973)	1996)		

Appendix – 1b: Pest Categorisation for Stone Fruit from New Zealand – Pathway Association

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
ARTHROPODS				
Acari (mites)				
Diptactus gigantorhynchus (Nalepa) [Acari: Eriophyidae]	Big beak plum mite	No	Primarily feeds on leaves. Heavily infested leaves take on a silvery or bronze appearance, depending on the species. Severe infestations can interfere with photosynthesis.	No
Orthotydeus californicus (Banks) [Acari: Tydeidae]	Tydeid mite	Yes	Tydeid mites are commonly found on leaves rather than fruit (McLaren *et al*., 1999). *O. californicus* has been intercepted on New Zealand stone fruit (PDI, 2003).	**Yes**
Orthotydeus caudatus (Dugès) [Acari: Tydeidae]	Tydeid mite	Yes	Tydeid mites are commonly found on leaves rather than fruit (McLaren *et al*., 1999). Several consignments of apricots from New Zealand, under pre-clearance program implemented by AQIS, have been rejected due to the presence of these mites (Jones & Waddell, 1996).	**Yes**
***Orthotydeus* sp.** [Acarina: Tydeidae]	Tydeid mite	Yes	Other species of this genus has been reported on leaves and fruits (Jones & Waddell, 1996).	**Yes**
Phyllocoptes abaenus Keifer [Acari: Eriophyidae]	Plum leaf vagrant	No	Resides on abaxial leaf surface (Manson, 1984).	No
Suskia mansoni [Acari: Tarsonemidae]	Tarsonemid mite	No	Native, adults found on shuck of fruit. Feeding of mite on leaves cause distortion (NZ MAF, 2003).	No
Tarsonemus bakeri Ewing [Acari: Tarsonemidae]	Tarsonemid mite	Yes	Adults of tarsonemid mite are mainly found on insects, plants and litter. Adult larvae are parasitic, parasitoids, predaceous and phytophagous (Smith *et al*., 2003).	**Yes**
Tarsonemus parawaitei Kim *et al*. [Acari: Tarsonemidae]	Tarsonemid mite	Yes	This tarsonemid mite occurs on the older flower parts and the stem of apricot, peaches and nectarine fruits (McLaren *et al*., 1999).	**Yes**
Tarsonemus smithi Ewing [Acari: Tarsonemidae]	Tarsonemid mite	Yes	This tarsonemid mite has been intercepted in Australia on apricots from New Zealand (PDI, 2003).	**Yes**
Tarsonemus waitei Banks [Acari: Tarsonemidae]	Tarsonemid mite	Yes	This tarsonemid mite occurs on the older flower parts and the stem of apricot, peaches and nectarine fruits (McLaren *et al*., 1999).	**Yes**

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Coleoptera (beetle, weevils)				
Araecerus palmaris (Pascoe) [Coleoptera: Anthribidae]	Dried apple beetle	No	Larvae normally feed on overripe to rotten fruit (Kuschel, 1972)	No
Aridius bifasciatus (Reitter) [Coleoptera: Lathridiinae]	Fungus beetle	No	A mould beetle found in leaf litter, compost, grass tussocks etc. Adult stage secondary scavenger on decaying plant material.	No
Aridius nodifer (Westwood) [Coleoptera: Lathridiinae]	Fungus beetle	No	A mould beetle found in leaf litter, compost, grass tussocks etc. Secondary feeder on decaying plant material.	No
Atheta sp. [Coleoptera: Staphylinidae]	Rove beetle	No	Non-plant pest. *Atheta* spp. are voracious and efficient predators of some of the most troublesome soil insects such as fungus gnats, shore flies as well as the very damaging western flower thrips. As predators, these beetles are attracted to decomposing plant material and algae where their prey is likely to be found. Not associated with mature harvested fruit.	No
Conoderus exsul Sharp [Coleoptera: Elateridae]	Pasture wireworm	No	Interception data from 1988 to 2000 indicates that this insect has been intercepted once in Australia on apricots from New Zealand (PDI, 2003). Since then it has not been intercepted. Therefore, it is unlikely that this pest will be associated with export stone fruit.	No
Corticaria hirtalis Broun [Coleoptera: Lathridiidae]	Fungus beetle	No	Endemic, secondary pest on decaying plant material. Adults feed on moulds within the canopy (Matthews, 1992).	No
Costelytra zealandica (White) [Coleoptera: Scarabaeidae]	Grass grub	No	A pest of pastures mainly feeding on roots (Atkinson & Slay, 1994). Larvae feed on roots. Grass grub adults feed on new foliage of young trees and feeding produces large holes in leaves, giving a tattered appearance. All life-stages are subterranean, but the adults fly actively at times. No records of interceptions of this species on stone fruits from New Zealand (PDI, 2003).	No
Epilachna doryca (Boisduval) [Coleoptera: Coccinellidae]	Ladybird	Yes	Adults have been intercepted in Australia on nectarines and peaches from New Zealand (PDI, 2003).	**Yes**
Epurea takhtajani Medvedev & Ter-Minasyan [Coleoptera: Nitidulidae]	Yellow sap beetle	Yes	Adult beetles found on fruit (NZ MAF, 2003).	**Yes**

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Eucolaspis brunnea (Fabricius) [Coleoptera: Chrysomelidae]	Bronze beetle	Yes	Adults feed on fruit and foliage; larvae are soil dwelling (McLaren *et al*., 1999).	**Yes**
Irenimus parilis (Pascoe) [Coleoptera: Curculionidae]	Broad nosed weevil	No	This pest is indigenous to extensive dryland and high country areas of New Zealand and damage seedlings of legumes introduced as part of agricultural development (Evans *et al*., 1994).	No
Leptopius squalidus [Coleoptera: Cerambycidae]	Fruit tree root weevil	No	Larvae of this pest feed on roots and adults feed on leaves (Hely *et al*., 1982).	No
Naupactus leucoloma (Boheman) [Coleoptera: Curculionidae]	Whitefringed weevil	No	The adults of this polyphagous pest feed on leaf margins but are unable to fly and disperse by walking. The eggs are laid in chambers in the soil, or in ground litter and on the lower stems and leaves of plants. Both the larval and pupal stages occur in the soil. Adults or eggs are not associated with tree fruit. (EPPO, 2005)	No
Navomorpha sulcatus Fabricius [Coleoptera: Cerambycidae]	Cerambycid beetle	No	Larvae of this pest bore into the wood (Duffy, 1963).	No
Oemona hirta (Fabricius) [Coleoptera: Cerambycidae]	Lemon tree borer	No	Larvae of this pest bore into the wood of branches and stems of living trees and vines (Wang *et al*., 2002).	No
Otiorhynchus ovatus (Linnaeus) [Coleoptera: Curculionidae]	Strawberry root weevil	No	Larvae of other species of this genus live in soil and adults are foliage feeders (Scott, 1984).	No
Otiorhynchus sulcatus (Fabricius) [Coleoptera: Curculionidae]	Black vine weevil	No	Larvae live in soil and adults are foliage feeders (Scott, 1984).	No
Paraphloeostiba gayndahensis MacLeay (Coleoptera: Staphylinidae)	Rove beetle	No	Primarily associated with fermenting plant matter of various kinds and inflorescences of Araceae and as a pollinator of cherimoya. It breeds abundantly in rotting, fallen fruits of various trees (Thayer, 2001).	No
Stethorus bifidus Kapur [Coleoptera: Coccinellidae]	Apple mite ladybird	No	*Stethorus bifidus* is an endemic predatory coccinellid beetle found throughout New Zealand (Houston 1990). It often attacks populations of *Tetranychus lintearius* (Hill *et al*. 1991).	No
Zorion minutum Fabricius [Coleoptera: Cerambycidae]	Flower longhorn	No	Adults can be present on flowers.	No

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Collembola (springtails)				
Ceratophysella denticulata (Bagnall) [Collembola: Hypogastruridae]	Mushroom springtail	No	This is a widespread species, mainly found in soil, coniferous leaf litter and fungal fruiting bodies.	No
Diptera (flies)				
Melangyna novaezealandiae Macquart [Diptera: Syrphidae]	Large hoverfly	No	A predator fly (Bejakovich *et al*., 1998), endemic, larval stage predator of aphids (Scott, 1984).	No
Hemiptera (aphids, leafhoppers, mealybugs, psyllids, scales, true bugs, whiteflies)				
Aulacorthum circumflexum (Buckton) [Hemiptera: Aphididae]	Lily aphid	No	Aphids feed by sucking sap from their hosts. This often causes the plants to become deformed, the leaves become curled and shrivelled and in some cases, galls are formed on the leaves (Mau & Martin-Kessing, 1992).	No
Calocoris norvegicus (Gmelin) [Hemiptera: Miridae]	Potato bug	No	Damage restricted to new growth particularly that of young trees (McLaren *et al*., 1999).	No
Diaspidiotus ostreaeformis (Curtis) Borchsenius [Hemiptera: Diaspididae]	Oystershell scale	Yes	Adults infest branches and twigs not fruit (Scott, 1984). However, Penman (1984) reported that emerging crawlers establishing on it could contaminate fruit. There are reports that oystershell scale can settle on stone fruit (McLaren, 1992).	**Yes**
Diomocoris maoricus (Walker) [Hemiptera: Miridae]	Native mirid	No	Reported in Eyles (1999) to cause cat-facing damage to stone fruit, however these records are from the 1950's and 1960's. There are no recent records for this species on stone fruit. Mirid damage is reported to occur on young trees and very occasionally immature fruit. Not associated with mature stone fruit.	No
Myzus ornatus Laing [Hemiptera: Aphididae]	Ornate aphid	No	Not generally present in large number in field crops (Blackman and Eastop, 1984). Primarily foliage pest (Millar & Stoetzel, 1997).	No
Nysius huttoni White [Hemiptera: Lygaeidae]	Wheat bug	No	*Nysius huttoni* is endemic to New Zealand and is a pest of wheat and brassica crops (He *et al*., 2002).	No
Parlatoria pergandii Comstock [Hemiptera: Diaspididae]	Chaff scale	No	Predominantly a pest of citrus. Worldwide literature indicates that chaff scale is not a common pest of *Prunus* species.	No

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Parthenolecanium corni (Bouché) [Hemiptera: Coccidae]	European fruit scale	No	This soft scale 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 (Hodgson & Henderson, 2000).	No
Pseudococcus calceolariae (Maskell) [Hemiptera: Pseudococcidae]	Citrophilus mealybug	Yes	Can be found at stem end of fruit (McLaren *et al*., 1999).	**Yes**
Pulvinaria vitis (Linnaeus) [Hemiptera: Coccidae]	Cottony vine scale	No	Lifecycle completed on twigs and leaves (Hodgson & Henderson, 2000)	No
Rhypodes sp. [Hemiptera: Lygaeidae]	Seed bug	No	The bugs feed on the developing seeds and early flowers of different species.	No
Scolypopa australis (Walker) [Hemiptera: Ricaniidae]	Passionvine hopper	No	Adults and nymphs of this pest feed on leaves (Hely *et al*., 1982).	No
Hymenoptera (ants, wasps)				
Monomorium antarcticum (F. Smith) [Hymenoptera: Formicidae]	Southern Ant	No	Colonies of this ant are commonly constructed under the cover of stones, boards, and other objects or at the base of plants.	No
Vespula germanica Fabricius [Hymenoptera: Vespidae]	European wasp	No	The European wasp is a general predator that feeds on a variety of insects. Adult wasps are reported to feed on damaged and fermented fruit late in the stone fruit season. Such fruit would be rejected during harvest and grading.	No
Lepidoptera (leafrollers, moths, butterflies)				
Aenetus virescens (Doubleday [Lepidoptera: Hepialidae]	Puriri moth	No	Larvae of this pest are wood-borers (Alma, 1977).	No
Cnephasia jactatana (Walker) [Lepidoptera: Tortricidae]	Black-lyre leafroller	Yes	The larvae of the black lyre leafroller feed on the leaves but could also attack the surface of the fruit (Wearing *et al*., 1991).	**Yes**
Coscinoptycha improbana Meyrick [Lepidoptera: Carposinidae]	Guava moth	Yes	The larvae of guava moth bore into fruit. In fruit such as loquat, macadamia and peach, larvae are found feeding inside the kernel (Froud & Dentener, 2002)	**Yes**
Ctenopseustis herana (Felder & Rogenhofer) [Lepidoptera:	Brown headed leafroller	Yes	Fruit and foliage are attacked (Dugdale, 1990).	**Yes**

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Tortricidae]				
Ctenopseustis obliquana (Walker) [Lepidoptera: Tortricidae]	Brown headed leafroller	Yes	Larvae feed mainly on leaves but may also feed on shoots, buds, stems and externally or internally on fruit (Green, 1979).	**Yes**
Cydia pomonella (Linnaeus) [Lepidoptera: Tortricidae]	Codling moth	Yes	Codling moth larvae damage prunes by boring into fruit (Hely *et al*., 1982).	**Yes**
Eutorna phaulocosma Meyrick [Lepidoptera: Depressariidae]	Blackberry bud moth	No	Occasionally observed in stone fruit orchards (McLaren *et al*., 1999). This publication does not specify the part of plant affected. There is no record of this pest on fruit in the New Zealand Plant Pest Information Network database (NZ MAF 2004).	No
Graphania mutans (Walker) [Lepidoptera: Noctuidae]	Noctuid moth	Yes	This species is a major noctuid pest of apple orchards in New Zealand. Eggs are laid in batches on foliage or sometimes on fruit and larvae feed on fruit. Eggs of this species have been intercepted during pre-export inspections resulting in rejections of the consignment (Burnip *et al*., 1995).	**Yes**
Grapholita molesta (Busck) [Lepidoptera: Tortricidae]	Oriental fruit moth	Yes	Damages both twigs and fruit (Hely *et al*., 1982).	**Yes**
Harmologa amplexana (Zeller) [Lepidoptera: Tortricidae]	Native leafroller	Yes	Observed on stone fruit (NZ MAF, 2003).	**Yes**
Harmologa oblongana (Walker) [Lepidoptera: Tortricidae]	Native leafroller	No	Not present in sprayed orchards (McLaren *et al.*,1999).	No
Heterocrossa adreptella Walker [Lepidoptera: Carposinidae]		No	McLaren *et al.* (1999) referred to *Carposina adreptella* being occasionally observed in stone fruit orchards. This may be reference to this species or *H. rubophaga*. There is no record of this pest on fruit in the New Zealand Plant Pest Information Network database (NZ MAF 2004).	No
Heterocrossa rubophaga Dugdale [Lepidoptera: Carposinidae]	Raspberry bud moth	No	Larvae bore into terminal buds and canes of *Rubus* spp. (Scott, 1984).	No
Phyllonorycter messaniella (Zeller) [Lepidoptera: Gracillariidae]	Native leafminer	No	Larvae mine in leaves (Common, 1990).	No
Planotortrix excessana Walker	Green headed	Yes	Larvae feed mainly on leaves but may also feed on shoots, buds,	**Yes**

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
[Lepidoptera: Tortricidae]	leafroller		and stems and internally on fruit (Thomas, 1998). Eggs are laid in flat batches on leaves of stone fruit. All larval stages are completed on leaves or fruits. Pupae are rare on fruit (McLaren *et al*., 1999).	
Planotortrix flavescens Butler [Lepidoptera: Tortricidae]	New Zealand native leafroller	Yes	Incidental in stone and pome fruit orchards (Wearing *et al*., 1991).	**Yes**
Planotortrix notophaea (Turner) [Lepidoptera: Tortricidae]	Black headed leafroller	No	Occasionally observed in stone fruit orchards (McLaren *et al*., 1999). This publication does not specify the part of plant affected. There is no record of this pest on fruit in the New Zealand Plant Pest Information Network database (NZ MAF 2004).	No
Planotortrix octo Dugdale [Lepidoptera: Tortricidae]	Green headed leafroller	Yes	The larvae cause damage by feeding on leaves or fruit. Feeding on immature fruit may result in a gumming response or predispose fruit to fungal infection (McLaren *et al*., 1999). Eggs are laid in flat batches on leaves of stone fruit. All larval stages are completed on leaves or fruits. Pupae are rare on fruit (McLaren *et al*., 1999).	**Yes**
Pyrgotis plagiatana (Walker) [Lepidoptera: Tortricidae]	Native leafroller	Yes	Occasionally observed in unsprayed stone fruit orchards (McLaren *et al*., 1999).	**Yes**
Teia anartoides Walker [Lepidoptera: Lymantriidae]	Painted apple moth	No	Larvae of this pest are leaf feeders although green fruit can be grazed (Hely *et al*., 1982).	No
Orthoptera (crickets, grasshoppers, katydids)				
Hemideina thoracica (White) [Orthoptera: Stenopelmatidae]	Auckland tree weta	No	A nocturnal insect, emerging from holes in trees to feed on both plant and animal material. They can be found under bark on rotting logs and under the loose bark of gum trees (Parker, 2000).	No
Thysanoptera (thrips)				
Aeolothrips fasciatus (Linnaeus) [Thysanoptera: Aeolothripidae]	Banded thrips	No	Feed incidentally on the foliage of pipfruit and stone fruit.	No
Frankliniella occidentalis (Pergande) [Thysanoptera: Thripidae])	Western flower thrips (WFT)	Yes	WFT is primarily a flower feeder that eats both the flower petals and pollen. They also feed on foliage of certain hosts and produce a characteristic silvery appearance of thrips damage. Fruit scarring occurs on cucumber (Rosenheim *et al*., 1990) and table grapes (Lewis, 1997). WFT has been occasionally found associated with	**Yes**

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
			citrus fruit (Grafton- Cardwell *et al*. 2005) and also intercepted on stone fruit from New Zealand into Australia (PDI, 2003).	
Haplothrips niger (Osbom) [Thysanoptera: Phlaeothripidae]	Red clover thrips	No	Usually found in flowers (McLaren, 1992).	No
Linzothrips cerealiuni [[Thysanoptera: Thripidae]		No	Usually associated with flowers (McLaren, 1992).	No
Tenothrips frici (Uzel) [[Thysanoptera: Thripidae]	Dandelion thrips	No	Usually associated with flowers (McLaren, 1992).	No
Thrips obscuratus (J.C. Crawford) [Thysanoptera: Thripidae]	New Zealand flower thrips	Yes	Adults of this pest feed on flowers, small fruit of nectarines causing damage to the fruit and are also attracted to ripening stone fruit causing quarantine problems for export fruit (McLaren 1992).	**Yes**
BIOLOGICAL CONTROL AGENTS				
Acari (mites)				
Agistemus longisetus González-Rodríguez [Acari: Stigmaeidae]	Stigmaeid mite	Yes	This predatory mite feeds on European red mite, tydeid mites, *Bryobia* species and two spotted spider mites (Hortnet, 2003a). European red mites lay winter eggs on late-maturing stone fruit varieties. It therefore follows that this predatory mite can prey on egg laying females of European red mite on the fruit and is therefore associated with the fruit pathway.	**Yes**
Amblyseius waltersi Schicha [Acari: Phytoseiidae]	Phytoseiid mite	Yes	Predatory on grape leaf rust mite (CABI, 2004). Has been intercepted on nectarine in Australia from New Zealand (PDI, 2003).	**Yes**
Asca aphidioides Linnaeus [Acari: Mesostigmabnta]	Mesostigmatid mite	No	Predatory on nematodes and other insects.	No
Eryngiopus bifidus Wood [Acari: Stigmaeidae]	Stigmaeid mite	Yes	Endemic predator adult can be found on fruit (NZ MAF, 2003).	**Yes**
***Eugamasus* sp.** [Acari: Parasitidae]	Parasitid mite	Yes	Secondary scavenger, orchard contaminant on fruit (NZ MAF, 2003).	**Yes**
Hemisarcoptes coccophagus Meyer [Acari: Hemisarcoptidae]	Hemisarcoptid mite	No	Hemisarcoptid mites are predators of armoured scale insects (Diaspididae) (Charles *et al.*, 1995). The hosts of this mite include	No

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
			San Jose scale, oystershell scale, greedy scale, lantana scale and oleander scale, which were considered in this assessment. The host scales are primarily found on branches, and only rarely on fruit if population densities are high. Scales are a pest managed in New Zealand and maintained at low populations.	
Neoseiulus caudiglans Schuster [Acari: Phytoseiidae]	Phytoseiid mite	Yes	Predator of two-spotted spider mite. It occurs commonly in a range of unsprayed crops. In New Zealand, adults have been found on fruit during a NZ MAF stone fruit crop survey in 1997-98 (NZ MAF, 2003).	**Yes**
Neoseiulus fallacis (Garman) [Acari: Phytoseiidae]	Phytoseiid mite	No	Predator of spider mites (Bounfour & Tanigoshi, 2002). Densities of this mite increase with increase in spider mite densities. It therefore follows that this predatory mite can prey on spider mites on the fruit and is therefore associated with the fruit pathway.	**Yes**
Parasitus fimetorum (Berlese) [Acari: Parasitidae]	Parasitid mite	No	Parasitid mites are essentially predatory and feed upon other microarthropods, including their eggs, and on nematodes. They live in moss, forest litter, soil, dung, rotting seaweed, decaying organic substances, caves, and nests of small mammals and insects (Hyatt, 1980).	No
Pergamasus sp. [Acari: Parasitidae]	Parasitid mite	No	Parasitid mites are essentially predatory and feed upon other microarthropods, including their eggs, and on nematodes. They live in moss, forest litter, soil, dung, rotting seaweed, decaying organic substances, caves, and nests of small mammals and insects (Hyatt, 1980).	No
Typhlodromus pyri Scheuten [Acari: Phytoseiidae]	Phytoseiid mite	Yes	This predatory mite is the most important predator in integrated mite control for European red mite. It preys on the active stages (but not the eggs), and feeds similarly on a number of other mites, such as two-spotted spider mite, *Bryobia* spp. And various rust mites. It also consumes pollen, fungal tissue, and honeydew (Breth *et al*., 1998). European red mites lay winter eggs on late-maturing stone fruit varieties. It therefore follows that this predatory mite can prey on egg laying females of European red mite on the fruit therefore be associated with fruit pathway (McLaren *et al*., 1999).	**Yes**

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Coleoptera (beetles, weevils)				
Mecodema occiputale Brown [Coleoptera: Carabidae]		No	Carabids are predatory "ground beetles" that typically live on the surface of, or in the soil, sometimes burrowing deeply. A few species are associated with trees where they are found amongst loose bark or in rotten branches. Most carabids are nocturnal feeders (Larochelle and Lariviere, 2001). Ground beetles are not reported to be found on fruit.	No
Diptera (flies)				
Cryptochetum iceryae (Williston) [Diptera: Cryptochetidae]	Parasitoid fly	No	Biological control agent of *Icerya purchasi* (Waterhouse & Sands, 2001). This fly was introduced from Australia into New Zealand. Eggs are laid in the mature larvae and pupae of the cottony cushion scale.	No
Pales feredayi (Hutton) [Diptera: Tachinidae]	Tachinid fly	No	A parasitic fly of tortricid, noctuids and other species. Parasitoid of leafroller larvae (Hortnet, 2003h). Eggs of this fly are laid on the edges of leaves and subsequently ingested by leafrollers (Berry, 1990). Parasitism causes losses of less than 5% of leafrollers and typically less than 0.5% of light brown apple moth (Hortnet 2003i). Considering the low parasitism rates and likelihood that only leafrollers associated with leaves will ingest the eggs, it is unlikely that this parasitoid would be associated with fruit.	No
Pales funesta (Hutton) [Diptera: Tachinidae]	Tachinid fly	No	A parasitic fly of tortricid, noctuids and other species. Parasitoid of leafroller larvae (Hortnet, 2003h). Eggs of this fly are laid on the edges of leaves and subsequently ingested by leafrollers (Berry, 1990). Parasitism causes losses of less than 5% of leafrollers and typically less than 0.5% of light brown apple moth (Hortnet 2003i). Considering the low parasitism rates and likelihood that only leafrollers associated with leaves will ingest the eggs, it is unlikely that this parasitoid would be associated with fruit.	No
Syrphus ortas [Diptera: Syrphidae]	Hover fly	No	Adults are pollen feeders and are not associated with fruit. Of the hosts of *Syrphus* spp. listed by Valentine (1967), only light brown apple moth is recorded on stone fruit. Syrphid eggs are laid	No

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
			amongst aphid colonies on leaves and stems where the external feeding larvae will develop.	
Syrphus ropalus Walker [Diptera: Syrphidae]	Hover fly	No	Adults are pollen feeders and are not associated with fruit. Of the hosts of *Syrphus* spp. listed by Valentine (1967), only light brown apple moth is recorded on stone fruit. Syrphid eggs are laid amongst aphid colonies on leaves and stems where the external feeding larvae will develop.	No
Uclesiella irregularis Malloch [Diptera: Tachinidae]	Tachinid fly	No	Valentine (1967) listed light brown apple moth as a host species of this tachinid fly. However, there is no record of this fly as a biological control agent of light brown apple moth in HortResearch (1999), suggesting this species is either no longer found or is unimportant in stone fruit in New Zealand.	No
Hemiptera (aphids, leafhoppers, mealybugs, psyllids, scales, true bugs, whiteflies)				
Cardiastethus consors White [Hemiptera: Anthocoridae]	Anthocorid bug	No	This species has been reported to feed on two-spotted spider mite and is probably predator of psocids. It is unlikely that this predatory bug will be on the pathway because it is only encountered occasionally in stone fruit orchards.	No
Cardiastethus poweri White [Hemiptera: Anthocoridae]	Anthocorid bug	No	A predatory bug related to pirate bug (*Orius vicinus*) that is reported to feed on two-spotted spider mite (HortResearch, 1999). It is unlikely that this predatory bug will be on the pathway because it is encountered occasionally in pipfruit or stone fruit orchards.	No
Orius vicinus Ribaut [Hemiptera: Anthocoridae]	Orius bug	No	*Orius vicinus* is a general predator, which feeds on a number of orchard mites and insect pests including European red mite and New Zealand flower thrips (Wearing & Attfield, 2002). It overwinters as mated adult females, and these bugs are found in spring feeding on pollen and thrips in a variety of flowering trees, including stone fruit and pipfruit (Lariviere & Wearing, 1994). Orius bugs lay eggs in the floral peduncles or leaf veins of host plants (Lariviere & Wearing, 1994). These mobile predators are unlikely to be associated with fruit after picking, grading and packaging.	No
Ploiaria antipoda (Bergroth) [Hemiptera: Reduviidae]	Fragile assassin bug	No	Adults are mostly generalist predators in gardens and fields.	No

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Hymenoptera (ants; wasps)				
Adelius sp. [Hymenoptera: Braconidae]	Braconid parasitic wasp	No	Valentine (1967) listed the Brownheaded leafroller *Ctenopseustis obliquana* as host species of this parasitic wasp. However, there is no recent record of this species in HortResearch (1999). It is therefore unlikely that the wasp will be on the pathway.	No
Aphelinus abdominalis (Dalman) [Hymenoptera: Aphelinidae]	Parasitic wasp	No	*A. abdominalis* is reported to attack 11 species of aphids and one mirid (CABI, 2005) of which only *Myzus oratus* and *Aulacorthum circumflexum* are on the pest list for stone fruit from New Zealand. Oviposition in *M. oratus* is only recorded under laboratory conditions and not field conditions (Wahab, 1985). *A. circumflexum* is considered to be polyphagous, but is primarily a glasshouse pest and stone fruit is not amongst its recorded hosts and it not reported to affect the fruit (Helms *et al.,* 1984; CABI, 2005; Mau and Martin-Kessing, 2005).	No
Aphytis chilensis Howard [Hymenoptera: Aphelinidae]	Pine needle scale parasite	No	*Aphytis chilensis* is an ectoparasitoid of armoured scale insects (Hortnet, 2003c). The 2nd stage nymphs, young females and scale prepupae are attacked, but the ovipositing females are the preferred stage for parasitization (Alexandrakis & Neuenschwander, 1980). This parasitoid has not been intercepted on imported produce (PDI, 2003).	No
Aphytis diaspidis (Howard) [Hymenoptera: Aphelinidae]	Parasitic wasp	No	This parasitic wasp is widespread but of low incidence and has been reported to parasitise only a small proportion of San Jose scale in Nelson. This species is attracted to San Jose scale pheromone traps. In addition, adult *Aphytis* wasps also frequently feed on and kill scale insects. This parasitoid has not been intercepted on imported produce (PDI, 2003).	No
Aphytis mytilaspidis (Le Baron). [Hymenoptera: Aphelinidae]	Mussel scale parasite	No	This species is reported as a parasite of the oystershell scale, *Lepidosaphes ulmi* (Rosen and DeBach, 1979). Other armoured scales such as San Jose scale, *Diaspidiotus perniciosus,* are also reportedly parasitised (HortNet, 2005d). However, the host scale *Lepidosaphes ulmi* is considered to be uncommon except on unsprayed plum trees (McLaren *et al.*, 1999). Parasitism of San	No

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
			Jose scale by this wasp are reportedly low, from 3 to 9 per cent (Samarasinghe and Leroux, 1966; Neuffer, 1966). HortNet (2005e) reports that *L. ulmi* is the preferred host and that *A. mytilaspidis* only sometimes causes high mortality in San Jose scale.	
Apsicolpus hudsoni Turner [Hymenoptera: Braconidae]	Braconid parasitic wasp	No	Parasitoid of lemon tree borer *Oemona hirta* that bores in the trunk and branches of its host tree often damaging the framework of the host tree (Clearwater, 1989).	No
Ascogaster quadridentata Wesmael [Hymenoptera: Braconidae]	Codling moth parasite	No	Codling moth is listed as host species. This wasp lays its eggs individually in codling moth eggs. The adult parasitoid wasp does not emerge until the following spring, having taken a full year to develop within the codling moth caterpillar. It is considered that this wasp is unlikely to be on the pathway because (1) orchards designated for export will have very low populations of codling moth as stated above, (2) not every codling moth will be parasitised, and (3) fruit infested by codling moth are likely to be removed from the export pathway.	No
Campoplex sp. [Hymenoptera: Ichneumonidae]	Ichneumonid parasitic wasp	No	Parasitoid of lemon tree borer *Oemona hirta* that bores in the trunk and branches of its host tree often damaging the framework of the host tree (Clearwater, 1989).	No
Coccophagus gurneyi Compere [Hymenoptera: Aphelinidae]	Obscure mealybug parasite	No	This parasitic wasp is widespread throughout New Zealand. This species is reported to prefer citrophilus mealybug as a host and attacks primarily second and third stages (instars) and also adults (Hortnet, 2003f). Parasitism rates of up to 11% are reported for mealybugs on pipfruit (Hortnet, 2005f) and the highest parasitism levels are found in winter. As the main host of this parasitoid is considered a quarantine pest and only a small percentage of mealybugs on the pathway are likely to be parasitised, it is considered unlikely that this parasitoid will be associated with New Zealand stone fruit.	No
Coccophagus ochraceus (Howard) [Hymenoptera: Aphelinidae]	Aphelinid parasitic wasp	No	This parasitoid is recorded from the scale *Saissetia oleae* in New Zealand (Henderson, 2001a), which was considered in this report. The scale is reported to be found in orchards, which may include	No

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
			stone fruit (Henderson, 2001b). This scale is associated with stems and the underside of leaves, not fruit.	
Diadegma sp. [Hymenoptera: Ichneumonidae]	Ichneumonid parasitic wasp	No	*Diadegma* wasps are important parasitoids of diamondback moth however has been recorded to parasitise a very small percentage of brownheaded leafroller, greenheaded leafroller or light brown apple moths in orchards (HortResearch, 1999). These leaf rolling caterpillars are unlikely to be associated with the fruit and as only a very small percentage of caterpillars may be parasitised, it is unlikely that this parasitoid will be associated with the pathway.	No
Diplazon laetatorius (Fabricius) [Hymenoptera: Ichneumonidae]	Ichneumonid parasitic wasp	No	This wasp parasitises hover fly larvae which are important predators of plant pests, especially aphids. Of the hosts known in New Zealand listed by Valentine (1967), *Syrphus novae-zealandiae*, *Syrphus ortas*, *Syrphus viridiceps* and *Melanoma fasciatum* are considered in this assessment. Hover fly eggs and larvae are associated with leaves and not fruit.	No
Encarsia citrina Craw [Hymenoptera: Aphelinidae]	Armoured scale parasitoid	Yes	An endoparasite of armoured scale (Tomkins *et al*., 1995). The tiny wasp lays eggs in developing scales, from which adult wasps emerge (Tenbrink & Hara, 1990). Parasitism rate of up to 90 per cent are reported (Hortnet, 2005g). Parasitises a range of scales such as *Hemiberlesia* spp., some of which have been intercepted numerous times (PDI, 2003).	**Yes**
Encarsia perniciosi (Tower) [Hymenoptera: Aphelinidae]	Red scale parasite	Yes	This species is a common parasitoid of San Jose scale in both South and North Island locations. This species is considered an important biological control agent of San Jose scale in many overseas countries. Parasitism of up to 75 per cent of San Jose scale is reported. While San Jose scale is apparently not common on fruit the high level of parasitism justifies further consideration of this species.	**Yes**
Epitetracnemus zetterstedtii (Westwood) [Hymenoptera: Encyrtidae]	Encyrtid parasitic wasp	No	This species is a parasitoid of mussel scale, San Jose scale and oystershell scale. However, the importance of *Epitetracnemus zetterstedtii* in the control of these scales in New Zealand is unknown and it has rarely been reported (HortResearch, 1999).	No

Pest	**Common name**	**Pathway association**		**Consider further (yes/no)**
		Associated with fruit (yes/no)	Comment	
			Based on this evidence, it is considered that this parasitoid is unlikely to be on the pathway.	
Eupsenella sp. [Hymenoptera: Bethylidae]	Bethylid parasitic wasp	No	Hortnet (2005b) list this leafroller parasite as “yet to be recorded from light-brown apple moth” in New Zealand where it feeds externally on caterpillars in leaf rolls. It is considered unlikely to be associated with the fruit pathway.	No
Eupteromalus sp. [Hymenoptera: Ptreromalidae]	Ptreromalid parasitic wasp	No	Valentine (1967) listed the light brown apple moth, *Epiphyas postvittana,* as a host species of this parasitoid. However, there is no recent record of this species in HortResearch (1999), indicating the wasp is either no longer found or is unimportant in pipfruit or stone fruit orchards in New Zealand. It is therefore unlikely that the wasp will be on the pathway.	No
Euxanthellus philippiae Silvestri [Hymenoptera: Aphelinidae]	Aphelinid parasitic wasp	No	The host species *Coccus hesperidum* is found on stems, leaves and green twigs where they are associated with veins (Copland & Ibrahim, 1985) and are therefore not considered to be on the pathway.	No
Glabridorsum stokesii (Cameron) [Hymenoptera: Ichneumonidae]	Ichneumonid parasitic wasp	No	An Australian species introduced to New Zealand in the 1970s. It is now well established in the North and South Islands. This ichneumonid wasp parasitises the pupal stage of light brown apple moth and oriental fruit moth (Hortnet, 2003e). The pupal stage of light brown apple moth occurs in rolled up leaves or in flower debris and are therefore not associated with fruit.	No
Goniozus jacintae Farrugia [Hymenoptera: Bethylidae]	Bethylid wasp	No	*G. jacintae* is a gregarious external parasitoid (Danthanarayana, 1980) of some leafroller species, particularly *Ctenopseustis obliquana*, *Epiphyas postvittana* and *Planotortrix notophaea* in New Zealand (Berry, 1998). Parasitism of leafroller larvae occurs at up to 3% with an average of two adult wasps emerging per parasitised larvae (Danthanarayana, 1980 – pooled data). The low rate of parasitism, coupled with the removal of leafroller larvae from the export pathway justifies the unlikely association of this parasitoid with mature harvested fruit.	No

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Liotryphon caudatus (Ratzeburg) [Hymenoptera: Ichneumonidae]	Ichneumonid parasitic wasp	No	A parasitoid of codling moth *Cydia pomonella* introduced to New Zealand and reported from Hawke's Bay northwards. Only a very small percentage of codling moth caterpillars are attacked by this wasp, which is only rarely reported (HortResearch, 1999). This wasp specifically attacks moth pre-pupae under the bark of trees by paralysing the host and laying an egg externally.	No
Metaphycus claviger (Timberlake) [Hymenoptera: Encyrtidae]	Encyrtid parasitic wasp	No	Parasite of brown soft scale (*Coccus hesperidum*) (Gourlay, 1930; Davoodi *et al.*, 2004). Brown soft scale is primarily a pest of citrus, although prunus records exist. *C. hesperidum* is almost always limited to stems, twigs and leaves of its host (CABI, 2005). As the host is not likely to be associated with the pathway, neither is the parasite.	No
Meteorus pulchricornis (Wesmael) [Hymenoptera: Braconidae]	Braconid parasitic wasp	No	This species is a larval parasitoid of several families of Lepidoptera including Tortricidae and Noctuidae. Light brown apple moth is also a host (Berry, 1997). It is believed to have been introduced to New Zealand with a lepidopteran host (Berry and Walker, 2003). Parasitism rates for this parasitoid is reportedly low (Rogers, *et al.*, 2003) and combined with a low likelihood that hosts will be imported, it is considered that it is unlikely that this parasitoid would be present on New Zealand stone fruit.	No
Platygaster demades (Walker) [Hymenoptera: Platygasteridae]	Platygasterid parasitic wasp	No	Parasitoid of apple and pear leaf curling midges *Dasineura mali* and *D. pyri* (Tomkins *et al.*, 2000b). These midges are restricted to pome fruits and are not likely to be found on the stone fruit pathway.	No
Signiphora merceti Malenotti [Hymenoptera: Signiphoridae]	Signiphorid parasitic wasp	No	Parasitoid of greedy scale, *Hemiberlesia rapax*. In New Zealand, greedy scale is present in most North Island regions and has been found as far south as Canterbury. Greedy scale is primarily a pest of kiwifruit, however has been recorded as an infrequent pest on peaches (HortResearch, 1999). Damage caused by feeding scales of fruit such as kiwifruit and apples renders the fruit unexportable.	No

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Tetracnemoidea peregrina (Compère) [Hymenoptera: Encyrtidae]	Encyrtid parasitic wasp	No	This species is reared almost exclusively from long-tailed mealybug (*Pseudococcus longispinus*) although citrophilus mealybug (*Pseudococcus calceolariae*) may also be a host (Charles and Allan, 2002). Long-tailed mealybug is only rarely associated with stone fruit production (Cox, 2006).	No
Tetracnemoidea sydneyensis (Timberlake) [Hymenoptera: Encyrtidae]	Encyrtid parasitic wasp	No	Introduced from Australia to New Zealand, a survey of mealybug enemies in New Zealand from 1990-92 found this species in all regions surveyed. This parasitoid was always found associated with long tailed mealybug (*Pseudococcus longispinus*). Long-tailed mealybug is only rarely associated with stone fruit production (Cox, 2006).	No
Trichogramma funiculatum Carver [Hymenoptera: Trichogrammatoidea]	Trichogrammatoid parasitic wasp	No	Minute parasitic wasps, which attack the eggs of light brown apple moth. Parasitised eggs turn black as the wasp larvae develops inside, emerging as an adult. Eggs of light brown apple moth are laid on the upper surfaces of leaves and are unlikely to be associated with fruit.	No
Trichogrammatoidea bactrae Nagaraja [Hymenoptera: Trichogrammatoidea]	Trichogrammatoid parasitic wasp	No	Minute parasitic wasps, which attack the eggs of light brown apple moth. Parasitised eggs turn black as the wasp larvae develops inside, emerging as an adult. Eggs of light brown apple moth are laid on the upper surfaces of leaves and are unlikely to be associated with fruit.	No
Xanthocryptus novozelandicus (Dalla Torre) [Hymenoptera: Ichneumonidae]	Ichneumonid parasitic wasp	No	*Xanthocryptus novozelandicus* is a parasitic wasp, which attacks lemon tree borer larvae. Lemon tree borer larvae feed within the stems and branches of their host trees. Larvae pupate in the bore holes made by the beetle larvae.	No
Neuroptera (lacewings)				
Cryptoscenea australiensis (Enderlein) [Neuroptera: Coniopterygidae]	Lacewings	No	This lacewing is recorded as a predator of mealybugs such as citrophilus mealybug and long tailed mealybug which may be associated with stonefruit. However, this lacewing is an external parasite at all stages and has not been detected during AQIS inspections.	No

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Thysanoptera (thrips)				
Haplothrips kurdjumovi Karny [Thysanoptera: Phlaeothripidae]	Predatory thrips	No	This predatory thrips feeds on eggs and motile stages of some mites including European red mite. Eggs are typically laid onto the lower surface of a leaf (McLaren *et al*., 1999). While this thrips is generally considered to remain amongst leaf hairs or crevices in twigs, it may follow prey onto the fruit. Unidentified Phlaeothripidae have been intercepted on stone fruit from New Zealand (PDI, 2003)	**Yes**
BACTERIA				
Pseudomonas syringae pv. ***persicae*** Prunier *et al*.	Bacterial decline	Yes	This bacterium causes shoot dieback, limb and root injury, tree death, leaf spots and fruit lesions in nectarine and peach. Small, round, dark oily spots occur on fruit. These can spread within the fruit tissue, causing sunken, deforming lesions that ooze gum (Ogawa *et al*., 1995).	**Yes**
FUNGI				
Amylostereum sacratum (G. H. Cunningham)	Root rot	No	Causes a root rot in various hosts, indigenous to New Zealand, and occurs sporadically (McLaren *et al*., 1999).	No
Armillaria limonea (G. Stevenson) Boesewinkel	Root and crown rot	No	Causes root and crown rot. Infection of fruit is not known to occur (McLaren *et al*., 1999).	No
Armillaria novae-zelandiae (G. Stevenson.) Herink	Root and crown rot	No	Causes root and crown rot. Infection of fruit is not known to occur (McLaren *et al*., 1999).	No
Apiospora montagnei Sacc.		Yes	Isolated from fruit in New Zealand (ICMP, 2005)	**Yes**
Collybia drucei (G. Stevenson) E. Horak	Wood decay & litter fungus	No	Associated with wood rot and leaf litter.	No
Diatrype stigma (Hoffmann: Fries) Fries	Wood rot	No	Fungus associated with wood rot (Rappaz, 1987).	No
Eutypa lata (Per.: Fr.) L.R. Tulasne & C. Tulasne	Eutypa canker	No	Causes cankers on branches and dieback of trees, no infections have been recorded on fruit (Carter, 1995)	No
Fusarium poae (Peck) Wollenweber	Fusarium rot	No	Predominantly associated with cereal and grasses. *Fusarium* species are responsible for wilts, blights, root rots and cankers in	No

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
			legumes, coffee, pine trees, wheat, corn, carnations and grasses.	
Gibberella cyanogena (Desmaz.) Sacc.	Seedling blight	No	Secondary pathogen, rarely on fruit, gaining entry through damaged tissues and of no importance as a storage disease (NZ MAF, 2003).	No
Gibberella tricincta El-ghall *et al*.	Fusarium rot	No	A common soil-inhibiting fungus (Farr *et al*., 1989).	No
Nectria cinnabarina (Tode) Fr.	Coral spot	No	Recorded as a wound parasite on various hosts (Dingley, 1969).	No
Nectria ochroleuca (Schweinitz) Berkeley	Dieback	No	Commonly associated with frost and wind injuries as a wound parasite, causes dieback (Dingley, 1969).	No
Neofabraea malicorticis H.S. Jackson	Gleoesporium rot	No	This species is known to cause anthracnose, branch canker and bull-eye fruit rots of *Malus* and other pome fruits (Verkley, 1999).	No
Penicillium vulpinum (Cooke & Massee) Seifert & Samson		No	The sole record for this fungus in New Zealand did not state the affected part of the tree (ICMP, 2005). Other records of this fungus in New Zealand are associated with the soil, including records from the dung of rats and opossum (ICMP, 2005). There is no evidence to suggest that this fungus is associated with fresh stone fruit.	No
Phellinus robustus P. Karst.	White wood rot	No	Causes white rot of trunks and branches, not known to infect fruit (Adaskaveg & Gilbertson, 1995).	No
Phomopsis amygdali (Delacr.) Tuset & Portilla	Fusicoccum canker	No	The pathogen infects the current season's shoot growth in the fall and again during the following spring. The resulting fungal cankers eventually girdle and kill these fruiting twigs during the subsequent summer. The young fruit lost on these blighted twigs represents a direct crop loss (Lalancette, 1998). The pathogen may also cause large, circular to irregular, zonate, brown spots in the leaves (Jones & Sutton, 2003). Fruit infections are evidently rare (Ogawa *et al.* 1995) and have not been recorded from New Zealand.	No
Phytophthora syringae (Kleb.) Kleb.	Canker, crown and root rot	No	Causes root and crown rot of trees (Browne & Mircetich, 1995).	No
Podosphaera tridactyla (Wallr.) de Bary	Powdery mildew	Yes	Primarily occurs on shoots but occasionally found on fruit (NZ MAF, 2003).	**Yes**
Taphrina pruni Tulasne	Plum pocket	Yes	First signs of the disease on fruit are small, white blisters. These	**Yes**

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
			enlarge rapidly and soon involve the entire fruit. The fruit becomes spongy and tissues of the seed cavity wither and die (Ogawa *et al*., 1995).	
Trametes hirsuta (Wulfen) Pilát	Wood rot	No	Wood rot that infects trunk and branches (Adaskaveg & Gilbertson, 1995).	No
Trametes zonata Wettst.	Wood rot	No	Wood rot that infects trunk and branches (Adaskaveg & Gilbertson, 1995).	No
Truncatella laurocerasi (Westend.) Steyaert		No	The New Zealand culture for this fungus was associated with peach (ICMP, 2005), although the plant part is not recorded. The records available for this fungus are linked to leaves and vine canes, not fruit.	No
Valsa cincta Curr.	Leucostoma canker	No	Causes branch and twig cankers, no infections have been recorded on fruit (Biggs, 1995).	No
Valsa leucostoma (Persoon) Fries Höhn.)	Leucostoma canker	No	Causes branch and twig cankers, no infections have been recorded on fruit (Biggs, 1995).	No
NEMATODES				
Xiphinema diversicaudatum Filipjev & Schuurmans Stekhoven	Dagger nematode	No	A soil-borne nematode that feeds on root tips (McLaren *et al*., 1999).	No
VIRUSES/VIRUS-LIKE DISORDERS				
Apricot chlorotic leaf mottle		No	Chlorotic leaf spots and blotches. The disorder is only transmitted by budding and grafting (Foster, 1995).	No
Apricot Moorpark mottle		No	The disorder is only transmitted by grafting and budding (Foster, 1995).	No
Apricot stone pitting		No	The disorder is only transmitted by grafting and budding (Foster, 1995).	No
Cherry necrotic rusty mottle		No	The disorder is transmitted by grafting (Diekmann & Putter, 1996).	No
Peach calico		No	The disorder is only transmitted by grafting and budding (Foster, 1995).	No
Peach chlorotic spot		No	The disorder is only transmitted by grafting and budding (Foster,	No

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
			1995).	
Peach seedling chlorosis		No	The disorder is only transmitted by grafting and budding (Foster, 1995).	No
Peach yellow mottle		No	The disorder is only transmitted by grafting and budding (Foster, 1995).	No
Plum line pattern *ilarvirus*		No	Transmitted by mechanical means only. Seed transmission not recorded. (Ogawa *et al.,* 1995; McLaren *et al.,* 1999)	No
Plum mottle leaf		No	The disorder is only transmitted by grafting and budding (Foster, 1995).	No
Sour cherry green ring mottle virus		No	No known vectors. Transmission is by grafting (Ramsdell, 1995).	No
Strawberry latent ringspot *nepovirus*		No	The pathogen transmitted by grafting and by the nematode *Xiphinema diversicaudatum* (Diekmann & Putter, 1996).	No

Appendix – 1c: Potential for Establishment or Spread and Associated Consequences for Pests of Stone Fruit from New Zealand

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for consequences		Consider pest further? (yes/no)
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
ARTHROPODS						
Acari (mites)						
Orthotydeus californicus (Banks) [Acari: Tydeidae]	Tydeid mite	Feasible	Wide host range and high reproductive rate (McLaren *et al*., 1999). Tydeid mites are primarily considered fungivores or predators but a few are known to be facultative plant feeding (USDA, 2005). Tydeid mites are established in Mediterranean type climate zones indicating potential for establishment in Australia.	Not-significant	Some reports indicate that tydeid mites may be phytophagous (Fleschner & Arakawa, 1952; Bayan, 1984). Not associated with damage (Tomkins et al., 1997).	No
Orthotydeus caudatus (Dugès) [Acari: Tydeidae]	Tydeid mite					
Orthotydeus sp. [Acari: Tydeidae]	Tydeid mite					
Tarsonemus bakeri Ewing [Acari: Tarsonemidae]	Tarsonemid mite	Feasible	Wide host range (Chatterjee & Gupta, 1996; McLaren et al., 1999). Tarsonemid feeding habits are greatly diverse: many are fungivores; algivores; predators of other mites; parasites of insects; and possibly symbionts of insects (Lin & Zhang, 2001). *Tarsonemus parawaitei* and *Tarsonemus waitei* are already established across Australia (Kim *et al*., 1998; Smith *et al*., 1997) indicating suitability of the environment for establishment.	Not significant	Some phytophagous tarsonemids are important pest on agricultural crops (Lin & Zhang, 2001). However, these species are fungivores. Not associated with damage (Chatterjee & Gupta, 1996; McLaren *et al*., 1999).	No
Tarsonemus parawaitei Kim *et al*. [Acari: Tarsonemidae]	Tarsonemid mite					
Tarsonemus smithi Ewing [Acari: Tarsonemidae]	Tarsonemid mite					
Tarsonemus waitei Banks [Acari: Tarsonemidae]	Peach bud mite					

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for consequences		Consider pest further? (yes/no)
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
Coleoptera (beetles, weevils)						
Epilachna doryca (Boisduval) [Coleoptera: Coccinellidae]	Ladybird	Feasible	Wide host range	Not significant.	The lack of world literature on its economic importance indicates that this species is of little concern for its reported hosts.	No
Epurea takhtajani Medvedev & Ter-Minasyan [Coleoptera: Nitidulidae]	Yellow sap beetle	Feasible	Wide host range (Parsons, 1943).	Not significant	The lack of world literature on its economic importance indicates that this species is of little concern for its reported hosts.	No
Eucolaspis brunnea (Fabricius) [Coleoptera: Chrysomelidae]	Bronze beetle	Feasible	Wide host range (McLaren *et al*., 1999).	Significant	Feeding on fruit could allow secondary infections by other microorganisms.	**Yes**
Hemiptera (aphids, leafhoppers, mealybugs, psyllids, scales, true bugs and whiteflies)						
Diaspidiotus ostreaeformis (Curtis) Borchsenius [Hemiptera: Diaspididae]	Oystershell scale	Feasible	Polyphagous (Davidson & Miller, 1990) and already established in Victoria, New South Wales and Tasmania (APPD, 2004). Therefore, if introduced, it may establish in Western Australia.	Significant	Crop loss caused by this pest on different trees is difficult to assess. It causes red spots on the fruits, and therefore, affecting the marketability.	**Yes**
Pseudococcus calceolariae (Maskell) [Hemiptera: Pseudococcidae]	Citrophilus mealybug	Feasible	Already established in New South Wales, Victoria and South Australia in citrus orchards (Smith *et al*. 1997). Therefore, if introduced, it may establish in Western Australia.	Significant	Mealybugs produce honeydew that serves as the substrate for the development of sooty mould, which prevents photosynthesis in addition to making the plant unsightly.	**Yes**
Lepidoptera (leafrollers, butterflies, moths)						
Cnephasia jactatana (Walker) [Lepidoptera: Tortricidae]	Black-lyre leafroller	Feasible	Wide host range (McLaren *et al*., 1999).	Significant	Occasionally observed on stone fruit (McLaren *et al*., 1999).	**Yes**
Coscinoptycha improbana Meyrick [Lepidoptera:	Guava moth	Feasible	Australian native ranging from Queensland to Victoria and Tasmania (Common, 1990). Therefore, if	Significant	Larvae damage fruit by feeding internally (Froud & Dentener, 2002).	**Yes**

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for consequences		Consider pest further? (yes/no)
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
Carposinidae]			introduced, it may establish in Western Australia.			
Ctenopseustis herana (Felder & Rogenhofer) [Lepidoptera: Tortricidae]	Brown headed leafroller	Feasible	Wide host range and high reproductive rates (McLaren *et al*., 1999).	Significant	Feeding on immature fruit may result in a gumming response or predispose fruit to fungal infection (McLaren *et al*., 1999).	**Yes**
Ctenopseustis obliquana Walker [Lepidoptera: Tortricidae]	Brown headed leafroller	Feasible	Wide host range and high reproductive rates (McLaren *et al*., 1999).	Significant	Feeding on immature fruit may result in a gumming response or predispose fruit to fungal infection (McLaren *et al*., 1999).	**Yes**
Cydia pomonella Linnaeus [Lepidoptera: Tortricidae]	Codling moth	Feasible	Established in New South Wales, Queensland, Victoria, South Australia and Tasmania (APPD, 2004). Eradicated from Western Australia (Botha *et al*., 2000). Wide host range and high reproductive rates (McLaren *et al*., 1999).	Significant	Larvae damage developing shoots and fruit. However, the most severe damage occurs where larvae feed on fruit, causing it to be rated off grade (Hely *et al*., 1982).	**Yes**
Graphania mutans (Walker) [Lepidoptera: Noctuidae]	Noctuid moth	Feasible	Wide host range (NZ MAF, 2003) including apple (Collyer & Geldermalsen, 1975) and Apricots (NZ MAF, 2003).	Significant	Larval feeding immediately post-flowering could result in fruit rejection at harvest (Burnip *et al*., 1995).	**Yes**
Grapholita molesta (Busck) [Lepidoptera: Tortricidae]	Oriental fruit moth	Feasible	Established in New South Wales, Queensland, Victoria and Tasmania (APPD, 2004).	Significant	Attacks on fruits considerably reduce their quality and, therefore, their market value (Gonzalez, 1978).	**Yes**
Harmologa amplexana (Zeller) [Lepidoptera: Tortricidae]	Native leafroller	Feasible	Wide host range (McLaren *et al*., 1999).	Significant	Larvae cause damage by feeding on leaves or fruit (McLaren *et al*., 1999).	**Yes**
Planotortrix excessana Walker [Lepidoptera: Tortricidae]	Green headed leafroller	Feasible	Wide host range and high reproductive rates (McLaren *et al*., 1999).	Significant	Feeding on immature fruit may result in a gumming response or predispose fruit to fungal infection (McLaren *et al*., 1999).	**Yes**
Planotortrix flavescens	New	Feasible	Wide host range and environmental	Significant	Incidental in stone and pome fruit	**Yes**

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for consequences		Consider pest further? (yes/no)
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
Butler [Lepidoptera: Tortricidae]	Zealand native leafroller		similarities exist between New Zealand and Western Australia (Poole, 2003)		orchards (Wearing *et al*., 1991). Pest status may change in new environment.	
Planotortrix octo Dugdale [Lepidoptera: Tortricidae]	Green headed leafroller	Feasible	Wide host range and high reproductive rates (McLaren *et al*., 1999).	Significant	Feeding on immature fruit may result in a gumming response or predispose fruit to fungal infection (McLaren *et al*., 1999).	**Yes**
Pyrgotis plagiatana (Walker) [Lepidoptera: Tortricidae]	Native leafroller	Feasible	Wide host range (McLaren *et al*., 1999).	Significant	Larvae cause damage by feeding on leaves or fruit (McLaren *et al*., 1999).	**Yes**
Thysanoptera (thrips)						
Frankliniella occidentalis (Pergande) [Thysanoptera: Thripidae]	Western flower thrips	Feasible	Polyphagous pest and high reproductive rates (Mound & Teulon, 1995). Reported in all States except Northern Territory (Mound &. Gillespie, 1997).	Significant	WFT damage plants directly by feeding and laying eggs on the plant (Childers & Achor, 1995), and indirectly by acting as vectors for viruses.	**Yes**
Thrips obscuratus (J.C. Crawford) [Thysanoptera: Thripidae]	New Zealand flower thrips	Feasible	Wide host range and high reproductive rate (McLaren *et al*., 1999) and are highly mobile.	Significant	External scarring of stone fruit contributes to quality loss (McLaren *et al*., 1999).	**Yes**
BIOLOGICAL CONTROL AGENTS						
Acari (mites)						
Amblyseius waltersi Schicha [Acari: Phytoseiidae]	Phytoseiid mite	Feasible	*Amblyseius* species are generalist predators (McMurtry & Croft, 1997; Croft *et al*., 1998). Most generalist predators within the family can reproduce on various genera of tetranychid mites and pollens (Duso *et al*., 1991). A variety of plant exudates and honeydew may serve as food source	Significant	Generalist predators have the potential to damage non-target organisms (Howarth, 1991). Predacious mites interact interspecifically through competition for prey or feeding on each other (Croft & MacRae, 1993). Mutual predation reported among predatory mites could result in localised	**Yes**
Neoseiulus caudiglans Schuster [Acari: Phytoseiidae]	Phytoseiid mite					
Neoseiulus fallacis (Garman) [Acari: Phytoseiidae]	Phytoseiid mite					

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for consequences		Consider pest further? (yes/no)
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
Typhlodromus pyri Scheuten [Acari: Phytoseiidae]	Phytoseiid mite		in the absence of prey. In the presence of prey, these food sources can boost reproductive potential (Baker & Klein, 1992; McMurtry, 1992). Some species of this genus are already established across Australia (Halliday, 1998; Whitney & James, 1996), indicating suitability of the environment for establishment.		displacement of established mites in the natural ecosystem (Reitz & Trumble, 2002). *Typhlodromus pyri* has been recorded to displace *Metaseiulus occidentalis* (Croft & MacRae, 1993).	
Agistemus longisetus Gonzalez [Acari: Stigmaeidae]	Stigmaeid mite	Feasible	Other stigmaeid mites feed on a variety of prey, including phytophagous mites and pollen (Weeden *et al*., 2005). Some species of stigmaeid mites are established across Australia (Halliday, 1998).	Not significant	Although stigmaeid mites may displace phytoseiid mites in IPM systems (Croft & MacRae, 1993), there are no published reports of mutual predation of these species with other mites. Therefore, these stigaeid mite species are unlikely to impact on established IPM systems.	No
Eryngiopus bifidus Wood [Acari: Stigmaeidae]	Stigmaeid mite					
Eugamasus sp. [Acari: Parasitidae]	Parasitid mite	Feasible	Predator of two-spotted spider mite.	Not significant	There are no published reports on mutual predation among this genus and other mites. Therefore, are unlikely to impact on established IPM systems.	No
Hymenoptera (Wasps)						
Encarsia citrina Craw [Hymenoptera: Aphelinidae]	Armoured scale parasitoid	Feasible	This parasitoid is established in other regions of Australia. It is likely that suitable conditions also exist in Western Australia for the establishment of this insect.	Not significant	*Encarsia* spp. are specialised armoured scale parasitoids that have been widely introduced as biological control agents. There are no reports of these species causing negative impacts on native ecosystems or attacking other beneficial organisms.	No
Encarsia perniciosi	Red scale	Feasible	This parasitoid is established in other	Not significant	*Encarsia* spp. are specialised armoured	No

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for consequences		Consider pest further? (yes/no)
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
(Tower) [Hymenoptera: Aphelinidae]	parasite		regions of Australia. It is likely that suitable conditions also exist in Western Australia for the establishment of this insect.		scale parasitoids that have been widely introduced as biological control agents. There are no reports of these species causing negative impacts on native ecosystems or attacking other beneficial organisms.	
Thysanoptera (Thrips)						
Haplothrips kurdjumovi Karny [Thysanoptera: Phlaeothripidae]	Predatory thrips	Feasible	*H. kurdjumovi* are found in many regions around the world. It is likely that suitable environments exist for the establishment of this thrips.	Not significant	*H. kurdjumovi* is recorded as a predator of a small number of mites and the eggs of some moths. There is no evidence that this thrips attacks any non-pest species or other biological control agents.	No
PATHOGENS						
Bacteria						
Pseudomonas syringae* pv. *persicae Prunier *et al*.	Bacterial decline	Feasible	Almond, nectarine, peach and plum are the hosts of this bacterium (McLaren *et al*., 1999). Rain splash help spread this bacterium.	Significant	Economic damage to the local stone fruit industry could be substantial as a result of reductions in the amount of marketable fruit.	**Yes**
Fungi						
Apiospora montagnei Sacc.		Feasible	Reported from a wide range of host plants	Not Significant	Reported as a secondary saprophyte (Kirk, 1991). Anamorph is reported as causing kernel blight on barley	No
Podosphaera tridactyla (Wallr.) de Bary	Powdery mildew	Feasible	Hosts include almond, cherry, peach and plum (Farr *et al*., 1989).	Significant	Capable of causing crop losses (Ogawa *et al*., 1995).	**Yes**
Taphrina pruni Tul.	Plum pockets	Feasible	Hosts restricted to *Prunus* species. Wind blown ascospores spread this fungus (Ogawa *et al*., 1995).	Significant	Capable of causing losses if regular spray programs are not implemented (Ogawa *et al*., 1995).	**Yes**

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APPENDIX – 2: DATA SHEETS FOR QUARANTINE PESTS

2.1 Arthropods

2.1.1 Bronze beetle

Species: *Eucolaspis brunnea* (Fabricius) [Coleoptera: Chrysomelidae]

Synonym(s): *Colaspis brunnea* Fabricius.

Host(s): The bronze beetle has a wide host range including horticultural crops and ornamental species (Kay, 1980). Adults of this species have been recorded on *Chenopodium quinoa*, *Cynodon dactylon*, stone fruit, pome fruit, berry fruits (Penman, 1984), pine (Kay, 1980), eucalyptus, acacia, hawthorn, elm, clover, geranium and rose (Lysaght, 1930).

Distribution: New Zealand (Kay, 1980).

Biology: Developmental stages include egg, larvae, pupae and adult. The adult beetle, 3 to 5 mm in length, varies in colour from brown to black (Lysaght, 1930). Adult beetles emerge from the soil from mid spring to mid summer (Clearwater & Richards, 1984). Adult females lay eggs in dry soil, in batches of 3-14 eggs. Larvae emerge from the eggs after approximately three weeks and pass through 3 instars, feeding on grass and clover roots. Overwintering occurs underground (Clearwater & Richards, 1984). Although the larvae feed on roots, damage is considered to be insignificant even when numbers are high. Fully-grown larvae are about 5 mm long. In early spring, larvae break their diapause and pupate. Pupation takes about three weeks (Kay, 1980).

The adult beetle is the destructive stage of the life cycle through defoliation of the host plant. Defoliation tends to be haphazard and discontinuous. On broad-leaved plants, feeding commences on the lower surface of leaves, penetrating to the upper surface to produce a distinctive “shot-hole” appearance (Kay, 1980). Direct feeding of fruit has also been reported (Kay, 1980). Adults feed mainly at night and when disturbed, jump vigorously off the plant. It is for this reason they are also referred to as “flea beetles” (Kay, 1980).

Economic importance: The bronze beetle is capable of causing direct damage to a wide range of hosts. Severe defoliation may affect fruit production. Adult beetles may directly feed on fruit. Some fruit may be primarily attacked before maturity, such as Apples (Kay, 1980), while other fruit are attacked up until harvest (McLaren *et al.*, 1999). Blemishes caused by insect feeding can reduce the value of the crop.

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2.1.2 Citrophilus mealybug

Species: *Pseudococcus calceolariae* (Maskell) [Hemiptera: Pseudococcidae]

Synonym(s): *Dactylopius calceolariae* Maskell; *Erium calceolariae* (Maskell) Lindinger; *Pseudococcus citrophilus* Clausen; *Pseudococcus fragilis* Brain; *Pseudococcus gahani* Green.

Host(s): Citrophilus mealybug is a highly polyphagous species that has been recorded from hosts in 40 plant families (Ben-Dov, 1994). *Abutilon* (Indian mallow); *Arachis hypogaea* (groundnut); *Brachychiton*; *Brassica*; *Ceanothus*; *Chenopodium* (Goosefoot); *Citrus medica* (citron); *Conium maculatum* (Poison hemlock); *Crataegus* (hawthorns); *Cydonia oblonga* (quince); *Daucus carota* (carrot); *Dodonaea viscosa* (switch sorrel); *Eugenia*; *Ficus*; *Fragaria*; *Geranium* (cranesbill); *Hedera helix* (ivy); *Helianthus* (sunflower); *Heliotropium arborescens* (Cherry-pie); *Hibiscus* (rosemallows); *Juglans regia* (Carpathian walnut); *Laburnum anagyroides* (laburnum); *Ligustrum*, Lolium (ryegrass); *Malus pumila* (apple); *Malus sylvestris* (crab-apple tree); *Malva* (mallow); *Musa paradisiaca* (plantain); *Nerium oleander* (oleander); *Palmae* (plants of the palm family); *Pelargonium* (pelargoniums); *Pinus radiata* (radiata pine); *Pisum sativum* (pea); *Pittosporum tobira* (Japanese pittosporum); *Pittosporum undulatum* (Australian boxwood); *Polyscias*; *Prunus* (stone fruit); *Pyrus communis* (European pear); *Rheum hybridum* (rhubarb); *Rhododendron* (Azalea); *Ribes sanguineum* (Flowering currant); *Rosa* (roses); *Rubus* (blackberry, raspberry); *Schinus molle* (California peppertree); *Sechium edule*; *Solanum tuberosum* (potato); *Theobroma cacao* (cocoa); *Vitis vinifera* (grapevine).

Distribution: Australia (NSW, Qld, SA, Tas, Vic); Bulgaria; Chile; China; Czechoslovakia; France; Georgia (Republic); Ghana; Indonesia; Italy; Madagascar; Mexico; Morocco; Namibia; Netherlands; New Zealand; Portugal; South Africa; Spain; Ukraine; United Kingdom; USA (California, Louisiana).

Biology: Females lay in excess of 700 eggs within a waxy ovisac. Neonate crawlers spend the first few days of their lives sheltering under the disintegrating ovisac before dispersing to feed. They usually do not move far from their feeding site for the first moult. At the end of the second instar, males spin a tubular, silken cocoon in which they develop through a short-lived third (about 2 days) and a longer-lived fourth non-feeding instar (about 4 days) before moulting into a tiny, winged adult with a pair of stout, waxy terminal filaments. Females develop through three instars and undergo a final moult to the adult form. Males, at the end of the second instar, and females before oviposition, often seek out sheltered spots under bark or old vegetation for further development. Neither stage feeds from then on, so physical protection is more important than a food source.

Mature females produce a sex pheromone that attracts crawling males from short distances (Rotundo & Tremblay, 1981) or flying males from distances in excess of 1 m (Rotundo *et al*., 1980). The pheromone attracts large numbers of males in the field, and has been used to detect three seasonal male flight peaks in Italy (Rotundo *et al*., 1979). Adult females may mate almost immediately, but then spend up to several weeks maturing their eggs. Mature females commonly move to a protected site to lay eggs over a period of up to 2 weeks. They cease feeding before oviposition. Parthenogenesis has not been reported in this species, and experience suggests that sexual reproduction is obligate. In New Zealand there are probably up to three generations per year (Charles, 1981), in Australia four generations per year (Smith & Armitage, 1931), and in California three to four generations per year (Clausen, 1915).

Citrophilus mealybug feeds on the phloem of deciduous and evergreen plants in warm, temperate climates. Under these conditions, populations seldom reach sufficiently high levels to debilitate the plant, and the symptoms of attack are usually restricted to visual sighting of mealybugs or sooty mould. When mealybugs shelter on fruit, within the calyx, around the stalk or under fruit sepals they are often hidden from view, and cannot be seen without removing the calyx. Sooty mould growing around the calyx or sepals on excreted honeydew is a good indicator of the presence of mealybugs on the fruit.

Economic importance: Mealybugs cause direct damage to citrus by extracting relatively large quantities of sap and producing honeydew that serves as the substrate for the development of sooty mould. This prevents photosynthesis and makes the plant or fruit unsightly. Citrophilus mealybug is an endemic pest throughout most of Australia and has been reported as a serious pest of citrus in South Australia (Altmann & Green, 1991). It is commonly found throughout the major fruit growing regions in New Zealand, and may be very common locally on most fruit crops (Charles, 1993). It can be a severe pest, at least locally, in Italy (Laudonia & Viggiani, 1986).

Mealybugs are pests for several reasons. They may debilitate parts of the plant through depletion of sap, transmission of disease and scarring of fruit. For example, citrophilus mealybug feeding under the 'button' of citrus fruit causes a necrotic halo mark. A heavy infestation can cause fruit drop (Altmann & Green, 1991). More commonly, the presence of mealybugs in other perennial fruit crops leads to unacceptable growth of sooty mould fungi on honeydew deposits on the fruit, either as a deposit on the cheek or around the stalk, calyx or sepals. For growers producing fresh fruit for export markets, the presence of mealybugs or sooty mould may be sufficient to limit the sale of that fruit to local markets at reduced prices. Some countries accept the fruit following fumigation, but this is costly and results in poorer quality fruit with a shorter shelf life.

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2.1.3 Oystershell scale

Species: *Diaspidiotus ostreaeformis* (Curtis) [Hemiptera: Diaspididae]

Synonym(s): *Aspidiotus almaatensis* Borchsenius; *Aspidiotus betulae* Baerensprung; *Aspidiotus hippocastani* Signoret; *Aspidiotus ostreaeformis* Curtis; *Aspidiotus ostreaeformis* var. *oblongus* Goethe; *Aspidiotus oxyacanthae* Signoret; *Diaspidiotus ostreaeformis* (Curtis) Borchsenius; *Mytilococcus ellipticus* (Amerling); *Quadraspidiotus williamsi* (Takagi) Danzig.

Host (s): Oystershell scale is a polyphagous pest on deciduous trees, especially rosaceous species (Kosztarab, 1996). It is also an important pest of apple, plum, cherry and ornamentals in different parts of the World (Konstantinova, 1976; Davidson & Miller, 1990). *Acer* spp. (maples); *Aesculus* spp. (chestnut); *Betula* spp. (birch); *Carpinus betulus* (European hornbeam); *Fagus sylvatica* (beech); *Fraxinus* spp. (ash); *Malus domestica* (apple); *Populus spp*. (poplar); *Prunus amygdalus* (almond); *Prunus avium* (cherry); *Prunus domestica* (European plum); *Prunus persica* (peach); *Prunus persica* var. *nucipersica* (nectarine); *Prunus salicina* (Japanese plum); *Pyrus communis* (pear); *Quercus* spp. (oak); *Salix* spp. (willow); *Sorbus* spp. (ash); *Tilia* spp. (linden); and *Ulmus* spp. (elm).

Distribution: Algeria; Armenia; Argentina; Australia (SA, Tas, Vic); Austria; Azerbaijan; Belgium; Bulgaria; Canada; China; Czech Republic; Egypt; Finland; France; Georgia; Germany; Greece; Hungary; India; Iran; Iraq; Israel; Italy; Japan; Kazakhstan; Korea; Kyrgyzstan; Malta; Moldova; Morocco; Nepal; New Zealand; Netherlands; North Korea; Norway; Pakistan; Poland; Portugal; Romania; Russian Federation; Slovakia; Spain; Sweden; Switzerland; Tajikistan; Turkey; United Kingdom; USA; Uzbekistan; Yugoslavia (Kosztarab & Kozár, 1988; EPPO, 2004; CABI/EPPO, 2002).

Biology: Oystershell scale infests mostly the bark on stems and branches of the trees. Sometimes it can be found on fruit, where it causes red spots. In cases of heavy infestation, the branches of the trees can die. The mature adult female oystershell scale is grey coloured, conically shaped and approximately 1.3 mm in diameter. Oystershell scale has a similar appearance and is often confused with the more economically important San Jose scale (McLaren, 1989), which is established in Western Australia (Woods *et al*., 1996) and other regions of Australia (Brookes & Hudson, 1969). Developmental stages for oystershell scale include eggs, nymphs and adults. The mature male is typical of diaspid scales, being seldom seen and approximately 1 mm in length (Giliomee, 1990). The male develops through the pupal stages and emerges as a mobile winged insect devoid of mouthparts and lives for 1-3 days. The male is attracted to the female by pheromones and dies after mating. Oviposition occurs in the early summer with eggs being laid under the female covering. Mobile crawlers emerge from late summer to early autumn and as such are unlikely to settle on stone fruit as the main harvest occurs before this point. Overwintering occurs as diapausing second instar larvae.

Oystershell scale has one generation per year. There are 3 instars in the female and 5 in the male. In central Europe, the adults appear at the end of April, and in northern Europe 1 or 2 months later. Egg laying continues for 2 months and females each lay about 60-200 eggs. The first instar develops in 45-80 days (Kosztarab & Kozár, 1988).

Oystershell scale does not cause serious damage to its host plants but its similarity to San Jose scale makes oystershell scale a pest of quarantine concern in areas where San Jose scale is not established or in low numbers (McLaren, 1989). Mobile crawlers are the dispersal stage of diaspid scales, including oystershell scale, with most crawlers settling within the host plant. However, wind assisted dispersal can also occur (McClure, 1990). Long distance dispersal is facilitated by the distribution of infested nursery stock (Beardsley & Gonzalez, 1975). The nymphs and adult females are the destructive stage of this pest where they settle on fruit and branches of the host plant.

Oystershell scale has a large number of parasitoids including *Anagyrus schönherri*; *Aphytis aonidiae*; *Aphytis hispanicus*; *Aphytis mytilaspidis*; *Archenomus maritimus*; *Diaspiniphagus moeris*; *Encarsia citrina*; *Encarsia gigas*; *Epitetracnemus zetterstedtii*; and *Chilocorus renipustulatus* (Trapitzin, 1978; Kosztarab & Kozár, 1988).

Economic importance: Crop loss caused by oystershell scale on different trees is difficult to assess. The trees will lose vigour, lifespan will be shortened, and some plant parts can die.

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2.1.4 Codling moth

Species: *Cydia pomonella* Linnaeus [Lepidoptera: Tortricidae]

Synonym(s): *Carpocapsa pomonella* Linnaeus; *Carpocapsa pomonana* Treitschke; *Enarmonia pomonella* Linnaeus; *Laspeyresia pomonella* Linnaeus; *Phalaena pomonella* Linnaeus.

Host(s): Apple and pear are the main hosts for codling moth. Codling moth has been reported to develop on walnut, quince, apricot, peach, almond, maize, sweet cherry and Japanese plum. However, when infestations occur on these plants they do so when they are in close proximity to apple orchards. *Castanea dentata* (chestnut) (Hely *et al*., 1982); *Citrus sinensis* (orange); *Crataegus laevigata* (hawthorn); *Cydonia oblonga* (quince); *Diospyros kaki* (persimmon); *Juglans regia* (walnut); *Malus domestica* (apple); *Malus sylvestris* (crab apple); *Prunus armeniaca* (apricot); *Prunus avium* (cherry) (Moffitt *et al*., 1992); *Prunus damson* (plum); *Prunus domestica* (plum) (Yokoyama & Miller, 1988); *Prunus persica* (peach); *Prunus persica* var. *nucipersica* (nectarine); *Punica granatum* (pomegranate); and *Pyrus communis* (pear).

Distribution: Afghanistan; Albania; Algeria; Argentina; Armenia; Australia (NSW, Qld, SA, Tas, Vic); Austria; Azerbaijan; Belarus; Belgium; Bolivia; Brazil; Bulgaria; Canada; Chile; China; Colombia; Cyprus; Czech Republic; Denmark; Egypt; Estonia; Finland; France; Georgia; Germany; Greece; Hungary; India; Iran; Iraq; Ireland; Israel; Italy; Jordan; Kazakhstan; Kyrgyzstan; Latvia; Lebanon; Libya; Lithuania; Malta; Mauritius; Mexico; Moldova; Morocco; Netherlands; New Zealand; Norway; Pakistan; Peru; Poland; Portugal; Romania; Russian Federation; Slovakia; South Africa; Spain; Sweden; Switzerland; Syria; Tajikistan; Tunisia; Turkey; Turkmenistan; Ukraine; United Kingdom; Uruguay; USA; Uzbekistan; and Yugoslavia (EPPO, 2004).

Biology: Adults are small grey-brown moths with a wingspan of approximately 18 mm. Eggs are laid singly on developing fruit and foliage. Adult females usually lay approximately 250-300 eggs, over 4 to 7 days, and live for about 4 days after the last oviposition. After hatching, each larva burrows immediately into a fruitlet. In apple and pear, the larvae often enter through the calyx or the ripening cheek of maturing fruit, although entry may occur anywhere on the fruit surface. They then bore down to the core of the fruit, leaving a prominent entry hole, which has a red coloration around its rim. This hole becomes blocked with brown excreta as the larva continues to feed on the flesh and seeds of the fruit.

Larvae pass through five instars whilst feeding within the fruit, and then vacate it. Larvae then spin cocoons within cracks in the tree trunk, under loose bark, or amongst debris on the ground. Where the pest is multivoltine, a significant proportion of the population of the earlier generations commences pupation immediately. The number of generations per year varies from 1 to 4 depending on the climate, and sometimes the host plant. During each generation, a small proportion of the larvae enter diapause for up to 2 years (Yothers & Carlson, 1941).

Codling moth over-winters as cocooned larvae and can be found on the host in cracks and under bark. Cocoons can also be found in fruit containers and other equipment (Hely *et al*., 1982). Overwintering larvae usually emerge from mid October to early January, with second generation larvae emerging from mid December to mid February (Hely *et al*., 1982).

Codling moth can disperse within an orchard by flight, but as tortricid moths are not strong fliers, dispersal between orchards is most likely to be attributed to infested fruit and infested equipment such as picking boxes (Hely *et al*., 1982). Flight occurs at and after dusk, mainly on warm, still evenings. Female attract a mate by releasing a sex pheromone (Ferro & Akre, 1975).

Several natural enemies of codling moth have been exploited as biological control agents. These include *Apistephialtes caudate*; *Ascogaster quadridentatus*; *Cryptus sexannulatus*; *Mastrus carpocapsae*; *Microdus rufipes*; *Pristomerus vulnerator* and *Steinernema feltiae*. Many species of spider are also important predators of all life stages of the codling moth (Falcon & Huber, 1991).

Economic importance: Crop losses caused by codling moth on pome fruit around the world are difficult to assess, as the methods used to measure these losses are often inadequate and not strictly comparable. According to Vickers and Rothschild (1991), commercial orchards using broad-spectrum insecticides correctly can keep codling moth damage to below 2%. In Nova Scotia, the degree of infestation under insecticide-free conditions varied from 6 to 10% of the entire crop in an orchard over 12 years, depending on the cultivar (MacLellan, 1977). In an orchard in Lake Ontario, USA, where there is one generation and a partial second generation, similar to those seen in southern England, damage ranged from 7 to 35% (Glass & Lienk, 1971). In warmer climates, where two or more generations occur, damage to apples has been reported as being as high as 84% in the Crimea (Tanskii & Bulgak, 1981), or 65 to 100% in Australia (Geier, 1964).

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2.1.5 Guava moth

Species: *Coscinoptycha improbana* Meyrick [Lepidoptera: Carposindae]

Synonym(s):

Host (s): *Acca sellowiana* (feijoa); *Cassine australis* (red olive plum); *Citrus* spp.; *Citrus unshiu* (mandarin); *Citrus limon* (lemon); *Eriobotrya japonica* (loquat); *Macadamia integrifolia* (macadamia); *Prunus persicae* (peach); *Prunus domestica* (plum); *Psidium guajava* (guava); *Pyrus pyrifolia* (nashi pear); and *Schizomeria ovata* (white cherry) [Common, 1990; Froud & Dentener, 2002].

Distribution: Guava moth is native to Australia and ranges from Queensland to Victoria and Tasmania (Common, 1990). This species is also reported in Norfolk Island and New Zealand (Froud & Dentener, 2002).

Biology: Guava moth is a temperate to sub-tropical species. In the far north of Australia, breeding is continuous throughout the year with sufficient hosts available to sustain the population year round (Dymock, 2000). First to third/fourth instar larvae are found inside ripening fruit while the fruit is still on the tree. This species lays eggs in cracks on the surface or in joins on macadamia nuts. In fruit such as loquat, macadamia and peach, larvae are found feeding inside the kernel. Larvae leave the fruit to pupate when the fruit has fallen to the ground (Froud & Dentener, 2002). The adults of this family are nocturnal, resting on tree trunks during the day and are attracted to lights at night. All known larval stages feed internally, boring into soft and woody fruits, flowers buds and spikes, bark and galls. Some species lay their eggs individually on the outside of the fruit or on seed capsules.

Economic importance: This species is not considered as an economic pest in Australia. Of the 200 described species of this family, only two are considered serious pests: *Carposina sasakii* (peach fruit moth) reported from Japan, Korea and China; and *Heterocrossa rubophaga* (raspberry bud moth) reported in New Zealand (Froud & Dentener, 2002). In New Zealand, guava moth is considered an economic pest, primarily to feijoa and macadamia crops (Jamieson *et al.*, 2004), although other crops such as citrus and some stone fruit are also considered hosts in New Zealand (Froud and Dentener, 2002).

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2.1.6 Leafrollers

Species:

Cnephasia jactatana (Walker) [Lepidoptera: Tortricidae]

Ctenopseustis herana (Fold & Rogen) [Lepidoptera: Tortricidae]

Ctenopseustis obliquana Walker [Lepidoptera: Tortricidae]

Harmologa amplexana (Zeller) [Lepidoptera: Tortricidae]

Planotortrix excessana Walker [Lepidoptera: Tortricidae]

Planotortrix flavescens Butler [Lepidoptera: Tortricidae]

Planotortrix octo Dugdale [Lepidoptera: Tortricidae]

Pyrgotis plagiatana (Walker) [Lepidoptera: Tortricidae]

Synonym(s):

Cnephasia jactatana Walker:

Ctenopseustis herana (Felder & Rogenhofer): *Ctenopseustis obliquana: Cacoecia charactana* Meyrick; *Tortrix herana* Felder & Rogenhofer; *Cacoecia inana* Butler.

Ctenopseustis obliquana Walker: *Teras obliquana* Walker; *Sciaphila transtrigana* Walker; *Sciaphila turbulentana* Walker; *Teras spurcatana* Walker; *Tortrix ropeana* Felder & Rogenhofer; *Cacoecia charactana* Meyrick.

Harmologa amplexana (Zeller):

Planotortrix excessana Walker: *Teras excessana* Walker; *Teras biguttana* Walker; *Cacoecia excessana* (Walker); *Tortrix excessana* (Walker).

Planotortrix flavescens Butler:

Planotortrix octo Dugdale:

Pyrgotis plagiatana (Walker): *Conchylis plagiatana* Walker; *Conchylis recusana* Walker; *Paedisca luciplagana* Walker; *Grapholitha punana* Felder & Rogenhofer; *Grapholitha xylinana* Felder & Rogenhofer; *Catamacta trichroa* Meyrick; *Pyrgotis tornota* Meyrick; *Epagoge parallela* Salmon & Bradley.

Host(s):

Ctenopseustis herana (Felder & Rogenhofer) and *Ctenopseustis obliquana* Walker: Brownheaded leafroller caterpillars have been recorded on more than 200 plant species. While many of these are true host plants, which enable the insect to complete its full life cycle, others may only be temporary hosts for the caterpillars, which move off onto other host plants. Some of the more important and common hosts are: kiwifruit; apples; pears; grapes; citrus varieties; stone fruits; feijoa; and berry fruits. Other host plants include pohutakawa; karaka; mahoe; poroporo; coprosma; willow; honeysuckle; privet; poplar; eucalyptus; ivy; cyclamen; orchids; roses; and clover.

Planotortrix excessana Walker and *Planotortrix octo* Dugdale: Greenheaded leafroller caterpillars have been recorded on more than 200 plant species. Many of these are true host plants, enabling the completion of the full life cycle, others plant species may only be temporary hosts for the caterpillars. Some of the more important and common hosts are: apple; pear; grapes; citrus; stone fruit; kiwifruit; walnut; lupin; tree lupin; ivy; camellia; laurel; hebe; polyanthus; coprosma; and young conifers.

Pyrgotis plagiatana (Walker): *Cassinia* sp.; *Coprosma foetidissima* and *Coprosma* spp.; *Dacrydium* sp.; *Hebe elliptica, Pittosporum tenifolium; Pleurophyllum* spp.; *Podocarpus* spp.; and apple and pear (HortResearch, 1999).

Distribution: These leafrollers are native to New Zealand. The distribution and importance of each species in orchard areas in New Zealand varies with latitude (Foster *et al*., 1991).

Ctenopseustis herana is found on both the North and South Islands of New Zealand. It is absent from the Auckland, Bay of Plenty, Gisborne, Hawke's Bay, Wellington, Manawatu-Wanganui and Taranaki regions of the North Island. It is a pest species mainly in Nelson, Canterbury and the Waikato.

Ctenopseustis obliquana is found in both the North and South Islands but is less frequent on the east coast of the South Island where it may be replaced by *C. herana*. *C. obliquana* is a major pest of apples in Hawke's Bay, Gisborne, Nelson and the Waikato.

Planotortrix excessana is rare or infrequent in the eastern regions of the country. It is a major pest of apples in Nelson and the Waikato.

Planotortrix octo is found in both the North and South Islands and is particularly important in the eastern apple growing regions of Poverty Bay, Hawkes Bay, Marlborough, Canterbury and Central Otago. It is also a pest in the Waikato.

Biology: The biology of brownheaded and greenheaded leafrollers are very similar. Adult brownheaded leafrollers are extremely variable in colour and forewing pattern. The body length is generally 8-12 mm and the wingspan 20-28 mm. Greenheaded leafroller moths are larger than the other leafroller species. The body length of female moths is 8-14 mm and the wingspan 22-30 mm. Males tend to have a smaller body length, 7-12 mm, and a wingspan of 18-25 mm. The larvae may feed internally or externally on fruit. Internally feeding larvae eject droppings outside the fruit or protective shelter (Thomas, 1998).

Egg masses (3-186) are laid in clusters on the upper surface of host leaves and fruit (Penman, 1984). All five to six larval stages are completed on leaves or fruit. Pupae are rare on fruit (McLaren *et al*., 1999). Female *Ctenopseustis obliquana* lays egg masses of 30 or more eggs on leaves of the host plant. Larvae feed between leaves spun together with silk, and may also feed on shoots, buds, stems or the surface of fruits. Fully grown larvae are about 20 mm long and usually pupate within the larval shelter. There are several generations per year, and in summer a generation from egg to adult can be completed in 4-6 weeks. In New Zealand, this leafroller has been observed to overwinter as second to fourth instar larvae (Green, 1979; Thomas, 1998; McLaren *et al.*, 1999).

Female leafrollers produce distinct pheromones for long-range communication with males seeking a mate. Leafrollers pass through two to three generations annually in the central New Zealand region. There is some overlap in the generations, especially in late summer, although development is driven by temperature. In northern New Zealand, three overlapping generations are completed annually. In Auckland major flight periods occur during November-December, February-March, and May-July. In Canterbury, and particularly in Otago and Southland, the number of complete generations is reduced to two due to the cooler climatic condition.

Natural enemies include parasitic or predatory wasps (*Ancistrocerus gazella*, *Brachymeria phya*, *Brachymeria teuta*, *Diadegma* sp., *Dolichogenidea tasmanica*, *Dolichogenidea carposinae* and *Dolichogenidea* sp. *Eupsenella* spp., *Goniozus jacintae*, *Glabridorsum stokesii*, *Glyptapanteles demeter*, *Trichogramma* sp., *Trichogramma funiculatum* and *Trichogrammatoidea bactrae fumata*, *Vespula* spp.); predatory bugs (*Orius vicinus*, *Oechalia schellenbergii*, *Cermatulus nasalis* and *Sejanus albisignata*); parasitic flies (*Pales funesta*, *Pales feredayi*, and *Trigonospila brevifacies*); whirligig mite (*Anystis baccarum*); a number of bird species including the silvereye (*Zosterops lateralis*); and a range of spider species (*Achaearanea veruculata*, *Ixeuticus martius*, *Trite planiceps* and *Trite* sp., several *Diaea* spp. and *Clubiona* sp.).

Economic importance: All species of leafroller larvae cause similar damage to foliage and fruits; there is no way of differentiating between the damage caused by different species. Larvae often feed on the leaf tissue, shoot tips, or areas of new growth. Damage to developing buds will result in reduced fruit set.

Surface fruit damage is common in short stemmed apple varieties, which form compact fruit clusters. In crops such as kiwifruit, plum, grapefruit and apple, the maturing fruit produces a layer of corky tissue over the damage to prevent secondary infection by pathogens.

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2.1.7 Grey-brown cutworm

Species: *Graphania mutans* (Walker) [Lepidoptera: Noctuidae]

Synonym(s): *Hadena debilis* Butler; *Hadena lignifusca* Walker; *Hadena mutans* Walker; *Mamestra acceptrix* Felder & Rogenhofer; *Mamestra passa* Morrison; *Maoria mutans* ab.

pallescens Warren; *Melanchra mutans* (Walker); *Morrisonia mutans* (Walker); *Xylina spurcata* Walker; *Xylina vexata* Walker.

Host(s): *Graphania mutans* is polyphagous on a wide range of dicotyledonous herbaceous plants and occasionally trees or shrubs; rarely on grasses. Hosts include *Brassica rapa* (cabbage), *Malus domestica* (apple), *Pisum sativum* (garden pea), *Prunus* species, *Plantago* sp. (plantain) and *Triticum aestivum* (bread wheat).

Biology: Grey-brown cutworm (GBC) larvae feed on fruit and can cause characteristic scar tissue on fruit at harvest, as well as damage to apical shoots affecting tree vigour (Suckling *et al*., 1990). GBC lays eggs in batches on foliage or sometimes on young apple fruit (Burnip *et al*., 1995). However, there is no evidence that it lays eggs on stone fruit. The hatching larvae disperse to feed on foliage for a short time. Newly hatched larvae are pale yellow in colour with distinct black spots and covered in stiff, erect hairs.

The young larva first consumes the eggshell before commencing to feed on the foliage of the host-plant. Occasionally when eggs are laid on young fruit, larvae will damage the surface of the fruit. Larvae continue to feed on foliage of host trees until fully grown (Landcare Research, 1999). Mature larvae are approximately 25 mm long, light to dark brown in colour with a broken, white longitudinal stripe down each side (Landcare Research, 1999).

Economic importance: GBC is capable of causing direct harm to a wide range of hosts (Burnip *et al*., 1995). Feeding damage reduces marketability of produce.

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2.1.8 Oriental fruit moth

Species: *Grapholita molesta* (Busck) [Lepidoptera: Tortricidae]

Synonym(s): *Cydia molesta* (Busck); *Laspeyresia molesta* Busck; *Carpocapsa molesta* Busck.

Host(s): The principal economic hosts include *Cotoneaster*; *Crataegus laevigata* (hawthorn); *Cydonia oblonga* (quince); *Eriobotrya japonica* (loquat); *Malus domestica* (apple) (Zhao *et al*., 1989; Reis *et al*., 1988); *Prunus amygdalus* (almond); *Prunus armeniaca* (apricot); *Prunus avium* (cherry) (Bailey, 1985); *Prunus domestica* (plum) (Yokoyama & Miller, 1988); *Prunus persica* (peach) (Jones *et al*., 1984); *Prunus persica* var. *nucipersica* (nectarine) (Weakley *et al*., 1987); *Pyrus communis* (pear); and *Vitis vinifera* (grape vine) (Hely *et al*., 1982).

Distribution: Oriental fruit moth is native to northwest China, and began its spread at the beginning of the twentieth century. The pest has since been introduced into many countries (Gonzalez, 1978) including Argentina; Armenia; Australia (NSW, Qld, SA, Tas, Vic); Austria; Azerbaijan; Brazil; Bulgaria; Canada; Chile; China; Croatia; Czech Republic;

France; Georgia; Germany; Greece; Hungary; Italy; Japan; Kazakhstan; Korea; Malta; Mauritius; Moldova; Morocco; New Zealand; Portugal; Romania; Russian Federation; Slovakia; South Africa; Spain; Switzerland; Turkey; Ukraine; Uruguay; USA; Uzbekistan; Yugoslavia (EPPO, 2004).

Biology: Egg deposition usually begins 2-5 days after the females emerge and continues for 7-10 days or longer. The eggs are laid singly and each female lays 50-200 eggs. In peach orchards, especially on young trees, most of the eggs are found on the under-surface of leaves near the tips of growing twigs. The number of generations per year varies from four to six in the Black Sea region of Russia (Moiseeva, 1982), and depends on climatic conditions.

Oriental fruit moth overwinters as cocooned larvae or pupa. Cocoons are found in cracks and other rough places on the tree, under bark, under old bark wounds and in holes in twigs exposed by pruning. They are also found on the ground beneath infested trees in dried remains of fruit, in stubble and in soil cracks. Adults of the first generation survive 30-40 days, compared to 11-17 days in later generations (Rothschild & Vickers, 1991). Dispersal of oriental fruit moth within an orchard is by flight. However, as the moth is not a strong flyer, dispersal between orchards is mainly attributed to infested fruit, nursery stock, and equipment such as packing boxes (Hely *et al*., 1982).

Oriental fruit moth is considered a major pest of stone fruit throughout the world. In spring, larvae infest the young shoots of fruit trees resulting in tip dieback and subsequent interference with the structural development of young trees (Hely *et al*., 1982). Fruit can be attacked directly at any stage resulting in fruit drop or a downgrading of fruit quality. Damage from oriental fruit moth often predisposes fruit to brown rot infections.

Oriental fruit moth was detected in Western Australia at Bickley in 1952 (DAWA, 1952). A delimiting survey of the Bickley valley east of Perth established the valley as an oriental fruit moth quarantine area. Eradication measures were initiated in 1953 (DAWA, 1953). In 1955, with no infestations recorded, the pest was considered to have been eradicated (DAWA, 1955). The latest surveys for oriental fruit moth (using pheromone traps) were conducted from 1994 to 1996 in the Darling Scarp horticultural area, including the Bickley Valley. This survey did not detect the presence of the pest (Poole *et al*., 1998).

Economic importance: Oriental fruit moth is a serious pest of economic importance to commercial orchards of peach, nectarine and apricot, and can also cause economic damage to other commercial fruits. In severe attacks, young trees can suffer distortion of growing shoots and stems. Attacks on fruit considerably reduces yield, quality and market value.

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2.1.9 New Zealand flower thrips

Species: *Thrips obscuratus* (Crawford) [Thysanoptera: Thripidae]

Synonym(s): *Isoneurothrips obscuratus* Crawford; *Isothrips* (*Isoneurothrips*) *obscuratus* (Crawford); *Thrips* (*Isothrips*) *obscuratus* (Crawford).

Host(s): This species is polyphagous and has been reported on at least 225 plant species from 177 genera and 78 families (Teulon & Penman, 1990). Hosts include *Achillea millefolium* (common yarrow, thousand seal); *Aesculus hippocastanum* (horse chestnut); *Aesculus indica* (Indian horse chestnut); *Althea officinalis* (marshmallow); *Anisotome aromatica* (aniseed); *Aruncus dioicus* (goat's beard); *Brassica oleracea*; *Brassica hirta* (mustard); *Buddleia davidii* (butterfly bush, summer lilac); *Carmichaelia odorata* (leafy broom, scented broom); *Catalpa bignonioides* (cigar tree, Indian bean tree); *Celmisia spectabilis* (common mountain daisy, cotton daisy, cotton plant); *Chamaecytisus palmensis* (tree lucerne); *Choisya ternata* (Mexican orange blosssom); *Cordyline australis* (cabbage tree); *Corokia* x *virigata*; *Crataegus* x *lavallei*; *Cydonia oblonga* (quince); *Cytisus scoparius* (broom); *Dahlia* sp. (dahlia); *Deutzia* sp. (bridal wreath, wedding bells); *Gaultheria rupestris*, *Hebe speciosa* (purple hebe); *Hebe vernicosa*; *Hoheria angustifolia* (mountain lacebark, narrow-leaved houhere); *Hoheria sexstylosa* (houhere, lacebark); *Kunzea ericoides* (kanuka, white tea tree); *Leptospermum scoparium* (manuka, red tea tree, tea tree); *Ligustrum* sp. (privet); *Fuchsia* x *hybrida* (fuchsia); *Lupinus polyphyllus* (Russell lupin); *Malus sylvestris* (apple); *Medicago sativa* (lucerne); *Muehlenbeckia australis* (large-leaved muehlenbeckia, pohuehue); P*assiflora edulis* (passion fruit); *Phormium tenax* (flax, harakeke, New Zealand flax); *Prunus armeniaca* (apricot); *Prunus cerasoides* (sour cherry); *Prunus persica* (peach); *Prunus yedoensis* (Yoshino cherry); *Prunus.persica* var. *nucipersica* (nectarine); *Pterostyrax hispidus*; *Pyrus communis* (pear); *Robinia pseudoacacia* (black locust, false acacia); *Rosa* sp. (brier, rose); *Rosmarinus officinalis* (rosemary); *Rubus fruticosus* (blackberry); *Sambucus nigra* (black elder, elderberry); *Sophora tetraptera* (large-leaved kowhai, North Island kowhai); *Trifolium repens* (white clover); *Trifolium pratense* (red clover); *Ulex europaeus* (gorse); *Viburnum tinus* (laurustinus); *Vicia fabae* (broad bean).

The following additional hosts have been listed but not distinguished as breeding hosts: *Acca sellowiana* (feijoa); *Actinidia deliciosa* (kiwifruit); *Asparagus officinalis* (asparagus); *Brassica oleracea* var. *medullosa* (chou moellier); *Brassica rapa* subsp. *rapa* (turnips); *Bulbinella hookeri*; *Canna generalis*; *Citrus limon* (lemon); *Citrus* sp.; *Conium maculatum* (hemlock); *Cyclamen persicum* (cyclamen); *Fatsia* sp.; *Fragaria* sp.; *Freycinetia banksii*; *Hebe* sp.; *Nicotiana tabacum* (tobacco); *Paraserianthes lophantha*; *Phormium cookianum* (flax); *Pomaderris* sp.; *Protea cynaroides* (king protea); *Prunus domestica* (plum); *Pseudopanax simplex*; *Rhododendron* sp.; *Rhopalostylis sapida* (nikau palm); *Rosa* sp. (rose); *Rubus ursinus* var.*loganobaccus* (boysenberry); *Solanum tubersoum* (potato); *Tagetes erecta* (African marigold); *Vitex lucens* (puriri); *Vitis vinifera* (grape); *Zantedeschia* spp. (calla); *Zea mays* (maize).

Distribution: This species is reported throughout New Zealand (excluding the Chatham Islands), from alpine regions down to sea level in both introduced and native habitats (McLaren & Walker, 1998).

Biology: Adults are 2-5 mm in length and vary in colour, usually pale to dark brown, but sometimes yellowish. The eggs are kidney-shaped, transparent and are buried in plant tissue. On apricot and nectarine, eggs are laid under the skin at the stem end of the fruit (McLaren *et al*., 1999). The tiny nymph hatches from the egg and feeds on the exposed surface of the fruitlet. Males and females occur throughout the year in the northern part of the North Island, but in regions with colder winters only the females overwinter. In Central Otago during winter, females, and occasionally second instar larvae, are found in old flower heads of the introduced weeds flannel leaf and horehound, and in the alpine zone on the native trees *Podocarpus halli* and *Phyllocladus alpinus* (McLaren & Walker, 1998).

On apricot and nectarine, eggs are deposited under the epidermis of the calyx, but the larvae migrate to the inside of the flower. On rose, the eggs are laid at the base of petals. On New Zealand flax, the eggs are laid in the flower buds, stalks and sepals. The larvae feed deep within the bracts, around the unopened flowers and in the opened flowers. The prepupae drop to the ground, where they complete the pupal stage. Mated females lay eggs that produce female thrips, whereas eggs from unmated females produce males. A pollen supply is necessary for continuous egg laying (McLaren & Walker, 1998).

Economic importance: New Zealand flower thrips can cause economic damage to stone fruit. On apple, this thrips occurs on flowers in spring and is also seen on the foliage. However, it does not cause economic damage to pome fruit. Some brown flecking of apple petals may be due to its feeding (HortResearch, 1999). New Zealand flower thrips can cause russet on nectarine fruits by feeding on the fruitlets. To prevent damage to nectarine in the spring, insecticides are usually applied (Lo *et al*., 2000). The fruit are at risk of thrips infestation until they emerge from the calyx and the skin hardens.

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2.1.10 Western flower thrips

Species: *Frankliniella occidentalis* (Pergande) [Thysanoptera: Thripidae]

Synonym(s): *Euthrips helianthi* Moulton; *Euthrips occidentalis* Pergande; *Frankliniella californica* Moulton; *Frankliniella canadensis* Morgan; *Frankliniella chrysanthemi* Kurosawa; *Frankliniella conspicua* Moulton; *Frankliniella dahliae* Moulton; *Frankliniella dianthi* Moulton; *Frankliniella nubila* Treherne; *Frankliniella umbrosa* Moulton; *Frankliniella venusta* Moulton; *Frankliniella helianthi* (Moulton); *Frankliniella moultoni* Hood; *Frankliniella trehernei* Morgan

Host(s): *Allium cepa* (onion); *Amaranthus palmeri* (Palmer amaranth); *Arachis hypogaea* (groundnut); *Begonia*; *Beta vulgaris* (beetroot); *Beta vulgaris* var. *saccharifera* (sugarbeet), *Brassica oleracea* var. *capitata* (cabbage); *Capsicum annuum* (bell pepper); *Carthamus tinctorius* (safflower); *Chrysanthemum* x *morifolium* (chrysanthemum); *Citrus* x *paradisi* (grapefruit); *Cucumis melo* (melon); *Cucumis sativus* (cucumber); *Cucurbita maxima* (banana squash); *Cucurbita pepo* (ornamental gourd); *Cucurbitaceae* (cucurbits); *Cyclamen*; *Dahlia*; *Daucus carota* (carrot); *Dianthus caryophyllus* (carnation); *Euphorbia pulcherrima* (poinsettia); *Ficus carica* (common fig); *Fragaria ananassa* (strawberry); *Fuchsia*; *Geranium* (cranesbill); *Gerbera jamesonii* (African daisy); *Gladiolus hybrids* (sword lily); *Gossypium* (cotton), *Gypsophila* (baby's breath); *Hibiscus* (rosemallows); *Impatiens* (balsam); Kalanchoe; *Lactuca sativa* (lettuce); *Lathyrus odoratus* (sweet pea), *Leucaena leucocephala* (leucaena); *Limonium sinuatum* (sea pink); *Lycopersicon esculentum* (tomato); *Malus pumila* (apple); *Medicago sativa* (lucerne); *Petroselinum crispum* (parsley); *Phaseolus vulgaris* (common bean); *Pisum sativum* (pea); *Prunus armeniaca* (apricot), *Prunus domestica* (plum); *Prunus persica* (peach); *Prunus persica* var. *nucipersica* (nectarine); *Purshia tridentata* (bitterbrush); *Raphanus raphanistrum* (charlock); *Saintpaulia ionantha* (African violet); *Secale cereale* (rye); *Sinapis arvensis* (wild mustard); *Sinningia speciosa* (gloxinia); *Solanum melongena* (aubergine); *Syzygium jambos* (rose apple); *Triticum aestivum* (wheat); *Vitis vinifera* (grapevine).

Distribution: Albania; Argentina; Australia (NSW, Qld, SA, Tas, Vic, WA); Austria; Belgium; Brazil; Bulgaria; Canada; Central Russia; Chile; Colombia; Costa Rica; Croatia;

Cyprus; Czech Republic; Denmark; Dominican Republic; Eastern Siberia; Ecuador; Estonia; Finland; France; Germany; Greece; Guatemala; Guyana; Hungary; Ireland; Israel; Italy; Japan; Kenya; Korea; Kuwait; Lithuania; Macedonia; Malaysia; Martinique; Mexico; Netherlands; New Zealand; Norway; Peru; Poland; Portugal; Puerto Rico; Réunion; Romania; Russian Far East; Russian Federation; Scotland; Slovakia; Slovenia; South Africa; Southern Russia; Spain; Sri Lanka; Sweden; Switzerland; Turkey; United Kingdom; USA; Venezuela; Western Siberia; Zimbabwe (EPPO, 2004; CABI/EPPO, 1998).

Biology: Under favourable conditions, *F. occidentalis* will reproduce almost continuously, with up to 15 generations in a year being recorded under controlled conditions (Bryan & Smith, 1956; Lublinkhof & Foster, 1977). Adult female thrips sometimes enter closed buds, to lay eggs in the parenchymatous tissues. Eggs are also laid in similar tissues of leaves, flower parts and young fruit. Eggs hatch in about 4 days at 27°C, but take 13 days at 15°C. The eggs are probably susceptible to desiccation and subject to high mortality, but there is also high mortality due to failure of first instar larvae to emerge safely from their egg.

There are four developmental stages in the life cycle, two active larval stages and two non-feeding pupal stages. First-instar larvae begin feeding soon after emergence, and moult within 3 days at 27°C (7 days at 15°C). Second-instar larvae are very active, often seeking concealed sites for feeding. A newly emerged female is relatively quiescent during the first 24 hours but soon becomes active, particularly at higher temperatures. Females usually live about 40 days under laboratory conditions, but can survive as long as 90 days. Males live half as long as females. Oviposition normally begins 72 h after emergence and continues intermittently throughout adult life. At 27°C, females lay an average of 0.66 to 1.63 eggs per day, but McDonald *et al*. (1997) have demonstrated that adults and larvae of this species can survive sub-zero temperatures and still reproduce effectively. Reproduction may occur parthenogenetically in this species. Males are produced from unfertilised eggs, whereas females are derived from fertilised eggs. Most populations have many more females than males, possibly because males have a shorter adult life, but it has yet to be determined how much control a mated female exerts over the sex of offspring.

Biological control agents include various species in the anthocorid genus *Orius*, important predators in natural systems, and the predacious mite *Amblyseius cucumeris*.

Economic importance: Thrips affect commercial plant production either directly by reducing yield and market quality through feeding damage, or indirectly by the transmission of viral diseases. In addition, the presence of thrips on commodities may result in rejection of export consignments.

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2.2 Biological control agents

2.2.1 Phytoseiid mites

Species:

Amblyseius waltersi Schicha [Acari: Phytoseiidae]

Neoseiulus fallacis (Garman) [Acari: Phytoseiidae]

Neoseiulus caudiglans Schuster [Acari: Phytoseiidae]

Typhlodromus pyri Scheuten [Acari: Phytoseiidae]

Synonym(s):

Amblyseius waltersi Schicha: none.

Neoseiulus caudiglans Schuster: *Anthoseius caudiglans* (Schuster).

Neoseiulus fallacis (Garman): *Amblyseius fallacis* Garman.

Typhlodromus pyri Scheuten: *Typhlodromus tillae* Oudemans.

Distribution:

Amblyseius waltersi Schicha: New Zealand, Australia - no other information.

Neoseiulus caudiglans Schuster: New Zealand - no other information.

Neoseiulus fallacis (Garman): China, India, Japan, former USSR, Switzerland, Canada, USA, Australia, New Zealand.

Typhlodromus pyri Scheuten: Armenia; Australia (NSW; Qld; TAS.); Austria; Azerbaijan; Canada; Czech Republic; Denmark; Egypt; Finland; Greece; Israel; Moldova; Netherlands; New Zealand; Norway; Poland; Portugal; Russian Federation; Slovakia; Sweden; Switzerland; Turkey; Ukraine; United Kingdom; USA (EPPO, 2004).

Host (s):

Biology: The life stages of phytoseiid mites are the egg, a six legged larva, eight-legged protonymph and deutonymph stages and the adult (Sabelis, 1985).

Plants infested by phytophagous mites emit volatile organic compounds and predatory mites use these volatiles to locate their prey (Dicke *et al.*, 1986; Llusia & Penuelas, 2001). Phytophagous mites also directly emit volatile organic compounds that can elicit searching behaviour in phytoseiid mites (Dicke *et al.*, 1986).

Neoseiulus fallacis adults and immature stages will search all parts of the plant for prey (Weeden *et al.*, 2005) or alternative food, for example pollen, and are strongly attracted to chemicals given off either by plants damaged by the prey species or by the prey species itself (Gilstrap & Friese, 1985).

Neoseiulus fallacis has a strong preference for tetranychid mites such as the European red mite and the two-spotted spider mite (Weeden *et al*., 2005). *Neoseiulus fallacis* is a voracious consumer of mites and its population increases quickly in relation to that of its prey, allowing it to overtake expanding pest populations (Weeden *et al*., 2005).

Phytoseiid mites need time to adapt to new environmental conditions (Castagnoli *et al*., 2001). Among the phytoseiid mite life stages, the eggs and larvae are most sensitive to moderate humidities (Croft *et al*., 1993). Eggs are particularly sensitive to desiccation (Karban *et al*., 1995). Extended cold storage can reduce the survival of phytoseiid mites (Gillespie & Ramey, 1988).

Neoseiulus fallacis can survive for a few days without eating prey by feeding on other food sources when facing starvation (Pratt *et al*., 1999).

Typhlodromus pyri can survive on pollen in the absence of prey. However, pollen does not provide adequate sustenance for development and reproduction (CABI, 2004).

Mites from the genus *Amblyseius* have been reported to survive on pollen, allowing them to survive periods when pest populations are low.

Neoseiulus fallacis is a highly mobile, generalist predator. Movement of mites may occur within a patch or plant (Strong *et al.*, 1999) and or from one plant to another (interpatch movement). Interpatch movement exposes the mite to a higher risk of mortality (Nachman, 1988). Movement is influenced by a number of factors including prey density (Croft *et al*., 1995), prey emitted volatiles (Zhang & Sanderson, 1997), predator hunger (Croft & Jung, 2001), temperature, humidity and wind (Penman & Chapman, 1990; Sabelis & van den Weel, 1993) and the spatial arrangement of the patch (Strong *et al*., 1999). *Neoseiulus* species are capable of aerial dispersal (Johnson & Croft, 1981; McMurtry & Croft, 1997; Tixier *et al*., 1998) which permits movement over the whole crop (Croft & Jung, 2001).

Development of phytoseiids is typically quite rapid, with mean egg-to-egg developmental periods above 20°C being less than two weeks for almost all species (Tanigoshi, 1982), and successive generations are produced continually as long as conditions remain favourable. In temperate zones, short day lengths and relatively cool temperature induce a reproductive diapause in adult females after mating, which is the only life stage that overwinters (Overmeer, 1985). Overwintering phytoseiid mites have been collected mainly from fruit trees, where they are found in bark crevices and under insect scales (Kinsley & Swift, 1971; Ivancich-Gambro, 1990).

Diapause occurs only in adult females after mating and the most conspicuous characteristic of diapause is the failure of mated females to produce eggs (Overmeer, 1985). Diapausing females also tend to be less active than non-diapausing mites, feed rarely (Hoy & Flaherty, 1970; Rock *et al*., 1971; Wysoki, 1974; Van Houten *et al*., 1988; Morewood & Gilkeson, 1991) and are much more resistant to starvation (Croft, 1971; Ivancich-Gambro, 1990). The ability to diapause is not universal in phytoseiid mites, as some species and some populations within a species have been shown to lack a diapause response or to overwinter without diapausing (Wysoki & Swirski, 1971; McMurtry *et al*., 1976; Overmeer, 1985).

Female phytoseiid mites lay between 22 (at 15 to 16°C) and 47 (at 25 to 26°C) eggs throughout their life. Eggs hatch after 2 or 3 days, followed by 4 days for immature development at 25°C. Adults live up to 30 days, depending on the temperature (CABI, 2004).

Neoseiulus fallacis eggs are laid on the underside of leaves. Development is more rapid under higher temperature and humidity conditions, taking about 15 days at 15ºC and 5.5 days at 25ºC. Hatched larvae do not feed and remain near their place of emergence. Predation commences in the mobile protonymphal and deutonymphal stages (CABI, 2004).

Female *Typhlodromus pyri* overwinter in bark crevices and other sheltered areas on the tree and commence egg laying in spring. Egg laying estimates range from 16 (Zemek, 1993) to 37

(Genini *et al*., 1991) eggs per female. Multiple matings are required for maximum egg production (CABI, 2004).

Economic importance: Generalist predators have the potential to damage non-target organisms (Howarth, 1991). Predacious mites interact interspecifically through competition for prey or feeding on each other (Croft & MacRae, 1993). Mutual predation reported among predatory mites could result in localised displacement of established mites in the natural ecosystem (Reitz & Trumble, 2002). *Amblyseius aberrans* has been recorded to displace *Typhlodromus pyri* (Duso *et al*., 1991). *Typhlodromus pyri* has been recorded to displace *Metaseiulus occidentalis* (Croft & McRae, 1993).

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2.3 Pathogens

2.3.1 Bacterial decline

Species: *Pseudomonas syringae* pv. *persicae* (Prunier *et al*.) Young *et al*.

Synonym(s): *Pseudomonas mors-prunorum* f.sp. *persicae* Prunier *et al*.

Host(s): Almond, Japanese plum (*Prunus salicina*), myrobalun plum (*P. cerasifisa*), nectarine and peach.

Distribution: United Kingdom (ICMP, 2005), France (Vigouroux & Blache, 1967) and New Zealand (Young, 1988).

Biology: This bacterium enters shoots in autumn and winter through leaf scars to cause the characteristic lesions whose development leads to dieback symptoms. It was first suggested that at low temperatures, and due to its capacity for ice nucleation, the bacterium can penetrate directly into buds on shoots, branches or trunks to cause necrosis and allow infection of the shoot, branch or trunk. However, Vigouroux (1989) stated that the freezing-thawing cycle creates a water-soaked condition in the bark and shoots of peach that facilitates ingress of the bacterium. Pruning wounds also provide a means of entry, particularly those made in winter on susceptible tissues and with pruning tools carrying the pathogen (Luisetti *et al*., 1981). In spring, the bacterium spreads to young shoots and passes into an epiphytic phase (Gardan *et al*., 1972). Leaf lesions provide abundant inoculum in spring. However, it is the epiphytic population on the leaves in autumn that constitutes the inoculum for infection via leaf scars.

The characteristic symptom on peach is an olive-green discoloration around dormant buds on young shoots. These buds rapidly turn brown. Infection can spread rapidly to reach the older shoots or even the main branches. In spring, symptoms of infection range from the death of a few buds or dieback of a few shoots in mild cases, to the wilting and death of main branches or the whole tree in severe cases. Young trees (up to 5-6 years) are most susceptible. Affected tissues appear brownish-red. On the trunk, large lesions with ill-defined borders are formed. Cankers are sometimes seen, corresponding to a defence reaction in less susceptible cultivars. Cankers are mostly observed around pruning cuts, or sometimes at the point of attachment of an affected shoot on a branch. In wet springs, the bacterium causes necrotic spots of young leaves, 1-2 mm in diameter, surrounded by a chlorotic halo. The necrotic tissue subsequently falls out, causing a 'shot-hole' effect. Seriously affected leaves fall prematurely. Fruit spots are reported to be small, round, dark and oily. These spots can spread within the fruit tissue resulting in sunken, deforming lesions that ooze gum.

Natural spread is unlikely to occur over long distances. The main path for international spread would be on infected planting material. Fruit without symptoms do not present a significant risk. Control of further spread depends essentially on prophylactic measures: production of disease-free nursery stock and disinfection of pruning tools. Use of less susceptible cultivars for new plantings in risk areas should help to limit spread. In infected orchards, three-fold treatment with copper-based products during leaf-fall will reduce losses (Luisetti *et al*., 1976). Fertilising techniques such as increasing the calcium content have been reported to limit the disease in orchards (Vigouroux *et al*., 1987).

Economic importance: This is a serious disease whose spread has been favoured by a combination of circumstances including susceptible cultivars, favourable climatic and soil conditions; and ease of transmission by pruning.

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2.3.2 Powdery mildew

Species: *Podosphaera tridactyla* (Wallr.) De Bary

Synonym(s): *Podosphaera oxyacanthae* var. *tridactyla* Salmon; *Podosphaera clandestina* (Wallr.: Fr.) Lev. var *tridactyla* Cooke; *Podosphaera oxyacanthae* (DC) De Bary var *tridactyla* (Wallr.) Salmon; *Oidium passerinii* Bert.

Host(s): *Prunus* sp.(stone fruit); *Prunus armeniaca* (apricot); *Prunus avium* (sweet cherry); *Prunus dulcis* (almond); *Prunus domestica* (European plum); and *Prunus pensylvanica* (bird cherry) (Farr *et al*., 1989).

Distribution: Worldwide (Mukerji, 1968).

Biology: Powdery mildew is a common disease on many types of plants including apricot, plum, and cherry. Different powdery mildew fungi cause similar diseases on different plants. However, a few plants are susceptible to more than one type of powdery mildew. Powdery mildews are particularly prevalent when conditions are warm and dry during the day and cold at night, and on dry soils, so are often most severe at the end of the growing season (HDRA, 2003).

Powdery mildew fungi generally do not require moist conditions to establish and grow, and normally do well in warm climates. Powdery mildew fungi require living plant tissue in order to grow. On deciduous perennial hosts such as grapevines, raspberry and fruit trees, powdery mildew survives from one season to the next in infected buds or as fruiting bodies which reside on the bark of cordons, branches and stems (Teviotdale *et al*., 2001). Areas of white powdery fungal growth, roughly circular in shape, develop on the fruit in spring. These infected areas later become scabby and dry. In late summer and autumn, similar fungal growth appears on leaves. Occasionally, symptoms may develop on fruit and leaves in spring. Powdery mildew appears as weblike white growth on fruit, leaves and stems. Older lesions on fruit are scabby (Teviotdale *et al*., 2004).

Podosphaera tridactyla can be found on the upper surface of leaves in the inner canopy late in the growing season. *Podosphaera tridactyla* overwinters as cleistothecia on the surface of shoots, on dead leaves on the orchard floor, and on bark. Spores are produced from these structures during spring rains, and they infect the developing foliage. Growth of the pathogen is favoured by cool, moist nights and warm days. Cleistothecia are formed in abundance on both apricot and plum late in the growing season (Ogawa *et al*., 1995). Ascospores are produced from cleistothecia during spring rains and infect the developing foliage (Ogawa *et al*., 1995). The conidia are carried by wind currents and germinate on the leaf surface. Although humidity requirements for germination vary, many powdery mildew species can germinate and infect leaves in the absence of water. In fact, conidia of some powdery mildews are killed and germination and growth are inhibited by water on plant surfaces. Conidia and mycelium are sensitive to extreme heat and direct sunlight. The time from germination to formation of new conidia may be as short as 48 hours. High humidity favours the formation of conidia, while low humidity favours the dispersal of conidia (Moorman, 2002).

Economic importance: Stone fruit are susceptible to powdery mildew and the largest economic losses usually result from fruit infection in the orchards. Foliar mildew is more damaging in nursery plantings. The disease occurs on various hosts over a wide geographic area and is particularly troublesome in the semiarid areas of California, the Pacific Northwest and Eastern Europe (Ogawa *et al*., 1995). The disease can cause serious damage on fruit trees where it attacks new growth including buds, shoots, flowers and leaves. New growth is dwarfed, distorted and covered with a white powdery growth. Severely infected leaves may become distorted and fold longitudinally.

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2.3.3 Plum pockets

Species: *Taphrina pruni* Tulasne

Synonym(s): *Exoascus pruni* (Tulasne) Fuckel; *Taphrina insititiae* (Sedebeck) Johans.

Host(s): *Prunus* spp.

Distribution: Australia – except WA (APPD, 2004); Europe (wide spread), Japan, North America (Booth, 1981) and New Zealand (McLaren *et al*., 1999).

Biology: The fungus, *Taphrina pruni*, related to the fungus that causes peach leaf curl, causes plum pockets and occurs on wild and cultivated plums (Behrendt & Floyd, 1999). The most conspicuous symptoms occur on the fruit. The fungus causes small, white blisters on immature fruit. These blisters enlarge as the fruit develops and soon cover the entire fruit. Infected fruit becomes abnormally large, misshapen, and bladder-like with a thick spongy flesh (Behrendt & Floyd, 1999). Seeds do not form and the fruit is hollow. Young leaves and shoots may be distorted but symptoms are not common (Flynn, 1997). Infected fruit is initially red coloured but later appears gray as it becomes covered with fungal growth (Behrendt & Floyd, 1999). Eventually, infected fruit withers and falls from the tree.

The fungus overwinters as dormant spores in bud scales, bark crevices, infected shoots and old fruit. During cool, wet periods spores germinate and infect expanding leaves and young fruit (Tisserat, 2004). Later, the fungus produces great numbers of new spores, which are splashed or blown from tree to tree. These spores remain dormant until the following spring and do not infect mature leaves and fruit. Thus, disease development is limited to a short period (Tisserat, 2004). Infection occurs during spring just as the buds begin to swell. Spring rains wash spores of the fungus to the surface of leaf buds and provides conditions for spores to multiply. Once bud scales loosen in spring, spores are carried in water film to the emerging leaf tissue where infection takes place. Rain and low temperatures are necessary for infection; when temperatures are cool, slowly emerging leaves are exposed to the fungus for longer periods of time. After infection occurs in late winter or early spring, there is no further spread of the disease during that season (Hartman & Bachi, 1994).

Plum pockets can be controlled effectively with a single application of an appropriate fungicide, however, the timing of the fungicides is extremely important. Lime sulfur, ferbam, chlorothalonil, ziram, Bordeaux mixture and other copper fungicides have been used to control this disease (Tisserat, 2004).

Economic importance: Plum pockets could cause losses if regular spray programs are not implemented. However, this disease is rarely considered a serious threat or economically important (Behrendt & Floyd, 1999).

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